PLANNING REPORT NO. 35

A COMPREHENSIVE PLAN FOR THE PIKE RIVER WATERSHED

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Special acknowledgement is due Mr. Curtis R. Hulterstrum, P. E., SEWRPC Principal Engineer, for his effort in the conduct of this study and in the preparation of this report.

Cover Photo Courtesy of Kenosha County Parks Department.

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A COMPREHENSIVE PLAN FOR THE PIKE RIVER WATERSHED

Prepared by the

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STATEMENT OF THE CHAIRMAN

This report documents the findings and recommendations of a three-year study of the serious and costly flooding, water pollution, and related land use problems of the Pike River watershed. The study was undertaken by the Regional Planning Commission in response to formal requests received from the Kenosha and Racine County Boards. The conduct of the study was guided by the Pike River Watershed Committee, a Committee of 23 elected and appointed public officials and concerned citizens from throughout the watershed created by the Commission for this purpose. The study was intended to produce a comprehensive plan, a plan designed to assist the local, state, and federal units and agencies of government concerned in managing in a cost effective and environmentally sound manner the water resources of this urbanizing watershed.

This report presents a summary of the factual findings of the planning and engineering inventories conducted under the watershed study; identifies, and to the extent possible, quantifies the water resource-related problems of the watershed; presents pertinent forecasts of anticipated growth and change within the watershed; sets forth recommended watershed development objectives, principles, and standards; presents a comparative evaluation of alternative flood control, water quality management, and related land use plan elements; and presents a recommended comprehensive plan for the development of the watershed. This report also specifically identifies the actions which must be taken by each of the units and agencies of government concerned to carry out the recommended plan over time. Full implementation of the recommended plan set forth herein will result in resolution of the costly and disruptive flooding and water pollution problems of the Pike River watershed and will avoid the creation of new problems of this sort within the watershed.

As is true of all of the Commission's plans, the Pike River watershed plan is entirely advisory to the local, state, and federal units of government concerned. The watershed plan is intended to provide a point of departure against which development proposals within the watershed can be evaluated by concerned officials and interested citizens as such proposals arise. Upon formal adoption of the watershed plan by the Commission, an official copy thereof will be transmitted to all affected units and agencies of government, along with a request for consideration and formal adoption of the plan and subsequent appropriate implementing action. Full implementation of the watershed plan will require the cooperative action of all of the units and agencies of government operating within the watershed.

In its continuing role of acting as a center for cooperative, areawide planning within southeastern Wisconsin, 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 Pike River watershed plan.

Respectfully submitted,

Alfred G. Raetz

Alfred G. Raetz
Chairman

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Chapter I

INTRODUCTION

The Pike River watershed study is the sixth comprehensive watershed planning program to be carried out by the Southeastern Wisconsin Regional Planning Commission. Since this watershed study is an integral part of the overall work program of the Commission, an understanding of the need for, and objectives of, regional planning and the manner in which these needs and objectives are being met in southeastern Wisconsin is necessary for a proper appreciation of the Pike River watershed study and its findings and recommendations.

NEED FOR REGIONAL PLANNING

In recent years, regional planning has become increasingly accepted as a necessary governmental function in most of the large urban areas of the United States. This tendency reflects growing awareness that certain pressing problems of physical and economic development and of environmental deterioration transcend the geographic limits, as well as the fiscal capabilities, of local units of government and require the cooperation of all units and agencies of government concerned for sound resolution.

The term region, as it is used in this context, applies to an area larger than a county but smaller than a state, united by economic interests and geography and by common problems brought about by rapid urbanization and changing regional settlement patterns. A regional basis is unquestionably necessary to provide a meaningful technical approach to the sound development of such areawide systems of public works as highway and transit, sewerage and water supply, and park and related open space facilities. A regional basis also is necessary to a sound approach to the resolution of such areawide problems as flooding, air and water pollution, deterioration or destruction of the natural resource base, and rapidly changing land use.

State, community, and private interests all are vitally affected by such areawide problems and by proposed solutions to these problems. It appears neither desirable nor possible for any one level or agency of government to impose the decisions required to solve these areawide problems. Such decisions can better come from a consensus of the various levels and agencies of government and private interests concerned, based on a common interest in the welfare of the entire Region. Regional planning is imperative for promoting such a consensus and the necessary cooperation between urban and rural, local and state, and private and public interests.

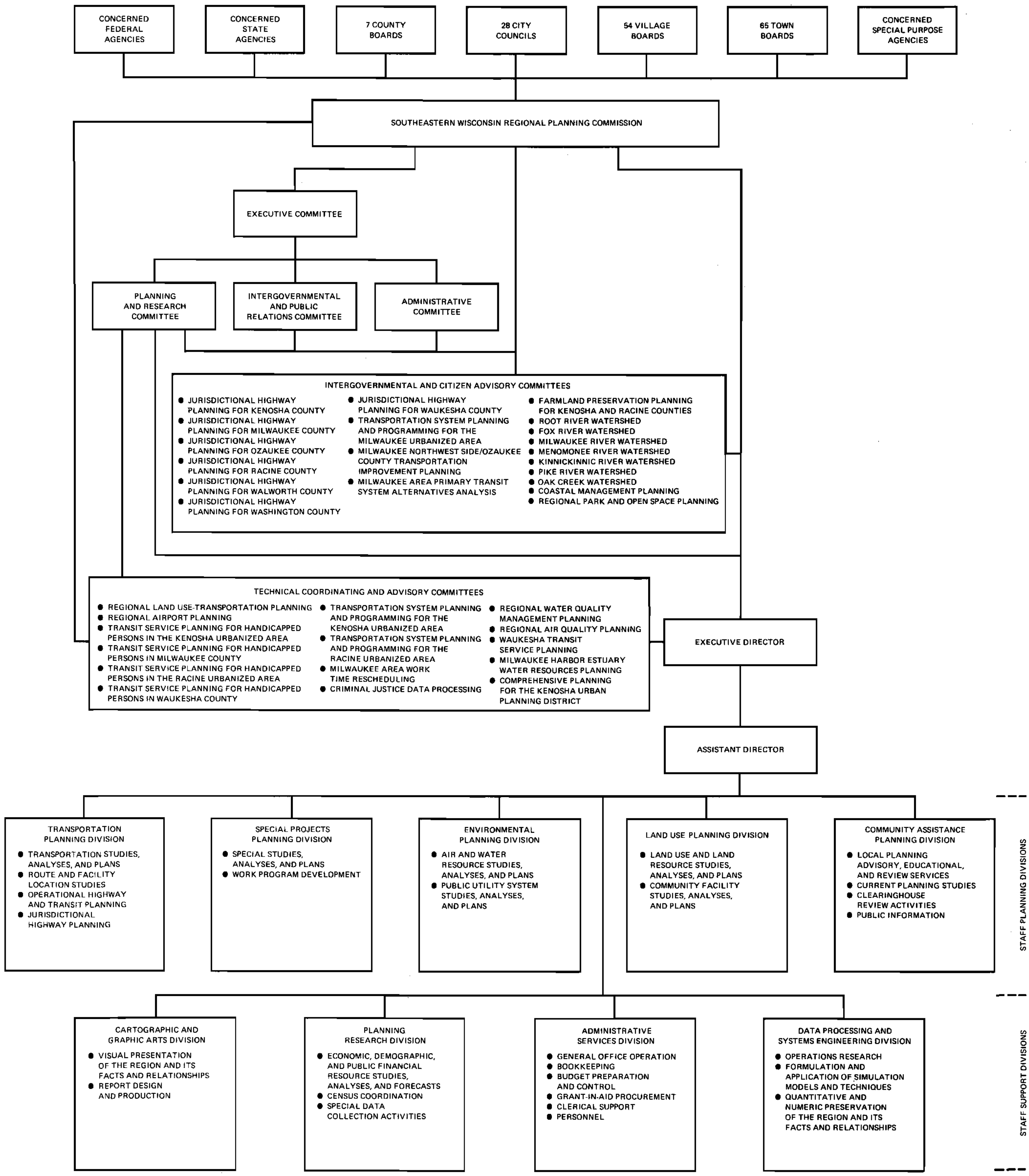
THE REGIONAL PLANNING COMMISSION

The Southeastern Wisconsin Regional Planning Commission (SEWRPC) represents an attempt to provide the necessary areawide planning services for one of the large urbanizing regions of the nation. The Commission was created in August 1960, under the provisions of Section 66.945 of the Wisconsin Statutes, to serve and assist the local, state, and federal units of government in planning for the orderly and economic development of southeastern Wisconsin. The role of the Commission is entirely advisory, and participation by local units of government in the work of the Commission is on a voluntary, cooperative basis. The Commission itself is composed of 21 citizen members, three from each county within the Region, who serve without pay.

The powers, duties, and functions of the Commission and the qualifications of the Commissioners are carefully set forth in state enabling legislation. The Commission is authorized to employ experts and a staff as necessary for the execution of its responsibilities. Basic funds necessary to support Commission operations are provided by the member counties, the budget being apportioned among the seven counties on the basis of relative equalized valuation. The Commission is authorized to request and accept aid in any form from all levels and agencies of government for the purpose of accomplishing its objectives and is authorized to deal directly with the state and federal governments for this purpose. The organizational structure of the Commission and its relationship to the constituent units and agencies of government comprising or operating within the Region are shown in Figure 1.

Figure 1

SOUTHEASTERN WISCONSIN REGIONAL PLANNING COMMISSION: ORGANIZATIONAL STRUCTURE



Source: SEWRPC.

THE REGIONAL PLANNING CONCEPT IN SOUTHEASTERN WISCONSIN

Regional planning as conceived by the Commission is not a substitute for but a supplement to local, state, and federal planning efforts. Its objective is to aid the various levels and units of government in finding solutions to areawide developmental and environmental problems which cannot be properly resolved within the framework of a single municipality or a single county. As such, regional planning has three principal functions:

1. Inventory—the collection, analysis, and dissemination of basic planning and engineering data on a uniform, areawide basis so that, using such data, the various levels and agencies of government and private investors operating within the Region can better make decisions concerning community developments.

2. Plan Design—the preparation of a framework of long-range plans for the physical development of the Region, these plans being limited to those functional elements having areawide significance. To this end, the Commission is charged by law with the function and duty of "making and adopting a master plan for the physical development of the Region." The permissible scope and content of this plan, as outlined in the enabling legislation, extend to all phases of regional development, implicitly emphasizing, however, the preparation of alternative spatial designs for the use of land and for the supporting transportation and utility facilities.

3. Plan Implementation—the provision of a center for the coordination of the many planning and plan implementation activities carried on by the various levels and agencies of government operating within the Region. To this end, all of the Commission work programs are intended to be carried out within the context of a continuing planning program which provides for the periodic reevaluation of the plans produced, as well as for the extension of planning information and advice necessary to convert the plans into action programs at the local, regional, state, and federal levels.

THE REGION

The Southeastern Wisconsin Planning Region, as shown on Map 1, is composed of Kenosha, Milwaukee, Ozaukee, Racine, Walworth, Washington, and Waukesha Counties in southeastern Wisconsin. Exclusive of Lake Michigan, these seven counties have a total area of 2,689 square miles, and together comprise about 5 percent of the total area of the State of Wisconsin. About 38 percent of the state population, however, resides within these seven counties, which contain three of the eight and one-half standard metropolitan statistical areas in the State. The Region contains approximately 38 percent of all the tangible wealth in the State of Wisconsin as measured by equalized valuation, and represents the greatest wealth-producing area of the State, with about 39 percent of the state labor force employed within the Region. The seven-county Region contains 154 local units of government, exclusive of school and other special-purpose districts, and encompasses all or parts of 11 natural watersheds. The Region has been subject to rapid population growth and urbanization and, in the period 1960 to 1975, accounted for about 34 percent of the total population increase of the entire State.

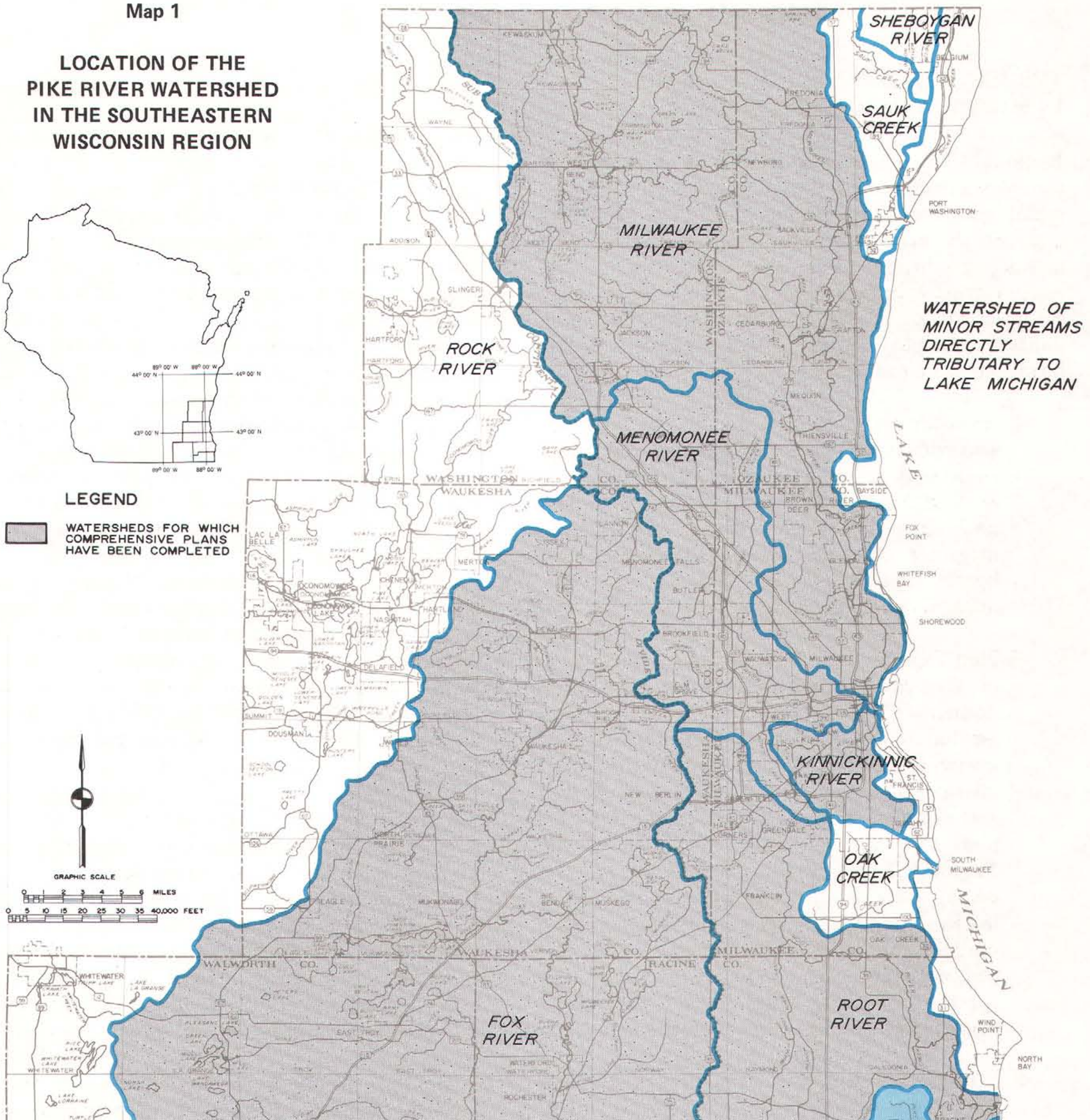
Geographically the Region is located in a relatively good position with regard to continued growth and development. It is bounded on the east by Lake Michigan, which provides an ample supply of fresh water for both domestic and industrial use as well as being a recreational attraction and an integral part of the major international transportation network. It is bounded on the south by the rapidly expanding northeastern Illinois metropolitan region and on the west and north by the fertile agricultural lands and desirable recreational areas of the rest of the State of Wisconsin. Many of the most important industrial areas and heaviest population concentrations in the Midwest lie within a 250-mile radius of the Region, and over 33 million people reside within this radius.

COMMISSION WORK PROGRAMS

The Pike River watershed planning program was conducted within the context of, and has been fully coordinated with, the Commission's ongoing comprehensive planning program for southeastern Wisconsin. It is appropriate to review briefly

Map 1

LOCATION OF THE PIKE RIVER WATERSHED IN THE SOUTHEASTERN WISCONSIN REGION



The Pike River watershed is an integral part of the rapidly urbanizing seven-county Southeastern Wisconsin Region. This Region, while comprising only 5 percent of the total area of the State, contains about 38 percent of the State's population, provides employment for about 39 percent of the State's labor force, and contains approximately 38 percent of all of the tangible wealth of the State. The Pike River watershed is the fifth smallest of the 11 major watersheds located wholly or partly in the Region. About 1.6 percent of the 1975 population of the Region resides within this primarily rural watershed, which comprises only about 1.9 percent of the area of the Region.

Source: SEWRPC.

selected aspects of the Commission's past and current work programs inasmuch as some of the data obtained and some analytic techniques developed under those programs were used in the Pike River watershed planning program. Furthermore, water control facility recommendations contained within the Pike River watershed plan are based in part on, and are coordinated with, land use and other recommendations from other Commission planning programs.

Initial Work Program

The initial work program of the Commission was directed entirely toward basic data collection. It included six basic regional planning studies, which were initiated in July 1961 and completed by July 1963: a statistical program and data processing study, a base mapping program, an economic base and structure study, a population study, a natural resources inventory, and a public utilities study. All of these initial studies were directed toward providing a basic foundation of planning and engineering data for regional planning and were documented in six published planning reports. None of these studies involved the preparation of plans. Their findings, however, provided a valuable point of departure for all subsequent Commission work, including the Pike River watershed planning program.

Also as part of its initial work program, the Commission adopted a policy of community planning assistance in which functional guidance and advice on planning problems are extended to local units of government and through which regional planning studies are interpreted locally and regional plans may be integrated with local plans. Six local planning guides have been prepared to date under this community assistance program to provide municipalities throughout the Region with information helpful in the preparation of sound local planning and plan implementation codes and ordinances. These guides will aid in implementing both regional and local plans and will further assist local public officials in carrying out their day-to-day planning functions. The subject of these guides are land development, official mapping, zoning, organization of local planning agencies, floodland and shoreland development, and use of soil survey data in planning and development. All include model ordinances, and all provide a framework for plan implementation through local land use control measures.

Other Regional and Subregional Work Programs

Additional regional planning programs undertaken by the Commission since its initial work effort, all directed toward the preparation of major elements of a comprehensive plan for the physical development of the Region, include among others: a regional land use and transportation planning program, completed in 1966, with the resulting plans being revised in 1978; a library system planning program, completed in 1974; a regional sanitary sewerage system planning program, completed in 1974; a regional housing planning program, completed in 1975; a regional airport system planning program, completed in 1976; a regional park, outdoor recreation, and related open space study, completed in 1977; a transportation planning program for the elderly and handicapped, completed in 1978; and a regional air quality maintenance planning program, scheduled for completion in 1980. In addition, watershed planning programs were completed for the Root, Fox, Milwaukee, Menomonee, and Kinnickinnic River watersheds; jurisdictional highway system planning programs for all seven constituent counties were completed; and transit development planning programs were completed for the Kenosha and Racine urbanized areas. The Commission also has completed more detailed urban development plans for certain subareas of the Region, including the Kenosha and Racine Planning Districts.

Areawide Water Quality Management Planning Program

In July 1979 the Commission completed an areawide water quality management planning program that has particularly important implications for the Pike River watershed study. The areawide water quality management planning program updated and refined previous water quality and water quality-related plan elements such as the regional sanitary sewerage system plan and earlier comprehensive watershed plans. At the same time this planning program extended those previous water quality and related plan elements to the portions of the Region not then covered with watershed plans and updated all the plan recommendations to the new plan design year 2000. The areawide water quality management plan consists of the following five major elements: 1) an element addressing land use; 2) an element addressing elimination of pollution from point sources; 3) an element addressing elimination of pollution from nonpoint sources; 4) an element addressing the handling, recycling, and disposal of sewage sludge; and 5) an element addressing water quality monitoring. The plan includes the designation of wastewater treatment and water quality management agencies. The findings and recommendations of the areawide water quality management plan are set forth in SEWRPC Planning Report No. 29, A Regional Wastewater Sludge Management Plan for Southeastern Wisconsin, and SEWRPC Planning Report No. 30, A Regional Water Quality Management Plan for Southeastern Wisconsin. This plan was adopted by the Commission on July 12, 1979, and by the Wisconsin Department of Natural Resources on July 25, 1979. The Governor approved and certified the plan to the U. S. Environmental Protection Agency on December 3, 1979. Progress toward implementation of the plan is documented in the Commission's annual reports.

THE PIKE RIVER WATERSHED STUDY

The Pike River watershed study is the sixth comprehensive watershed planning program to be undertaken by the Commission. The watershed encompasses approximately 52 square miles, or 1.9 percent of the seven-county planning area, and about 1.6 percent of the population of the Southeastern Wisconsin Region reside within the watershed. The problems of this watershed typify those found in areas experiencing changing land use patterns and water resource-related problems, and have a direct affect on the property and general welfare of the residents of the watershed.

Initiation of the Pike River Watershed Study

On May 17, 1978, the Southeastern Wisconsin Regional Planning Commission, at the request of the Village of Sturtevant, held an intergovernmental meeting to discuss the serious flooding and drainage problems which exist along Pike Creek and the Pike River in Racine and Kenosha Counties. The meeting was attended by representatives of eight local municipalities, as well as by concerned citizens. After extended discussion of the flooding and drainage problems of the watershed and of past unsuccessful efforts to resolve those problems, extending as far back as January 1970, it was the consensus of the representatives of the municipalities present that sound resolution of the problems of the watershed would require a comprehensive study of the entire watershed, a study which would define the precise nature of existing and probable future drainage and flood control problems of the watershed.

The municipalities represented at the meeting accordingly requested the Regional Planning Commission to direct a letter to the Chairman of each of the two County Boards describing the logical steps to be taken if those Boards wished to sponsor the comprehensive study. That letter was sent on May 19, 1978. On November 6, 1978, and December 14, 1978, respectively, the County Boards of the Counties of Kenosha and Racine formally requested and appropriated funds for the Commission to undertake a comprehensive study of the Pike River watershed, a study looking to the ultimate resolution of the serious and costly flooding and related problems existing in that watershed.

On December 4, 1978, the Commission formed the Pike River Watershed Committee, comprised of 24 local, state, and federal officials and concerned citizen leaders from throughout the watershed, to assist the Commission in its study of the problems of the Pike River watershed. The Pike River Watershed Committee commenced immediately to prepare a prospectus for the comprehensive watershed planning program.[1] The membership of the Pike River Watershed Committee is listed in Appendix A.

The Committee identified and described in the prospectus the four serious resource-related problems within the watershed that require areawide study and resolution: 1) flooding, storm water drainage, and attendant damages; 2) water pollution; 3) changing land use, as related to flooding and storm water drainage and to water pollution; and 4) deterioration and destruction of the natural resource base, particularly the loss of important natural areas and wildlife habitat. The Committee completed the prospectus on March 8, 1979, and urged that the Southeastern Wisconsin Regional Planning Commission approve the prospectus and seek the funding necessary to perform the required study.

The prospectus prepared by the Committee was endorsed by the Commission on April 23, 1979, was published, and, in accordance with the advisory role of the Commission, was transmitted on August 23, 1979, to the governmental agencies concerned for their consideration and action. The Kenosha and Racine County Boards formally

[1] *See Pike River Watershed Planning Program Prospectus, SEWRPC, April 1979.*

endorsed the prospectus on October 2, 1979, and September 11, 1979, respectively, and, as already noted, agreed to provide the funds necessary for execution of the recommended planning program following normal county budgetary procedures.[2] A formal agreement governing the conduct of the study was entered into between the Kenosha and Racine County Boards and the Commission on January 14, 1980, and work on the study was initiated. The total study cost of $116,600 was, as recommended in the prospectus and agreed upon in the aforementioned agreement, apportioned between the two counties concerned on the basis of the estimated proportion of the equalized assessed valuation of the watershed contained within each county. On this basis, the Kenosha County Board agreed to pay 44 percent of the study costs, and the Racine County Board 56 percent.

The prospectus was not a finished study design. It was a preliminary design prepared to obtain support and financing for the necessary study, an objective which was fully achieved. Major work elements, a staff organization, a time schedule, and cost estimates were set forth in the prospectus. Work on the study, as recommended in the prospectus, began in January 1980.

Study Objectives

The primary objective of the Pike River watershed planning program, as set forth in the prospectus, is to help abate the serious water resource and water resource-related problems of the Pike River basin by developing a workable plan to guide the staged development of multi-purpose water resource facilities and related resource conservation and management programs for the watershed. To be effective, this plan must be amenable to cooperative adoption and joint implementation by all levels and agencies of government concerned. It must be capable of functioning as a practical guide for decision-making on both land and water resource development within the watershed so that, through such development, the major water resource and water resource-related problems within the watershed may be abated and the full development potential of the watershed realized. More specifically, the objectives of the planning program are to:

1. Prepare a plan for the management of floodlands along the major waterways of the Pike River watershed, including measures for the mitigation of existing flood and storm water drainage problems and elements for the minimization of future flood problems.

2. Prepare a plan for surface water quality management for the Pike River watershed, incorporating measures to abate existing pollution problems and elements intended to prevent future pollution problems. Local refinement and detailing of sanitary sewer service areas, as well as other local actions to implement the adopted regional water quality management plan, will be incorporated and properly reflected in the watershed planning process.

3. Prepare a plan for public open space preservation, including measures for the preservation and enhancement of the remaining woodlands, wetlands, and fish and wildlife habitat of the watershed.

4. Refine and adjust the regional land use plan to reflect the conveyance, storage, and waste assimilation capabilities of the waterways and floodlands of the watershed; to include feasible water control facilities; and generally to promote the rational adjustment of land uses in this still largely rural, but rapidly urbanizing, basin to the surface water resources.

Special Consideration for the Lake Michigan Estuary

The entire Pike River watershed, from its headwater areas to its confluence with Lake Michigan, was included in the comprehensive watershed

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[2] *In addition to endorsing the prospectus for the Pike River watershed study, the Kenosha County Board on April 3, 1979, authorized and provided funding in the amount of $54,000 for the preparation of 1" = 200' scale, two-foot contour interval topographic maps based upon a monumented survey control network, as recommended by the Regional Planning Commission, of all that part of the Pike River watershed lying in Kenosha County. The completion of that mapping by January 1, 1980, together with the availability of similar maps from Racine County for the Racine County portion of the watershed, permitted the watershed study to proceed immediately in January 1980 in the most efficient and effective manner possible.*

planning program for purposes of the flood control and floodland management and related land use plan elements of the study. Primary attention with respect to the water pollution element of the study was focused on that part of the watershed lying upstream of the lagoon on the Carthage College Campus in the City of Kenosha. That 1.4-mile reach of the Pike River lying below the lagoon forms an estuary of Lake Michigan, as shown on Map 2. Because of the complex nature of the effect of this estuary on water quality, it is the Commission's position that it be studied separately from the free-flowing portions of the Pike River stream system. The north end of the Carthage College lagoon was selected as the upstream terminus of the Lake Michigan estuary because 1) channel width and depth increase dramatically at this location; 2) reverse currents have been observed up to this point; and 3) Lake Michigan backwater effects are minimal upstream of the lagoon. The watershed study, accordingly, will incorporate only those aspects of the estuary that have a direct bearing on the watershed above the estuary. An example of the study content is the determination of the effect of Lake Michigan levels on Pike River flood stages above the Carthage College lagoon.

Map 2

THE LAKE MICHIGAN ESTUARY SUBWATERSHED FORMED BY THE CONFLUENCE WITH THE PIKE RIVER

The Pike River joins the Lake Michigan estuary within the City of Kenosha before discharging to Lake Michigan. The northerly terminus of the estuary is located 1.4 miles up the Pike River at the Carthage College lagoon in the City of Kenosha. It is the Commission position that, because of the complexity of the estuary, a water quality study of the estuary should be made separately from a study of the free-flowing portion of the Pike River not affected by backwater from Lake Michigan.

Source: SEWRPC.

Staff, Cooperating Agency, Consultant, and Committee Structure

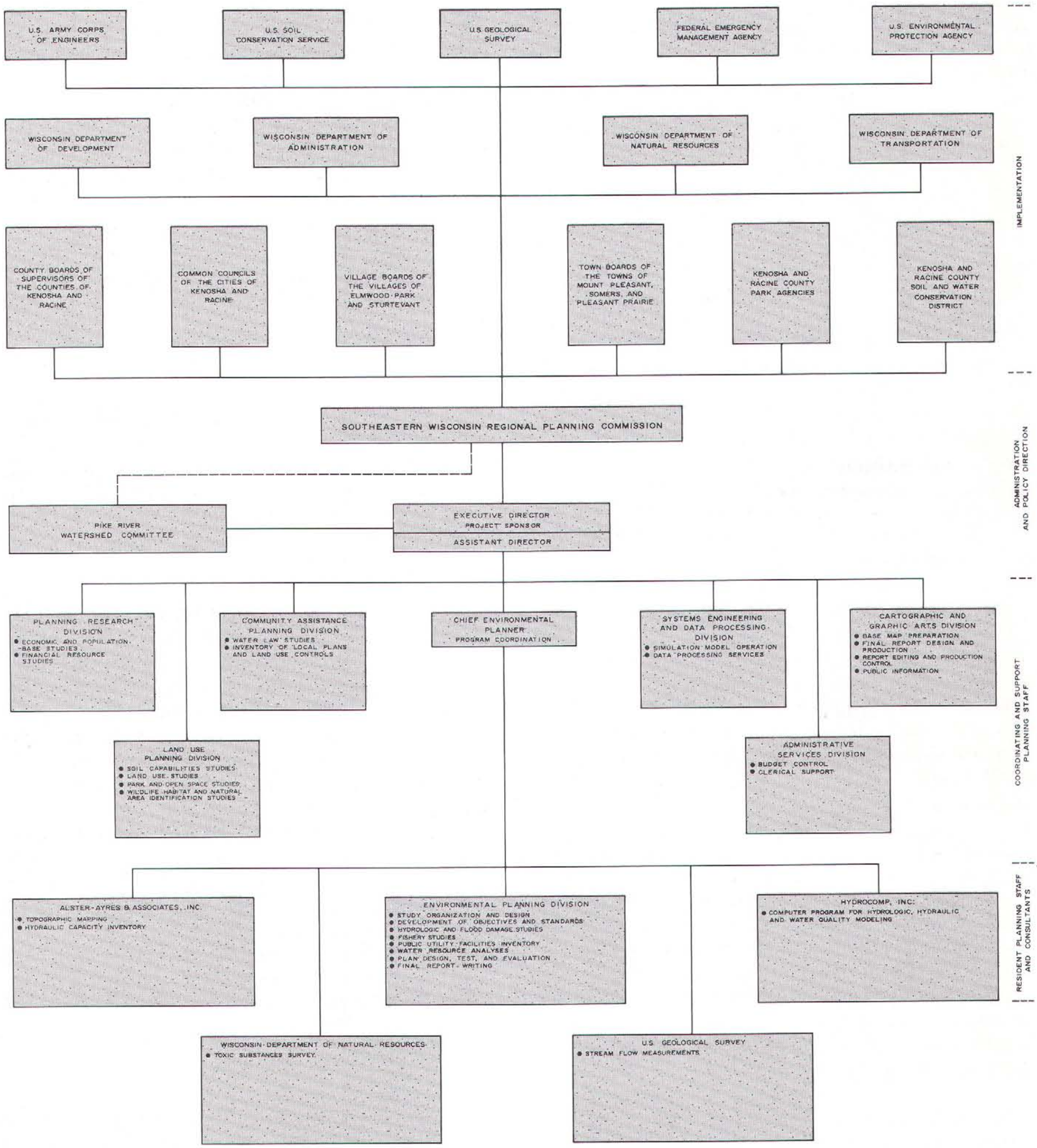
The basic organizational structure for the study is outlined in Figure 2, and consists of the cooperating state and federal agencies, consultants, and Commission staff, along with the designated responsibilities of these agencies, consultants, and staff in the conduct of major elements of the planning study.

A comprehensive watershed planning program necessarily covers a broad spectrum of related governmental and private development programs, and thus no agency, whatever its function or authority, can operate independently in the conduct of a watershed study. The basic Commission organization provides for the attainment of the necessary interagency coordination through the establishment of advisory committees, as well as through interagency staff assignment.

One such advisory committee created by the Commission for watershed planning is the Pike River Watershed Committee, which, as already mentioned, was established in December 1978. The purpose of this Committee is to actively involve governmental bodies, technical agencies, and private interest groups within the watershed in the planning study. The Committee is intended to assist the Commission in determining and coordinating public policies involved in the conduct of the study and in the resultant plans and plan implementation programs. Active involvement of

Figure 2

ORGANIZATIONAL STRUCTURE FOR THE PIKE RIVER WATERSHED STUDY



Source: SEWRPC.

state and federal, as well as of local, public officials in the watershed planning program through this Committee is particularly important to any ultimate implementation of the watershed plans in view of the advisory role of the Commission in shaping regional and subregional development. The Watershed Committee also performs an important educational function in familiarizing local leadership within the watershed with the study and its findings, in generating an understanding of basic watershed development objectives and implementation procedures, and in encouraging plan implementation.

The watershed planning work program has been conducted by the resident Commission staff, supplemented as needed by contractual services provided by two consulting engineering firms. The Commission staff managed and directed all phases of the engineering and planning work. More specifically, the Commission staff was responsible for preparation of the detailed study design; formulation of watershed development objectives, principles, and standards; conduct of certain inventories; conduct of all analyses of the inventory data to identify the problems and development potential of the watershed; synthesis and evaluation of alternative plan elements; and report preparation.

The efforts of the Commission professional and supporting staff were supplemented with the services of specialists in the areas of surveying and hydrologic-hydraulic-simulation modeling. A contractual agreement was executed with the firm of Alster-Ayres & Associates, Inc., of Madison, Wisconsin, for the provision of physical data and related vertical control survey information on selected hydraulic structures in the watershed. Similarly, a contractual agreement was made with Hydrocomp, Inc., of Chicago, Illinois, for the provision of the computer programs used in simulating the hydrologic, hydraulic, and water quality characteristics of the watershed surface water system.

Scheme of Presentation

The major findings and recommendations of the Pike River watershed planning program are documented and presented in this report. The report first sets forth the basic concepts underlying the study and the factual findings of the extensive inventories conducted under the study. It identifies and, to the extent possible, quantifies the developmental and environmental problems of the watershed, and sets forth forecasts of future economic activity, population growth, and land use and concomitant environmental problems. The report presents alternative plan elements for floodland management, pollution abatement, and land use, and sets forth a recommended plan for the development of the watershed based upon regional and watershed development objectives adopted by the Watershed Committee and the Commission. In addition, it contains financial and institutional analyses and specific recommendations for plan implementation. This report is intended to allow careful, critical review of the alternative plan elements by public officials, agency staff personnel, and citizen leaders within the watershed, and to provide the basis for plan adoption and implementation by the federal, state, and local agencies of government concerned.

This report can only summarize briefly the large volume of information assembled in the extensive data collection, analysis, and forecasting phases of the Pike River watershed study. Although the reproduction of all of this information in report form is impractical due to the magnitude and complexity of the data collected and analyzed, all of the basic data are on file in the Commission offices and are available to member units and agencies of government and to the general public upon specific request. This report, therefore, serves the additional purpose of indicating the types of data which are available from the Commission and which may be of value in assisting federal, state, and local units of government and private investors in making better decisions about community development within the Region.

Chapter II

BASIC PRINCIPLES AND CONCEPTS

INTRODUCTION

Watershed planning is not new. Plans have been developed in the past for many watersheds, both large and small, throughout the United States. Most of these plans, however, have been developed either to meet the needs of one or more specific revenue-producing functions, such as irrigation or hydroelectric power generation, or to fulfill a single-purpose requirement for which specific benefits are assignable to existing properties, such as flood control or soil and water conservation. Generally speaking, watershed planning efforts have traditionally employed a narrow range of means to achieve essentially a narrow range of goals, with emphasis on those goals for which attainment could be directly measured in monetary terms.

The application of comprehensive planning principles and practices to water and water-related resource problems as described in this report, however, is a relatively new concept. Consequently, at the time the Commission undertook its first comprehensive watershed planning program, that for the Root River watershed, little practical experience had been accumulated in such comprehensive watershed planning, and the now widely accepted principles governing such planning had not been established. Moreover, the need to carry out comprehensive watershed planning as an integral part of a broader regional planning effort required the adaption and modification of the limited body of watershed planning experience which did exist to the specific needs of the Root River watershed planning program.

These factors necessitated, as part of the Root River watershed study, the development of a unique approach to watershed planning, an approach which proved to be sound and which was, therefore, adopted for use in subsequent studies of the Fox, Milwaukee, Menomonee, Kinnickinnic, and Pike River watersheds. This approach can only be explained in terms of the conceptual relationships existing between watershed planning and regional planning and the basic principles applicable to watershed planning set within the framework of regional planning. Once this foundation of conceptual relationships and applicable principles has been established, the approach taken to identify the specific problems of the Pike River watershed and to recommend solutions to these problems, as presented herein, can then be properly understood.

THE WATERSHED AS A PLANNING UNIT

Planning for water and water-related natural resources could conceivably be carried out by geographic units, including areas defined by governmental jurisdictions, economic linkages, or watershed boundaries. None of these is perfect as a water and water-related resources planning unit. There are many advantages, however, to selecting the watershed as a water and water-related resources planning unit because many problems of both rural and urban development and of natural resource conservation are water-oriented.

Floodland management measures and flood control and storm water drainage facilities should form a single integrated system in an entire watershed. Streams and watercourses, as hydraulic systems, must be capable of carrying both present and future runoff loads generated by changing land use and changing water control facility patterns within the watershed. Therefore, flood control and storm drainage problems and facilities can best be considered on a watershed basis. Drainage and flood control problems are closely related to other land and water use problems. Consequently, floodland protection, park and related open space reservation, and other recreational needs associated with surface water resources also can best be studied on a watershed basis.

Water supply and sewerage frequently involve problems that cross watershed boundaries, but strong watershed implications are involved if the source of water supply comes from the surface water resources of the watershed, or if the sewerage systems discharge pollutants into the surface water system. Groundwater divides do not necessarily coincide with surface water divides, and therefore planning for groundwater use and protection must incorporate both intrawatershed and interwatershed considerations. Changes in land use and transportation requirements ordinarily are not controlled primarily by watershed factors, but they can, nevertheless, have major effects on watershed problems. Land use and transportation patterns may significantly affect the amount and spatial distribution of the hydraulic and pollution loadings to be accommodated by water control facilities. In turn, the water control facilities and their effect upon the historic floodlands determine to a considerable extent the use to which such land areas may be put.

Finally, the related physical problems of a watershed tend to create a strong community of interest among the residents of the watershed, and citizen action groups can readily be formed to assist in solving water-related problems. The existence of a community of interest around which to organize enlightened citizen participation in the planning process is one of the most important factors contributing to the success of such a process.

It may be concluded, therefore, that the watershed is a logical unit for water resources planning, provided that the relationships existing between the watershed and the surrounding region are recognized. Accordingly, the regional planning program in southeastern Wisconsin embodies a recognition of the need to consider watersheds within the Region as rational planning units if workable solutions are to be found to intensifying interrelated land and water use problems.

The foregoing discussion implies that the term watershed may have two meanings. Defined in a strictly physical sense, a watershed is simply a geographic area of overland drainage contributing surface runoff to the flow of a particular stream or watercourse at a given point. Under this definition, the terms watershed and drainage basin are synonymous. However, the meaning of the term watershed may be expanded to include planning concepts by adding to the above definition the phrase: whose natural and man-made features are so interrelated and mutually interdependent as to create a significant community of interest among its residents. This expanded definition of the term watershed contains within it the characteristics which a drainage basin, such as that of the Pike River, must exhibit if it is to form a rational unit for comprehensive water resources planning. It is thus recognized that a watershed is far more than a system of interconnected waterways and floodlands which, in fact, comprise only a small proportion of the total watershed area. Land treatment measures, soil and water management practices, and land use over the entire watershed, as well as all related water resource problems, are of major importance in the proper development of watershed resources.

RELATIONSHIP OF WATERSHED TO REGION

Although recognizing the importance of the watershed as a rational planning unit within the Region, the regional planning program in southeastern Wisconsin also recognizes the need to conduct individual watershed planning programs within the broader framework of areawide, comprehensive regional planning. This is essential for two reasons. First, areawide urbanization and the developmental and environmental problems resulting from such urbanization indiscriminately cross watershed boundaries and exert an overwhelming external influence on the physical development of the affected watershed. Second, the meandering pattern of natural watershed boundaries rarely, if ever, coincides with the artificial, generally rectangular boundaries of minor civil divisions and special-purpose districts.

Important elements of the necessary comprehensive, areawide planning program have been provided by the regional land use-transportation study and by other areawide planning programs of the Commission, such as the regional sanitary sewerage system planning program and the areawide water quality management planning program. Conversely, within the context of the regional planning program, the comprehensive watershed planning programs provide one of the key elements of a comprehensive regional development plan—namely, a long-range plan for water-related community facilities. While the proposed watershed plans may be centered on water quality and flood control facilities and on floodland management measures, it must be recognized that these facility plans and management measures must reflect consideration of the related problems of land and water use and of park and related open space reservation needs. Recognition of the need to relate water control facility plans and management measures to areawide regional development plans is the primary factor underlying the unique nature of the Commission watershed planning efforts. Ultimate completion of planning studies covering all of the watersheds within the Region will provide the Commission with a framework of plans encompassing drainage, flood control, and water pollution control facilities as well as floodland management measures properly related to comprehensive, areawide development plans.

THE WATERSHED PLANNING PROBLEM

Although the water-related resource planning efforts of the Commission are focused on the watershed as a rational planning unit, the watershed planning problem is closely linked to the broader problem of protecting and maintaining the quality of the environment in urban and urbanizing areas. In the past, environmental protection, or what was then more commonly called "conservation," was largely concerned with protecting large natural tracts in rural areas and with the possible future shortages of mineral or other resources resulting from chronic mismanagement. The major problem which environmental protection now faces is occasioned by the ever-increasing areawide diffusion of urban development over large areas of the earth's surface, together with the relentless pursuit of an ever higher material standard of living.

Enlightened public officials and citizen leaders are gradually becoming aware of this new and pressing need for the protection and, in some cases, the enhancement of the physical environment in urbanizing areas. The need to adjust the physical fabric of urban development to the ability of the underlying natural resource base to sustain such development is critical in urbanizing areas such as the Pike River watershed. In such urbanizing areas, as opposed to more sparsely settled rural watersheds, the overall quality of the environment becomes highly dependent on present and future land use activities and supporting public facilities, and the viable options remaining for environmental protection and enhancement are limited.

The growing awareness of the need for environmental protection in urban areas is often heightened by a major disaster or the imminent threat of such a disaster. In many cases, such as in the Pike River watershed, the initial concern with environmental protection is centered on such highly visible problems as flooding and water pollution. Even then, however, the magnitude and degree of the interrelationship of environmental problems may not always be fully realized.

The ultimate resolution of these problems will require many important public policy determinations. These determinations must be made in recognition of an urbanizing Region which is constantly changing, and therefore should be based upon a comprehensive planning process able to objectively scale the changing resource demands against the ability of the limited natural resource base to meet these demands. Only within such a planning process can the effects of different land and water use and water control facility construction proposals be evaluated, the best course of action intelligently selected, and the available funds most effectively invested.

The ultimate purposes of such a planning process are two-fold: 1) to permit public evaluation and choice of alternative development and environmental protection and enhancement policies and plans, and 2) to provide, through the medium of a long-range plan for water-related community facilities, for the full coordination of local, state, and federal development and environmental protection programs within the Region and within the watersheds of the Region. Important among the goals to be achieved by this process are the protection of floodlands; the protection of water quality and supply; the preservation of land for park and open space; and, in general, the promotion of the wise and judicious use of the limited land and water resources of the watershed and of the Region of which the watershed is an integral part.

BASIC PRINCIPLES

Based upon the foregoing considerations, eight basic principles were developed under the Root River watershed study. Together, these form the basis for the specific watershed planning process applied by the Commission in that study. These same principles were used in the Fox, Milwaukee, Menomonee, and Kinnickinnic River watershed studies, and provide the foundation for the planning process applied in the Pike River watershed study:

1. Watersheds must be considered as rational planning units if workable solutions are to be found to water and water-related resource problems.

2. A comprehensive, multi-purpose approach to water resource development and to the control and abatement of the water-related problems is preferable to a single-purpose approach.

3. Watershed planning must be conducted within the framework of a broader areawide regional planning effort, and watershed development objectives must be compatible with, and dependent upon, regional development objectives and plans based on those objectives.

4. Water control facility planning must be conducted concurrently with, and inseparably from, land use planning.

5. Both land use and water control facility planning must recognize the existence of a limited natural resource base to which urban and rural development must be properly adjusted to ensure a pleasant and habitable environment.

6. The capacity of each water control facility in the integrated watershed system must be carefully fitted to the present and future hydraulic loads, and the hydraulic performance and hydrologic feasibility of the proposed facilities must be determined and evaluated.

7. Primary emphasis should be placed on in-watershed solutions to water resource problems. The export of water resource problems to downstream areas is unwise on a long-range and regional basis.

8. Plans for the solution of watershed problems and development of resources should offer as flexible as possible an approach to avoid "dead-end" solutions and should provide latitude for continued adaptation to changing conditions.

THE WATERSHED PLANNING PROCESS

Based upon the foregoing principles, the Commission has developed a seven-step planning process by which the principal functional relationships existing within a watershed can be accurately described, both graphically and numerically; the hydrologic, hydraulic, and water quality characteristics of the basin simulated; and the effect of the different courses of action on land use and water control facility development evaluated. The watershed planning process not only provides for the integration of all the complex planning and engineering studies required to prepare a comprehensive watershed plan, but also provides a means whereby the various private and public interests concerned may actively participate in the plan preparation. The process thus provides a mechanism for resolving actual and potential conflicts between such interests; a forum in which the various interests may better understand the interrelated problems of the watershed and the alternative solutions available for such problems; and finally, a means whereby all watershed interests may become committed to implementation of the best alternative for the resolution of the problems.

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 synthesis, 6) plan testing and evaluation, and 7) plan selection and adoption. Plan implementation, although necessarily beyond the foregoing planning process, must be considered throughout the process if the plans are to be realized.

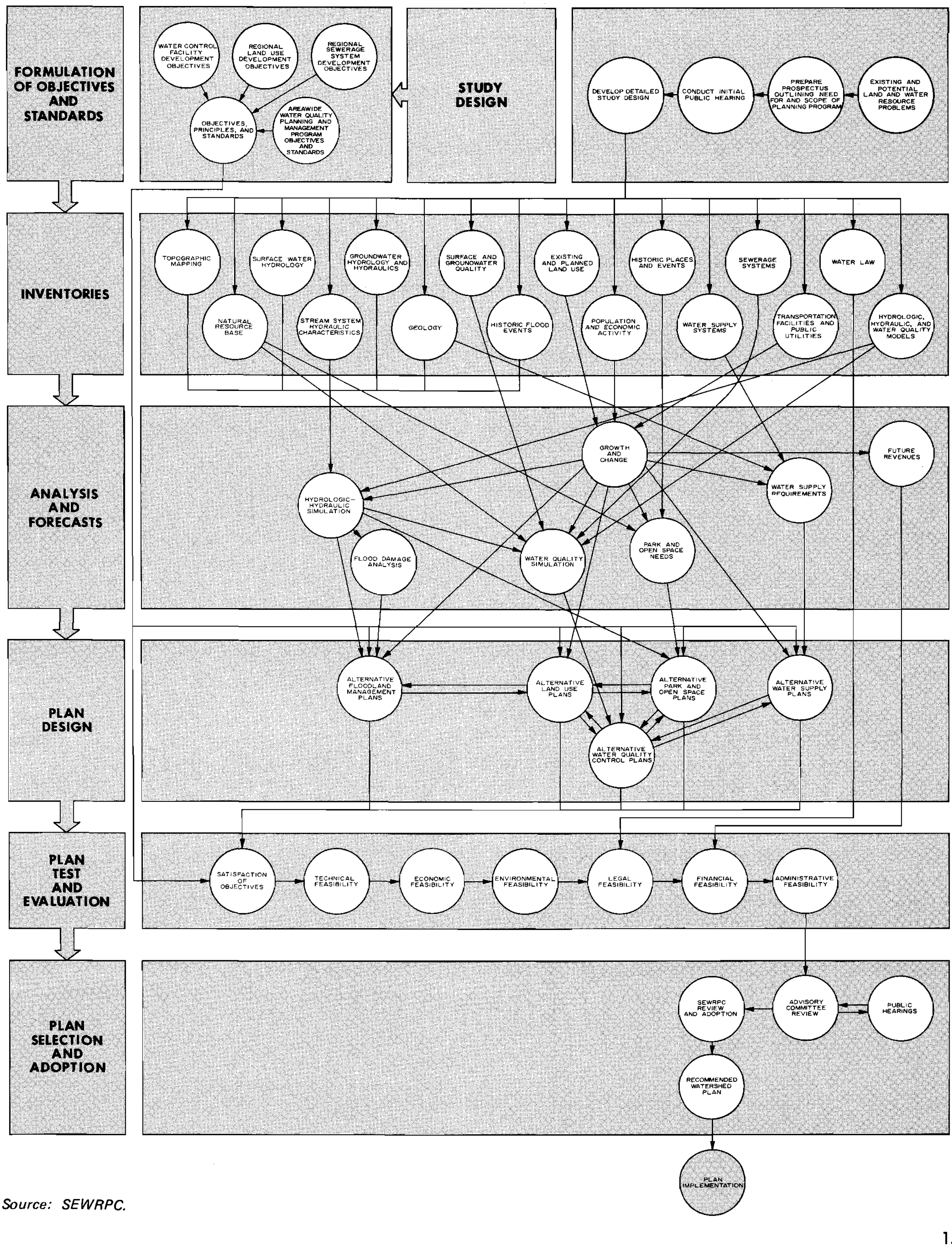
The principal results of the above process are land use and water control facility plans scaled to future land use and resource demands and consistent with regional development objectives. In addition, the process represents the beginning of a continuing planning effort that permits modification and adaption of the plans and the means of implementation to changing conditions. Each step in this planning process includes many individual operations which must be carefully designed, scheduled, and controlled to fit into the overall process. An understanding of this planning process is essential to an appreciation and understanding of the results. Each step in the process, together with its major component operations, is diagrammed in Figure 3 and described briefly below.

Study Design

Every planning program must embrace a formal structure or study design so that the program can be carried out in a logical and consistent manner. This study design must specify the content of the fact-gathering operations, define the geographic area for which data will be gathered and plans prepared, outline the manner in which the data collected are to be processed and analyzed, specify requirements for forecasts and forecast accuracy, and define the nature of the plans to be prepared and the criteria to be used in their evaluation and adoption.

Figure 3

GENERAL STEPS IN A COMPREHENSIVE WATERSHED PLANNING PROGRAM



Source: SEWRPC.

The need for, and objectives of, the Pike River watershed study were set forth in the Pike River Watershed Planning Program Prospectus prepared by the Pike River Watershed Committee. The prospectus also identified major work elements to be included in the comprehensive watershed study and set forth in the study design framework. In addition, a public hearing was held by the Watershed Committee on February 7, 1980, to elicit public opinions concerning the need for, objectives of, and scope and content of the proposed watershed study. The testimony presented at this hearing, which was attended by about 30 interested persons, is set forth in the published minutes of the hearing.[1] The prospectus, supplemented by the testimony presented at the initial public hearing, was used by the Commission staff to prepare a detailed study design which was used for project management purposes throughout the duration of the study.

The staff of the Southeastern Wisconsin Regional Planning Commission expanded and refined this study design during the course of the study as a result of continuous staff level communication with those governmental agencies and private consultants contributing certain specialized services to the Pike River watershed planning program, and with the Watershed Committee.

Formulation of Objectives and Standards

In its most basic sense, planning is a rational process for establishing and meeting objectives. The formulation of objectives is, therefore, an essential task to be undertaken before plans can be prepared. In order to be useful in the regional and watershed planning process, the objectives to be defined must not only be clearly stated and logically sound, but must also be related in a demonstrable way to alternative physical development proposals. This is essential because it is the duty and function of the Commission to prepare a comprehensive plan for the physical development of the Region and its component parts and, more particularly, because it is the objective of the Pike River watershed planning study to prepare one of the key elements of such a physical development plan: a long-range plan for water-related community facilities. Only if the objectives are clearly relatable to physical development and subject to objective testing can a choice be made from among alternatives of a plan which best meets the agreed-upon objectives. Finally, logically conceived and well expressed objectives must be translated into detailed design standards to provide the basis for plan preparation, testing, and evaluation. Because the formulation of objectives and standards involves both technical and nontechnical policy determinations, all objectives and standards were carefully reviewed and adopted by the Pike River Watershed Committee and the Commission.

The objectives and standards ranged from general development goals for the watershed as a whole to detailed engineering and planning analytical procedures and design criteria covering rainfall intensity-duration-frequency relationships; digital computer simulation of hydrology, hydraulics, and water quality; flood frequency analyses; design floods; and economic and financial analyses. Most of the general development goals were superimposed on the watershed study from previous watershed planning programs, the regional land use-transportation planning program, the regional sanitary sewerage system planning program, and the areawide water quality management planning program.

Inventory

Reliable basic planning and engineering data collected on a uniform, watershedwide basis are absolutely essential to the formulation of workable development plans. Consequently, inventory growing out of the study design becomes the first operational step in any planning process. The crucial need for factual information in the planning process should be evident, since no intelligent forecasts can be made or alternative courses of action selected without knowledge of the historic and current state of the system being planned.

The sound formulation of comprehensive watershed development plans requires that factual data be developed on topographic features, the quantity of surface- and groundwater, precipitation, hydraulic characteristics of the stream system, historic flooding, flood damages, water quality and wastewater sources, water use, soil capabilities, land use, economic activity, population, recreation facilities, fish and wildlife habitat, unique natural areas, historic sites, water supply and sewerage systems and other public utilities, and water law.

[1] *SEWRPC, Minutes of Informational Meeting and Initial Public Hearing—A Comprehensive Plan for the Pike River Watershed.*

In the Pike River watershed study, the most expedient methods of obtaining adequate information of the necessary quality were followed. These included review of prior publications, perusal of agency files, personal interviews with private citizens and public officials, committee meetings of staff and technical advisors, and original field investigations.

Analysis and Forecast

Inventories provide factual information about historic and present situations, but analyses and forecasts are necessary to provide estimates of future needs for land, water, and water control facilities. These future needs must be determined from a sequence of interlocking forecasts. Economic activity and population forecasts enable the determination of future growth within the watershed which, in turn, can be translated into future demands for land, other resources, and water control facilities. These future demands can then be scaled against the existing supply, and plans can be formulated to meet deficiencies.

To illustrate the complexity of this task in comprehensive watershed planning, consider that to prepare a forecast of future floodland management and flood control facility needs it was necessary to analyze and to interrelate the following factors: precipitation characteristics; relationship between basin morphology and runoff; effect of urbanization and soil properties on runoff volume and timing; effect of the hydraulic characteristics of the stream network on streamflow; relationships between streamflow, flood stage, and frequency of flood occurrence; seasonal influence; and influence of floodland storage and conveyance.

Two important considerations involved in the preparation of the necessary forecasts are the target date and accuracy requirements. Both the land use pattern and the floodland management measures must be planned for anticipated demand at some future point in time. In the planning of water control facilities, this "design year" is usually based on the expected life of the first facilities to be constructed in implementation of the plan. Although it may be argued that the design year for land use development should be extended further into the future than that for facilities because of the basic irreversibility of many land development decisions, practical considerations dictate that the land use planning design year be scaled to the facility design year requirement. In the Pike River watershed study, the necessary forecast period was set as approximately 20 years, both as a very conservative approximation of facility life and as a means for locking the watershed forecast periods into the previously determined regional land use-transportation study forecast periods.

Forecast accuracy requirements depend on the use to be made of the forecasts. As applied to land use and water control facility planning, the critical question relates to the effect of any forecast inaccuracies on the basic structure of the plans to be produced. It is important to keep the forecast tolerances within that range in which only the timing and not the basic structure of the plans will be affected.

Plan Synthesis

Plan synthesis or design forms the heart of the planning process. The most well-conceived objective, the most sophisticated data collection, processing, and analysis operations, and the most accurate forecasts are of little value if they do not ultimately result in sound plans. The outputs of each of the three previously described planning operations—formulation of objectives and standards, conduct of inventories, and preparation of forecasts—become inputs to the design problem of plan synthesis.

The land use plan design problem consists essentially of determining the allocation of a scarce resource—land—between competing and often conflicting demands. This allocation must be accomplished so as to satisfy the aggregate needs for each land use and comply with all of the design standards derived from the plan objectives, all at a feasible cost. The water control facility plan design problem requires a similar reconciliation between the hydrologic, hydraulic, and pollution loading derived from the land use plan; adopted facility design standards; existing facilities; and new facility costs.

Plan Testing and Evaluation

If the plans developed in the design stage of the planning process are to be realized in terms of actual land use and water control facility development, some measures must be applied to quantitatively test alternative plans in advance of their adoption and implementation. The alternative plans must be vigorously subjected to all the necessary levels of review and inspection, including: 1) engineering and technical feasiblity, 2) environmental impact, 3) economic and financial feasibility, 4) legality, and 5) political reaction and acceptability. Devices used to test and evaluate the plans range from digital computer simulation programs to evaluate hydrologic-hydraulic responses under alternative plan elements to interagency meetings and public hearings. Plan testing and evaluation should demonstrate clearly which alternative plans or portions of plans are technically sound, economically and financially feasible, legally possible, and politically realistic.

Plan Selection and Adoption

It is proposed that the Pike River watershed study develop a land use plan representing a refinement of the adopted regional land use plan. This land use plan will be supported by various combinations of water control facility system plans for both flood control and pollution abatement, thus providing a number of alternative watershed development plans. The desirability of the recommended comprehensive plan will be supported by an analysis of some of the consequences that may be expected under conditions of uncontrolled development.

The general approach contemplated for the selection of one plan from among alternatives is to proceed through the use of the Pike River Watershed Committee structure, interagency meetings, and informational meetings and hearings to a final decision and plan adoption by the Commission in accordance with the provisions of state enabling legislation. The role of the Commission is to recommend the final plan to federal, state, and local units of government and private investors for their consideration and action. The final decisive step to be taken in the process is acceptance or rejection of the plan by the local governmental units concerned, and subsequent plan implementation by public and private action. Therefore, plan selection and adoption must be founded in the active involvement of the various governmental bodies, technical agencies, and private interest groups concerned with development in the watershed. The use of advisory committees and both formal and informal hearings appears to be the most practical and effective way to achieve such involvement in the planning process, and to openly arrive at agreement among the affected governmental bodies and agencies on objectives and on a final watershed plan which can be cooperatively adopted and jointly implemented.

Chapter III

DESCRIPTION OF THE WATERSHED MAN-MADE FEATURES AND NATURAL RESOURCE BASE

INTRODUCTION

The water resource and water resource-related problems of a watershed, as well as the ultimate solutions to those problems, are a function of the activities of man within the watershed and of the ability of the underlying natural resource base to sustain those activities. Comprehensive watershed planning seeks to rationally direct the future course of human actions within the watershed so as to favorably affect the overall quality of life.

The purpose of this chapter is to describe the natural resource base and man-made features of the Pike River watershed, thereby establishing a factual base upon which the watershed planning process may proceed. This description of the watershed is presented in this chapter in two major sections; the first describes the man-made features, and the second describes the natural resource base of the watershed.

DESCRIPTION OF THE WATERSHED: MAN-MADE FEATURES

The man-made features of a watershed, which are important to any comprehensive planning effort directed at the resolution of water resource and related problems, include its political boundaries, land use pattern, public utility network, and transportation system. Together with the population residing in and the economic activities taking place within the watershed, these features may be thought of as the socioeconomic base of the watershed. A description of this base is essential to sound watershed planning, for any attempt to protect and improve the environment must be founded in an understanding of not only the various demands for land and public facilities and resources generated by the population and economic activities of an area, but also the ability of the existing land use pattern and public facility systems to meet these demands.

In order to facilitate such understanding, the description of the socioeconomic base of the watershed is herein presented in five sections. The first section places the watershed in proper perspective as a rational planning unit within a regional setting by delineating its internal political and governmental boundaries and relating these boundaries to the Region as a whole. The second section describes the demographic and economic base of the watershed in terms of population size, distribution, and composition and in terms of commercial and industrial activity and employment levels and distribution. The third section describes the pattern of land use in the watershed both in terms of historical development and existing (1975) conditions. The fourth and fifth sections describe the public utility and transportation facility systems within the watershed. A final section summarizes the information presented on the man-made features and activities as well as on the natural resource base.

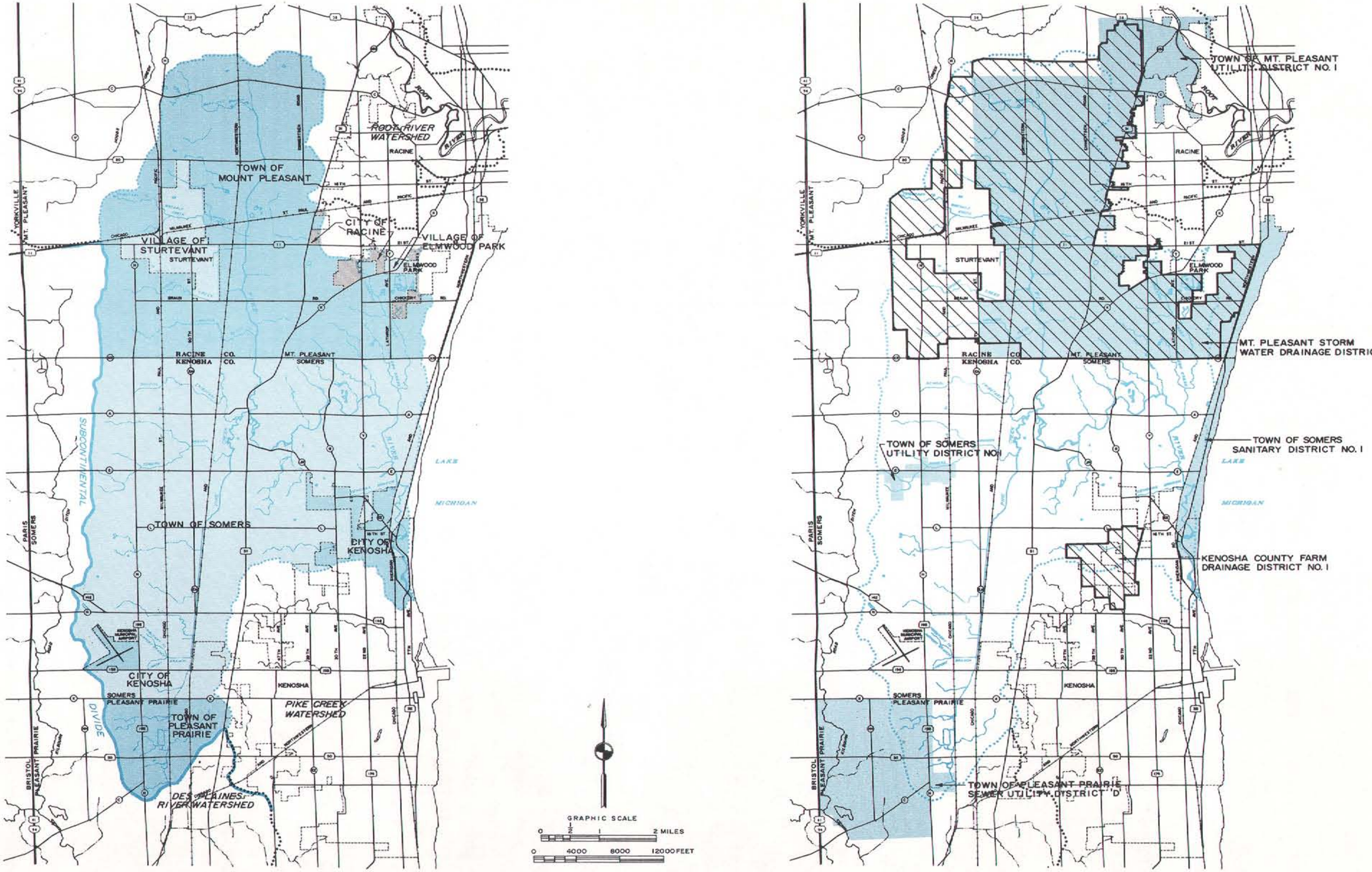
Regional Setting of Watershed and Political Boundaries

The Pike River watershed, as shown on Map 3, is an approximately 52-square-mile surface water drainage basin that discharges to Lake Michigan in the City of Kenosha at a point approximately one mile north of the City of Kenosha Harbor.[1] The Pike River acts as an estuary of Lake Michigan from its mouth to the lagoon located on the Carthage College Campus, a distance of about 1.4 miles. The Pike River watershed is the fifth

[1] *It should be noted that a 1.1 square mile area located in Sections 23 and 24, Township 2 North, Range 23 East, in the Town of Somers, constitutes a subbasin which historically drained to the Pike River. Storm sewers constructed by the City of Kenosha prior to 1980 diverted the runoff from this subbasin to the Pike Creek. In 1980, the City of Kenosha constructed a detention pond and appurtenant storm sewer improvements which rediverted storm water runoff from the area to the Pike River watershed. Thus, this area was again included in the Pike River watershed as originally defined by surface topographic conditions. The existing storm water drainage system is shown on Map 36 in Chapter VII of this report.*

Map 3

THE PIKE RIVER WATERSHED



The Pike River watershed is a 52-square-mile natural surface water drainage basin located within Racine and Kenosha Counties and containing parts of three townships, two villages and two cities. The watershed is also served by six special-purpose districts that carry out sewerage and drainage functions. The watershed is bounded on the north by the Root River watershed; on the west by the Des Plaines River watershed; and on the south and east by areas directly tributary to Lake Michigan. Serious flooding problems exist within the watershed. Sound resolutions for these problems require a comprehensive study of the entire basin.

Source: SEWRPC.

smallest of the 11 major natural watersheds located wholly or partly within the Region. It comprises only 2 percent of the total area of the Southeastern Wisconsin Region.

The Pike River watershed lies in the most rapidly urbanizing portions of Kenosha and Racine Counties; that is, that part of those counties lying east of IH 94. The river has its source in Section 10, Township 3 North, Range 22 East, in the Town of Mt. Pleasant. From its source, the river flows easterly for about one mile before turning south. Several perennial and intermittent streams join the main stem as it flows southerly to Petrifying Springs Park in the Town of Somers in Kenosha County. In Petrifying Springs Park the river is joined by a major tributary, Pike Creek. This watercourse should not be confused with the Pike Creek that flows through the City of Kenosha and is directly tributary to Lake Michigan. Approximately one-quarter mile downstream from the confluence of the Pike River and Pike Creek, the river flows into a four-acre impoundment located within Petrifying Springs County Park. The river's flow may be augmented by groundwater discharged from springs located within the impoundment and other points along the stream in the Park. From Petrifying Springs County Park, the river flows generally easterly to within approximately one mile of the Lake Michigan shoreline, where it is joined from the north by Sorenson Creek. The river then flows southerly for about four miles until it discharges to Lake Michigan, approximately one mile north of the City of Kenosha Harbor.

Six main tributaries discharge to the Pike River: Pike Creek, Bartlett Branch, Waxdale Creek also known as Worthington Lateral, Chicory Creek, Lamparek Ditch, and Sorenson Creek. In addition, two main tributaries discharge to Pike Creek: School Tributary and Somers Branch. Numerous minor, intermittent watercourses are also tributary to the Pike River and to Pike Creek. The perennial streams located in the Pike River watershed are listed in Table 17 and are shown on Map 3.

Civil Divisions: Superimposed on the irregular watershed boundaries is a pattern of local political boundaries. As shown on Map 3, the watershed lies in two counties, three townships, two villages, and two cities. Of the seven minor civil divisions, only the Village of Sturtevant lies entirely within the watershed boundaries. The portions of the watershed lying within each of the seven minor civil divisions involved are shown in Table 1. Geographic boundaries of the civil divisions are an important factor which must be considered in any areawide planning effort, like the Pike River watershed planning program, since the civil divisions form the basic foundation of the decision-making

Table 1

AREAL EXTENT OF CIVIL DIVISIONS IN THE PIKE RIVER WATERSHED: 1979

Civil Division	Area Within Watershed (square miles)	Percent of Watershed Area Within Civil Division	Percent of Civil Division Area Within Watershed
Kenosha County			
City of Kenosha	2.03	3.94	13.74
Town of Pleasant Prairie	2.66	5.16	7.25
Town of Somers	25.33	49.15	73.72
Subtotal	30.02	58.25	10.79
Racine County			
City of Racine	0.57	1.10	4.24
Village of Elmwood Park	0.15	0.29	93.75
Village of Sturtevant	1.56	3.03	100.00
Town of Mt. Pleasant	19.24	37.33	51.14
Subtotal	21.52	41.75	6.32
Total	51.54	100.00	- -

Source: SEWRPC.

framework within which intergovernmental, environmental, and developmental problems must be addressed. This is true because the counties and local municipal units of government all have important resource management responsibilities.

Special-Purpose Units of Government: Special-purpose units of government are of particular interest to the watershed planning program. Among these are the legally established, active town sanitary and utility districts which were created to provide various urban-related services—such as sanitary sewerage, water supply, drainage, and solid waste collection and disposal—to designated portions of rural towns having urban service needs. There are five such districts within the Pike River watershed, as shown on Map 3: the Town of Mt. Pleasant Utility District No. 1, the Mt. Pleasant Storm Water Drainage District, the Town of Pleasant Prairie Sewer Utility District D, the Town of Somers Sanitary District No. 1, and the Town of Somers Utility District No. 1.

Another special-purpose unit of government of concern to the watershed planning program is the farm drainage district. There remains one legally constituted drainage district lying partially within the Pike River watershed, as shown on Map 3. This is the Kenosha County Farm Drainage District No. 1. This District operates under the aegis of the Kenosha County Farm Drainage Board.

Other Agencies Having Resource Management Responsibilities: Superimposed upon these local and special-purpose units of government are the state and federal governments, certain agencies of which have important responsibilities for resource conservation and management. These include the Wisconsin Department of Natural Resources; the University Extension of the University of Wisconsin; the State Board of Soil and Water Conservation Districts; the U. S. Department of the Interior, Geological Survey; the U. S. Environmental Protection Agency; the U. S. Department of Agriculture, Soil Conservation Service; and the U. S. Army Corps of Engineers.

Demographic and Economic Base

Because of the direct relationships which exist between population levels and the demand for land, water, and other important elements of the natural resource base, as well as the demand for various kinds of transportation, utility, and community facilities and services, an understanding of the size, characteristics, and spatial distribution of this population is basic to any watershed planning effort. The size and other characteristics of the population of an area are greatly influenced by growth and other changes in economic activity. Population features and economic activity must, therefore, be considered together. It is important to note, however, that because the Pike River watershed lies within the urbanizing Kenosha and Racine areas, many of the economic forces that influence population growth within the watershed are centered outside the watershed proper. Thus, an economic analysis for watershed planning purposes must relate the economic activity within the watershed to the economy of the Kenosha and Racine metropolitan areas, and to that of the Southeastern Wisconsin Region. Similarly, the size, other characteristics, and distribution of the population residing within the watershed must be viewed in relation to similar characteristics of the population within the Kenosha and Racine metropolitan areas as well as within the Region.

Demographic Base: A study of the demographic base of the watershed includes consideration of population size, distribution, and composition.

Population Size: The 1975 resident population of the watershed was estimated at about 29,000 persons, or about 2 percent of the total population of the Region. As shown in Table 2 and Figure 4, the population of the watershed increased by 37 percent between 1950 and 1960, a rate of increase which was somewhat higher than that of Kenosha and Racine Counties and of the Region. From 1960 to 1970, the population of the watershed grew by 33 percent, a rate of growth somewhat lower than that of the preceding decade, but significantly higher than the rates of increase of Kenosha and Racine Counties and of the Region. This differential in growth rates intensified during the 1970-1975 period, when it is estimated that the population of the watershed increased by 19 percent, while that of Kenosha County, Racine County, and the Region grew by only 7 percent, 5 percent, and 2 percent, respectively. Consequently, the proportion of the total regional population which resides in the watershed has increased from 1 percent in the 1950's and 1960's to 2 percent in 1975. The higher growth rate of the watershed is consistent with the redistribution of population which has been occurring recently in the Region. The Pike River watershed is comprised largely of rural lands adjacent to the Cities of Kenosha and Racine, and is therefore subject to

Table 2

POPULATION IN THE PIKE RIVER WATERSHED, KENOSHA COUNTY, RACINE COUNTY, AND THE REGION: SELECTED YEARS 1950-1975

	Population								
	Pike River Watershed		Kenosha County		Racine County		Southeastern Wisconsin Region		
Year	Number	Percent Change During Preceding Period	Number	Percent Change During Preceding Period	Number	Percent Change During Preceding Period	Number	Percent Change During Preceding Period	Watershed Population as Percent of Regional Popuation
1950	13,262	- -	75,238	- -	109,585	- -	1,240,618	- -	1
1960	18,208	37	100,615	34	141,781	29	1,573,620	27	1
1970	24,224	33	117,917	17	170,838	20	1,756,083	12	1
1975	28,722	19	126,651	7	178,916	5	1,789,871	2	2

Source: SEWRPC.

rapid suburbanization and urbanization. The public preference in the recent past for low-density residential development and the concomitant diffusion of urban development outward from the older metropolitan centers has resulted in higher rates of growth in areas contiguous to cities such as Kenosha and Racine.

Population Distribution: The 1960, 1970, and 1975 watershed population by civil division is presented in Table 3. The Village of Sturtevant, the only civil division which lies entirely within the Pike River watershed, experienced the largest increase in population from 1960 to 1975, with a gain of about 2,900 persons. In 1960, 8 percent of the total watershed population resided in Sturtevant; by 1975, this proportion had risen to 15 percent. The City of Racine had a negligible population in the watershed in 1960, but by 1975, the City had about 1,900 persons residing in the watershed, or about 7 percent of the total watershed population. Other civil divisions, while showing only a small increase or even a decrease in their proportion of the total watershed population, also experienced significant absolute or relative population gains. The Town of Pleasant Prairie's population in the watershed almost doubled during the period 1960 to 1975, from about 350 in 1960 to 650 in 1975. The City of Kenosha and the Town of Mt. Pleasant experienced large population gains in the portion of these civil divisions within the watershed, of about 2,500 and about 2,400, respectively, during this time period, while both contained slightly smaller proportions of the total watershed population in 1975 than they did in 1960.

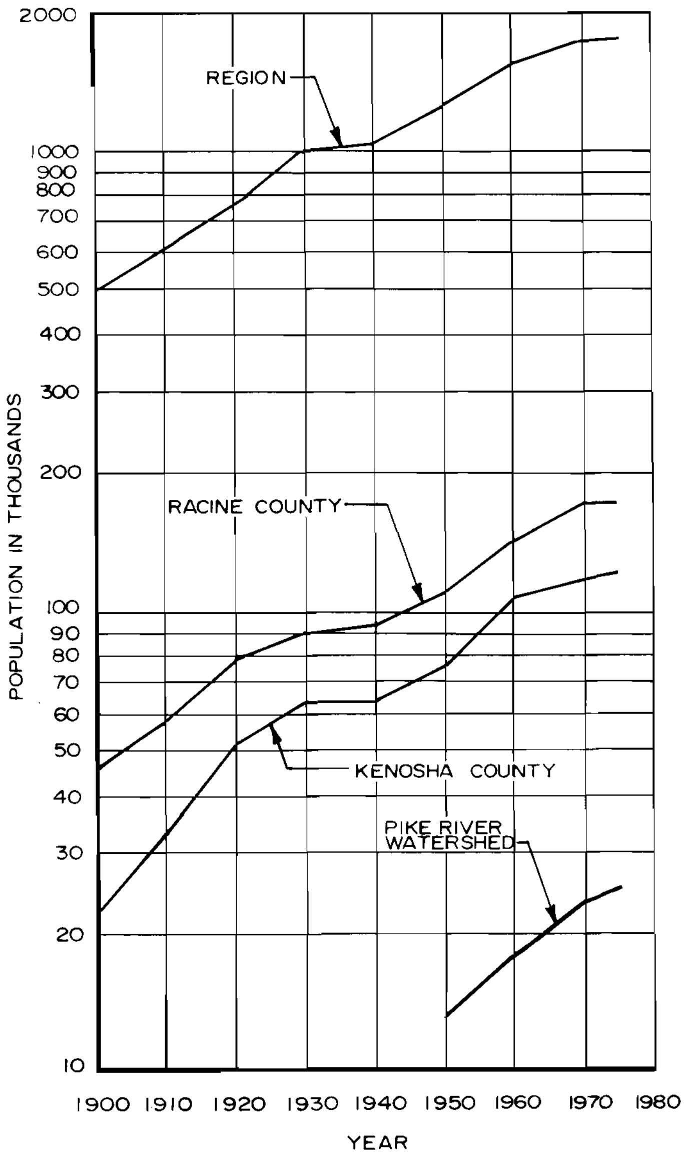
As shown on Map 4, most of the Pike River watershed has a density of less than 350 persons per gross square mile, reflecting the watershed's predominantly rural character. Only a small portion of the watershed in 1975 exhibited a population density in excess of 3,500 or more persons. These higher density areas included parts of the City of Racine, the Village of Sturtevant, and the City of Kenosha, which had densities exceeding 3,600 persons per gross square mile.

Between 1960 and 1975, the overall population density of the watershed increased from about 350 to about 550 persons per square mile, an increase of about 57 percent. The overall 1975 watershed population density, together with the population density of those portions of the various minor civil divisions within the watershed and the proportion of the watershed population residing in these minor civil divisions, is presented in Table 4.

Population Composition: In 1970 the median age of the resident population of the watershed was 25.2 years, while the median ages of the resident population of Kenosha and Racine Counties were about 26.9 years and 26.0 years, respectively, and of the Region as a whole about 27.6 years. This

Figure 4

POPULATION OF THE PIKE RIVER WATERSHED, KENOSHA COUNTY, RACINE COUNTY, AND THE REGION: 1900-1975



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

differential reflects the rural nature of the watershed, for slightly younger age distributions are normally found in rural-urban fringe and in rural areas. The average household size in the watershed in 1970 was 3.67 persons, while the average household sizes in Kenosha and Racine Counties were 3.26 persons and 3.35 persons, respectively, and in the Region as a whole 3.18 persons. This again reflects the predominantly rural character of the watershed, for larger household sizes are normally also more prevalent in rural and rural-urban fringe areas. In 1970, the average annual income for households within the watershed was estimated at $10,440, about equal to that of Racine County, which had an average income per household of $10,550, and that of the Region with an average of $10,330, and higher than that of Kenosha County with an average of $9,530. The highest average household income within the watershed—over $20,000—was found in the Village of Elmwood Park, while the lowest average income—less than $8,000—was found in the Kenosha City portion of the watershed.

Economic Base: The Pike River watershed is located adjacent to and partially within the Kenosha and Racine urbanized areas. As such its economic base cannot be differentiated in any meaningful way from that of the greater Kenosha and Racine areas. The resident population of the watershed can readily commute to jobs located outside of the watershed, while other residents in the greater Kenosha and Racine areas can readily commute to jobs located in the watershed. Some appreciation of the general character of the watershed can, nevertheless, be gained by an examination of the size and character of economic activities in the basin.

Figure 5 shows the relative concentration of jobs by eight major industrial divisions in 1975 for the Pike River watershed and the Region. Employment within the watershed in the eight major categories, estimated at a total of 9,200 jobs, is concentrated in four major industry categories. Manufacturing provided the largest number of jobs, with about 2,600 jobs, or about 28 percent of the total employment. Government services and education, private services, and wholesale and retail trade provided the next largest numbers of jobs; with about 24, 21, and 18 percent of the total, respectively. Recreation related jobs, which are included in the private services category, are becoming of increasing importance to employment within the watershed. The other four major industry groups each provided 3 percent or less of the total jobs in the watershed. About 140 jobs, or less than 2 percent of the total, were provided by agriculture.

The relative concentration of jobs within manufacturing, which provided the largest proportion within the watershed in 1975, is presented in Figure 6 for the Pike River watershed and the Region. The majority of manufacturing jobs are

Table 3

POPULATION IN THE PIKE RIVER WATERSHED BY CIVIL DIVISION: 1950, 1960, 1970, 1975

Civil Division[a]	1950 Population Within Watershed	1950 Percent of Watershed Population	1960 Population Within Watershed	1960 Percent of Watershed Population	1970 Population Within Watershed	1970 Percent of Watershed Population	1975 Population Within Watershed	1975 Percent of Watershed Population
Kenosha County								
City of Kenosha (part)	1,993	15	4,974	27	5,774	24	7,446	26
Town of Pleasant Prairie (part)	210	2	348	2	406	2	641	2
Town of Somers (part)	3,828	29	4,942	27	5,033	21	5,151	18
Kenosha County (part) Subtotal	6,031	46	10,264	56	11,213	47	13,238	46
Racine County								
Town of Mt. Pleasant (part)	6,055	46	6,456	36	8,118	33	8,803	31
City of Racine (part)	--[b]	--	--[b]	--	1,126	4	1,936	7
Village of Elmwood Park[c] (part)	--	--	--	--	391	2	391	1
Village of Sturtevant	1,176	9	1,488	8	3,376	14	4,354	15
Racine County (part) Subtotal	7,231	54	7,944	44	13,011	53	15,484	54
Total	13,262	100	18,208	100	24,224	100	28,722	100

[a] *The boundaries of these civil divisions have changed over time because of annexations.*

[b] *Negligible.*

[c] *The Village of Elmwood Park was incorporated on July 5, 1960, subsequent to the conduct of the federal census on April 1, 1960. Therefore, this population of this area is included in the Town of Mt. Pleasant for 1950 and also 1960.*

Source: SEWRPC.

in the chemical, petroleum, rubber, and plastic products category, which provided for about 72 percent of all manufacturing employment within the watershed. The manufacturing of non-electrical machinery and electrical equipment provided about 12 and 8 percent, respectively, of total manufacturing employment; other types of manufacturing each accounted for 4 percent or less of the total.

Land Use

An important concept underlying the watershed planning effort is that an adjustment must be effected between land use development and the ability of the underlying natural resource base to sustain such development. The type, intensity, and spatial distribution of land uses determine, to a large extent, the resource demands within a watershed. Water resource demands can be correlated directly with the quantity and type of land use, as can water quality deterioration. The existing land use pattern can best be understood within the context of its historical development. Thus, attention is focused herein upon historic as well as existing land use development and upon both regional and watershed factors influencing land use.

Historical Development:[2] The movement of European settlers into the watershed began after 1834. At that time there were no Europeans, except for

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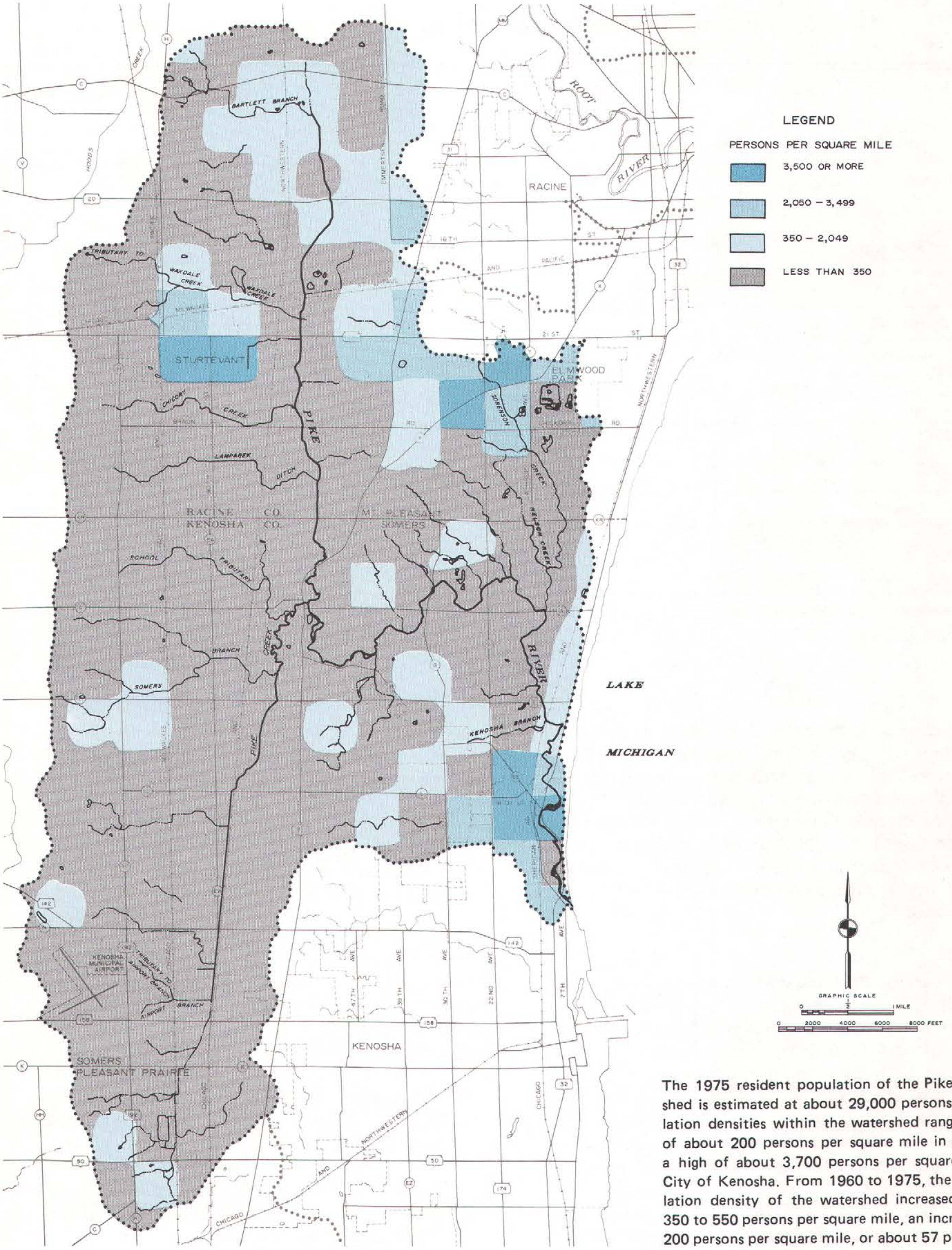
[2] *In addition to Commission inventories of historic places and events, the following references were used in preparing the brief account of the historical development of the Pike River watershed:*

- *Carrie Cropley, "Kenosha From Pioneer Village to Modern City," Kenosha County Historical Society, 1958.*
- *Frank H. Lyman, Kenosha and Kenosha County, Wisconsin, two volumes, S. J. Clarke Publishing Company, Chicago, 1916.*

Map 4

GROSS POPULATION DENSITY IN THE PIKE RIVER WATERSHED: 1975



Source: SEWRPC.

The 1975 resident population of the Pike River watershed is estimated at about 29,000 persons. Gross population densities within the watershed range from a low of about 200 persons per square mile in rural areas to a high of about 3,700 persons per square mile in the City of Kenosha. From 1960 to 1975, the overall population density of the watershed increased from about 350 to 550 persons per square mile, an increase of about 200 persons per square mile, or about 57 percent.

Table 4

TOTAL POPULATION AND POPULATION DENSITY IN THE PIKE RIVER WATERSHED BY CITIES AND VILLAGES: 1975

Civil Division	Population Within Watershed	Percent of Watershed Population	Area Included in Watershed (square miles)	Percent of Area in Watershed	Average Gross Population Density (per square mile)
Cities					
Kenosha.	7,446	26	2.03	3.94	3,668
Racine.	1,936	7	0.57	1.11	3,396
Villages					
Elmwood Park	391	1	0.15	0.29	2,607
Sturtevant.	4,354	15	1.56	3.03	2,791
Towns					
Mt. Pleasant.	8,803	31	19.24	37.33	458
Pleasant Prairie	641	2	2.66	5.16	241
Somers	5,151	18	25.33	49.14	203
Total	28,722	100	51.54	100.00	557

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

one family of hunters and trappers with a cabin near Petrifying Springs, who soon moved away. Even the number of Indians was small, and those still there remained hidden in the forests along the creeks much of the time. Not long before this, there had been three Indian villages in or near what is now the City of Kenosha,[3] but these were gone by 1834.

The only roads were old Indian trails, two of which were located approximately on the alignment of the present day STH 31 and STH 50. For centuries Indians going north toward Green Bay had traveled along that trail which is now STH 31. Indian hunters and trappers used a trail along or near the STH 50 location when traveling between Lake Michigan and the inland lakes to the west such as Geneva Lake.

The first European settlement in the Pike River watershed, the Village of Pike River, occurred in 1835 near the mouth of the Pike River one mile north of the present harbor of Kenosha. This settlement was once a rival of Southport, which became the City of Kenosha. Pike River once had dwellings, stores, mechanics' shops, and warehouses. But during 1842 and the following year, many of the buildings were moved to Southport, and the Village ceased to exist.

Settlements near the Pike River watershed include the aforementioned Southport, now the City of Kenosha, and Root River, now the City of Racine. Settlement of these areas began in 1835 and 1834, respectively. As shown on Map 5, urbanization occurred first within the watershed in the vicinity of the Village of Sturtevant and was generally limited to this area until about 1950. By 1963, urbanization had occurred in small areas throughout the Pike River watershed and constituted about 10 square miles of land, or approximately 19 percent of the area of the watershed. Between 1963 and 1975 approximately 4.7 square miles of additional land was converted from rural to urban use within the watershed; and approximately 28 percent of the total area of the watershed was in urban use.

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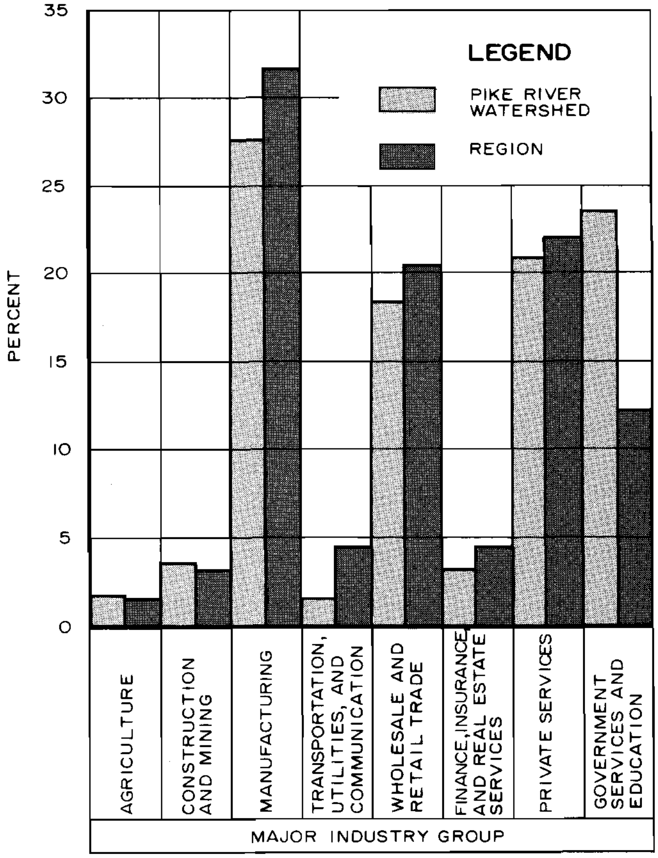
[3] *It is said that these villages, this vicinity, and the river were known as Kenosha ("pike") by Indians and traders because pike were plentiful in the waters of the lake and river.*

Figure 5

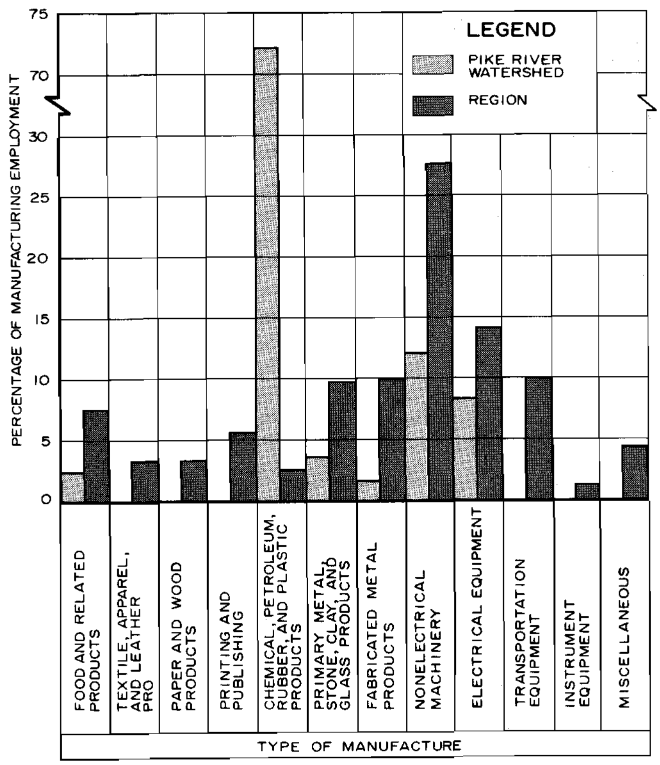
DISTRIBUTION OF TOTAL EMPLOYMENT BY MAJOR INDUSTRY GROUP FOR THE PIKE RIVER WATERSHED: 1975



Source: *Wisconsin Department of Industry, Labor and Human Relations and SEWRPC.*

Figure 6

DISTRIBUTION OF MANUFACTURING EMPLOYMENT BY TYPE OF MANUFACTURING EMPLOYMENT FOR THE PIKE RIVER WATERSHED AND THE REGION: 1975



Source: *Wisconsin Department of Industry, Labor and Human Relations and SEWRPC.*

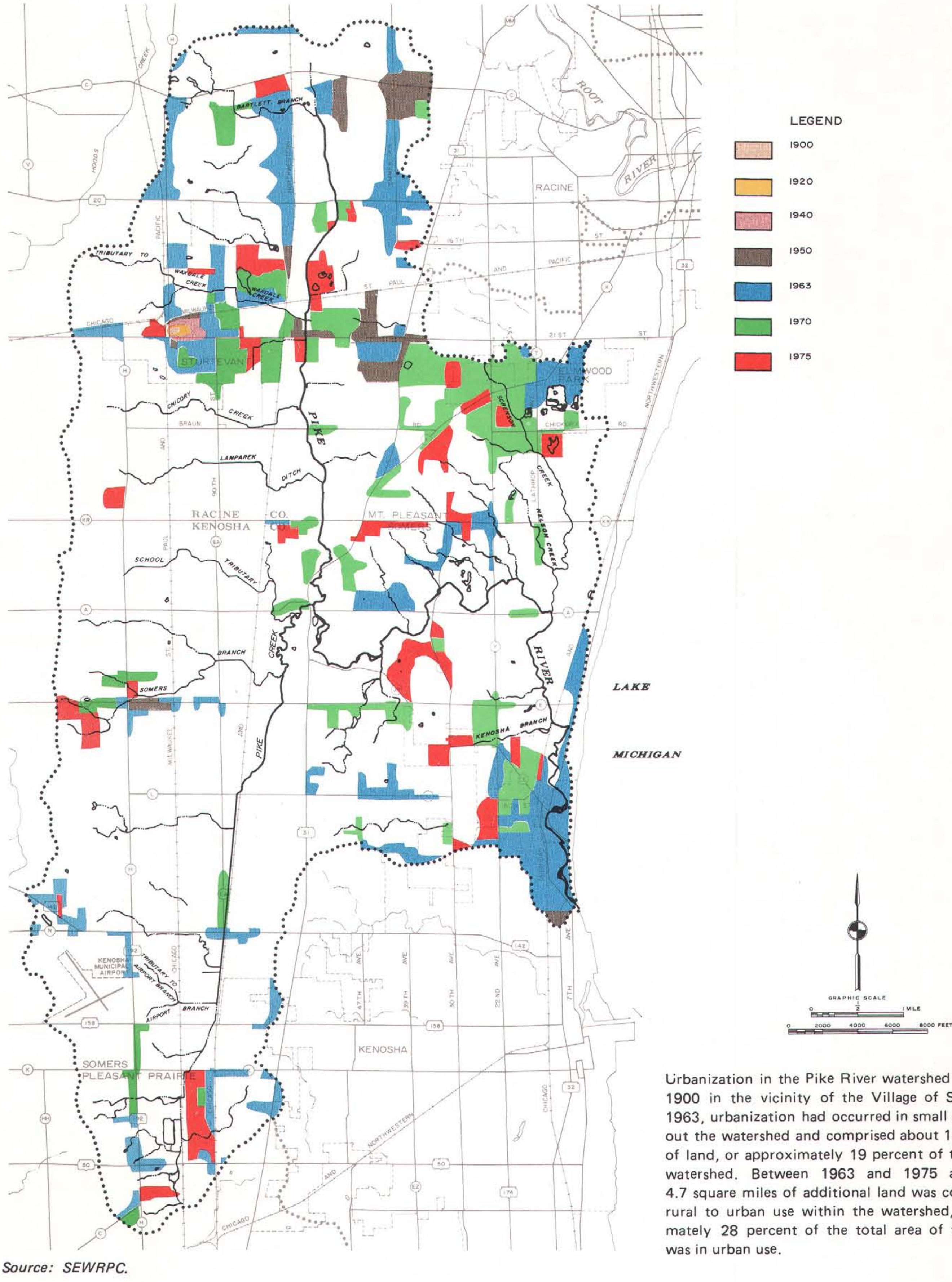
A number of sites and buildings of historic interest—churches, homes, and cultural and natural areas—are located in and near the watershed, and are shown on Map 6. Table 5 lists the historic sites and presents selected information about each, including location, name, and significance. Four of the sites are located at or near Petrifying Springs Park. Two others are located near the mouth of the Pike River and the remaining two are in the Town of Mt. Pleasant near Racine. The comprehensive watershed planning process, in conjunction with local planning efforts, can assist in protecting and restoring the most significant of these historic sites, thereby preserving the cultural and educational values inherent in such sites by recommending the development and maintenance of compatible contiguous park and related open space land uses.

Existing Land Use: The generalized existing land use pattern within the Pike River watershed is shown on Map 7 and the existing land uses are quantified in Table 6. Figure 7 graphically depicts the types and relative amounts of existing land uses within the watershed in 1963 and 1975.

As indicated in Table 6, the watershed is still predominantly rural with over 37 square miles, or over 72 percent, of the total watershed area being in rural land use. Agriculture is the predominant land use in the watershed occupying over 32 square miles, or about 63 percent, of the total watershed area. Urban land uses within the watershed presently occupy about 14 square miles, or about 28 percent, of the total watershed area. The single urban land use occupying the greatest area is residential which presently accounts for over

Map 5

HISTORICAL URBAN GROWTH IN THE PIKE RIVER WATERSHED: 1900-1975

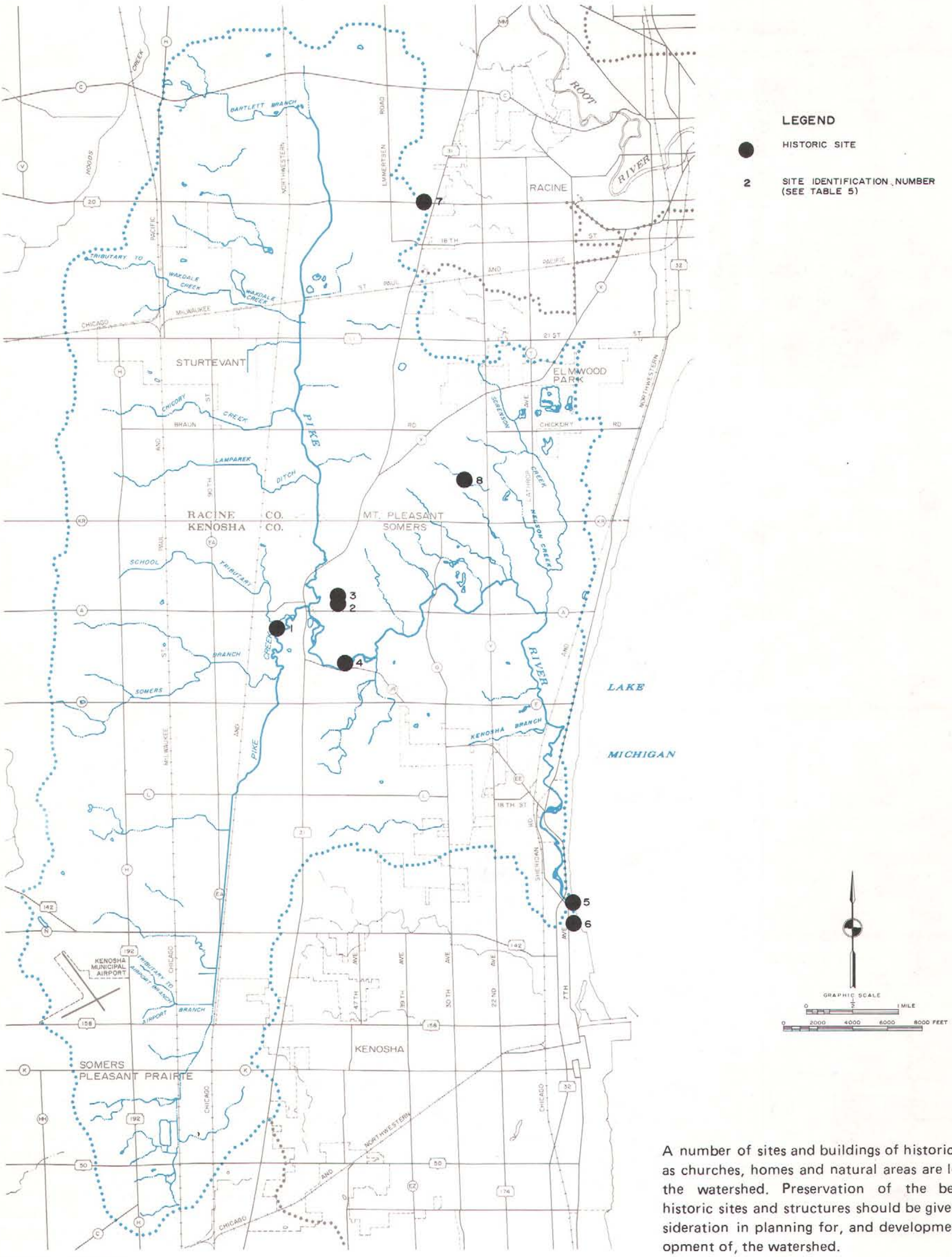


Source: SEWRPC.

Urbanization in the Pike River watershed began around 1900 in the vicinity of the Village of Sturtevant. By 1963, urbanization had occurred in small areas throughout the watershed and comprised about 10 square miles of land, or approximately 19 percent of the area of the watershed. Between 1963 and 1975 approximately 4.7 square miles of additional land was converted from rural to urban use within the watershed, and approximately 28 percent of the total area of the watershed was in urban use.

Map 6

HISTORICAL SITES IN OR NEAR THE PIKE RIVER WATERSHED: 1973



A number of sites and buildings of historic interest such as churches, homes and natural areas are located within the watershed. Preservation of the best remaining historic sites and structures should be given careful consideration in planning for, and development or redevelopment of, the watershed.

Source: SEWRPC.

Table 5

HISTORICAL SITES IN OR NEAR THE PIKE RIVER WATERSHED: 1973

Site Number[a]	Location: U. S. Public Land Survey: Township (north)	Range (east)	Section	Quarter Section	Location: Civil Division: County	City, Village, or Town	Site Name	Significant Dates	Significance
1	2	22	10	NE	Kenosha	Town of Somers	Hawthorne Hollow	1847	School, town hall, prairie
2	2	22	11	NW	Kenosha	Town of Somers	Petrifying Springs Park	1834	Indian meeting place, natural spring, park
3	2	22	11	NW	Kenosha	Town of Somers	Petrifying Springs Hardwoods		Significant woodlands, lake
4	2	22	11	SW	Kenosha	Town of Somers	Montgomery Cabin		Residence of first European settler in watershed
5	2	23	30	NE	Kenosha	City of Kenosha	Pike River Settlement Site	1835	Village site, Indian campsite, parks
6	2	23	30	NE	Kenosha	City of Kenosha	S.Y. Brande House	1880	Historic home
7	3	22	13	SW	Racine	Town of Mt. Pleasant	Mygatts Corners Churches	1845	Church, early road/trail, statues and monuments
8	3	22	36	SE	Racine	Town of Mt. Pleasant	Sanders Park Hardwoods		Museum, blacksmith shops, significant woodlands

[a] *See Map 6.*

Source: SEWRPC.

Table 6

LAND USE IN THE PIKE RIVER WATERSHED: 1963 AND 1975

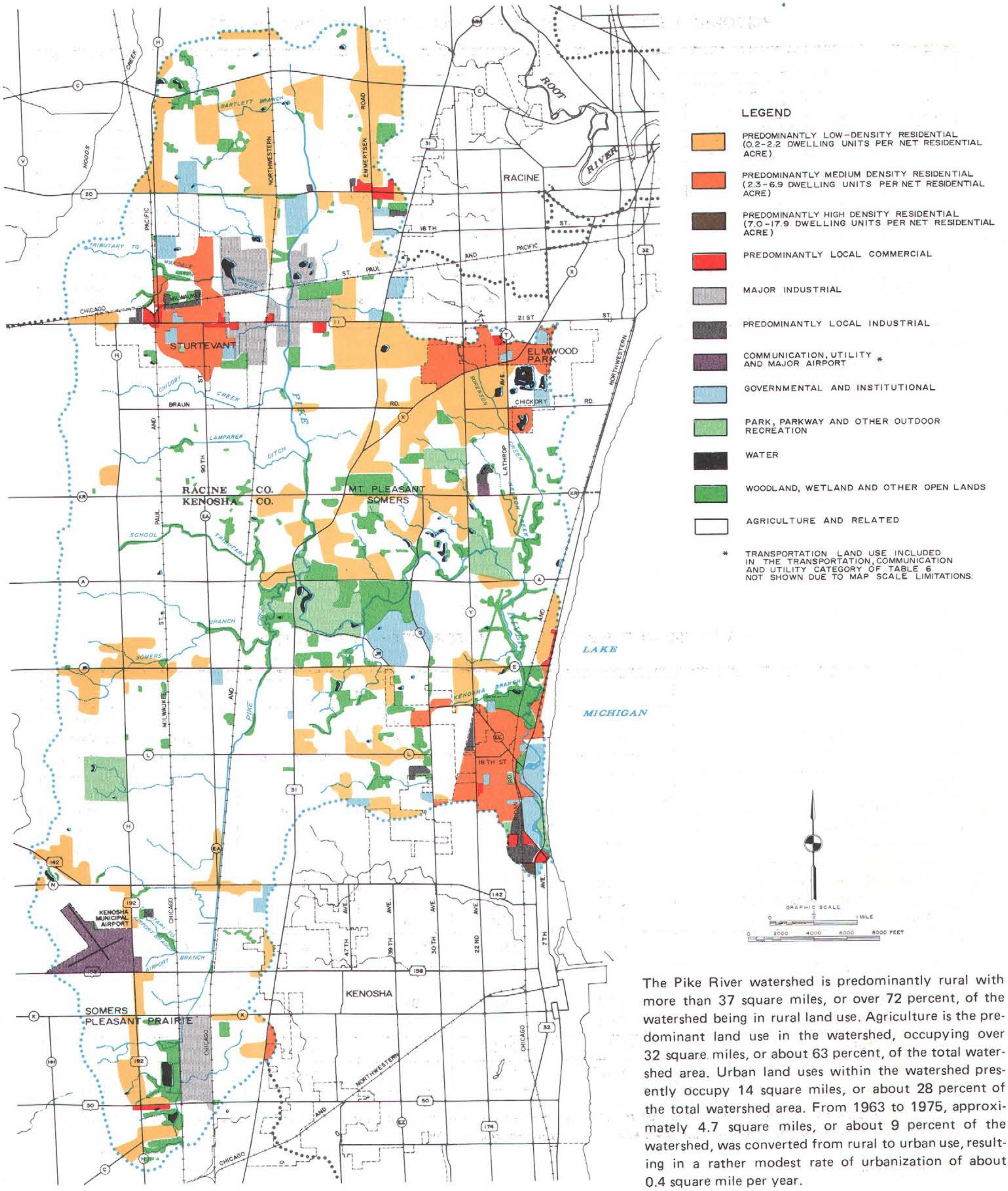
Land Use Category	1963: Area (square miles)	1963: Percent of Watershed	1963: Percent of Major Category	1975: Area (square miles)	1975: Percent of Watershed	1975: Percent of Major Category
Urban						
Residential	3.89	7.6	40.4	6.29	12.2	44.0
Retail and Services	0.11	0.2	1.1	0.23	0.4	1.6
Industrial	0.24	0.5	2.5	0.70	1.4	4.9
Transportation, Communication, and Utility Facilities	3.48	6.8	36.1	4.82	9.4	33.9
Governmental and Institutional	0.64	1.2	6.6	1.02	2.0	7.2
Park and Recreational	1.27	2.4	13.2	1.20	2.3	8.4
Urban Total	9.63	18.7	100.0	14.26	27.7	100.0
Rural						
Agricultural and Related	38.37	74.6	91.8	32.26	62.8	86.8
Other Open Lands	3.42	6.7	8.2	4.90	9.5	13.2
Rural Total	41.79	81.3	100.0	37.16	72.3	100.0
Total	51.42[a]	100.0	- -	51.42[a]	100.0	- -

[a] *This figure represents the total area of the watershed as determined through approximating the watershed boundary by U. S. Public Land Survey quarter sections. The actual measured watershed total is 51.54 square miles.*

Source: SEWRPC.

Map 7

GENERALIZED EXISTING LAND USE IN THE PIKE RIVER WATERSHED: 1975

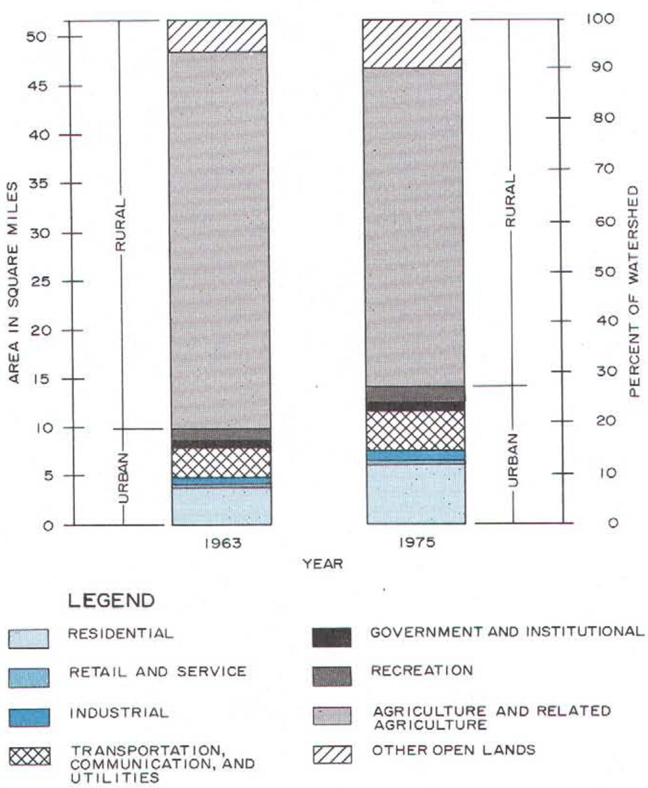


Source: SEWRPC.

The Pike River watershed is predominantly rural with more than 37 square miles, or over 72 percent, of the watershed being in rural land use. Agriculture is the predominant land use in the watershed, occupying over 32 square miles, or about 63 percent, of the total watershed area. Urban land uses within the watershed presently occupy 14 square miles, or about 28 percent of the total watershed area. From 1963 to 1975, approximately 4.7 square miles, or about 9 percent of the watershed, was converted from rural to urban use, resulting in a rather modest rate of urbanization of about 0.4 square mile per year.

Figure 7

DISTRIBUTION OF URBAN AND RURAL LAND USE IN THE PIKE RIVER WATERSHED: 1963 AND 1975



Source: SEWRPC.

six square miles, or over 12 percent, of the total watershed area. Also of significance is the transportation, communication, and utilities category which accounts for almost five square miles, or over 9 percent, of the total watershed area. From 1963 to 1975, the rate of urbanization in the watershed has been rather modest. Approximately 4.7 square miles, or 9 percent of the watershed, was converted from rural to urban use, resulting in a rate of urbanization of about 0.4 square mile per year.

Public Utility Base

Sanitary Sewer Service: In 1975, a total of eight sanitary sewerage systems or portions thereof served a total area of about 9.7 square miles within the watershed, or about 19 percent of the total area of the watershed, and a total population of about 24,000 persons, or about 84 percent of the total resident population of the watershed, as shown on Map 8. These eight sanitary sewerage systems are owned and operated by the City of Kenosha, the City of Racine, the Village of Elmwood Park, the Village of Sturtevant, the Town of Mt. Pleasant Utility District No. 1, the Town of Pleasant Prairie Sewer Utility District D, the Town of Somers Sanitary District No. 1, and the Town of Somers Utility District No. 1. It should be noted that the City of Racine is presently conducting a local facility planning program in coordination with the Towns of Caledonia and Mt. Pleasant and the Village of Sturtevant to evaluate future sewage treatment and conveyance needs. This local planning program may result in a refinement of the indicated sewer service area delineation.

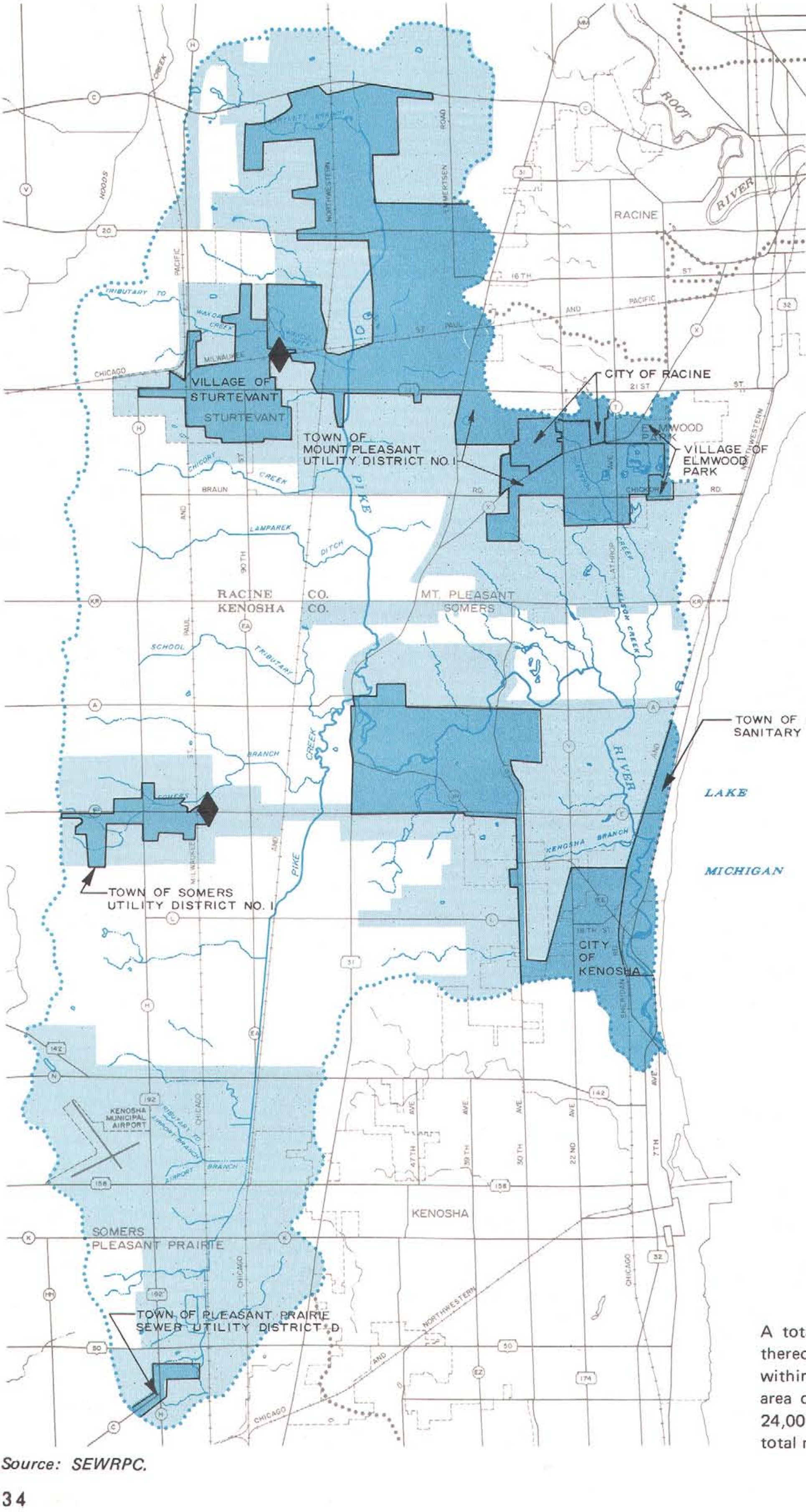
Two municipally owned sewage treatment plants are located in the Pike River watershed. The two plants, one of which serves the Village of Sturtevant[4] and the other portions of the Town of Somers, discharge treated effluents to the Waxdale tributary and the Somers tributary of Pike Creek, respectively. These two plants serve a combined population of 5,100 persons within the watershed, or 18 percent of the total population of the watershed, and 21 percent of the sewered population of the watershed. Five sewerage systems are connected to the Kenosha and Racine treatment plants, which discharge treated effluent to Lake Michigan. These two plants serve a combined population of 18,600 persons within the watershed, or 65 percent of the total population of the watershed, and 78 percent of the sewered population of the watershed. The Town of Pleasant Prairie Sewer Utility District D, which operates its own facility, serves a population of 300 persons within the watershed, or 1 percent of the total population of the watershed, and also about 1 percent of the sewered population of the watershed. That facility is, however, located outside of the watershed, and discharges to the Des Plaines River.

Water Supply Service: The Pike River watershed is served by four public water supply facilities. The service areas of these four public water supply systems—the Kenosha Water Utility, the Town of Somers Sanitary District No. 1, the Racine Water Department, and the Sturtevant Water and Sewer Utility—are shown on Map 9. About 5.4 square miles, or about 38 percent of the urbanized area of the watershed, and about 21,400 persons, or

[4] *The Village of Sturtevant sewage treatment plant was abandoned in May of 1980.*

Map 8

SANITARY SEWER SERVICE AREAS IN THE PIKE RIVER WATERSHED: 1975



A total of eight sanitary sewerage systems or portions thereof serve a total area of about 9.7 square miles within the watershed, or about 19 percent of the total area of the watershed, and a total population of about 24,000 persons, or approximately 84 percent of the total resident population of the watershed.

Source: SEWRPC.

about 74 percent of the total watershed population, are served by public water supply systems. The Kenosha Water Utility and Racine Water Department operate complete and independent water supply systems providing retail water service to portions of the Towns of Pleasant Prairie and Somers, and the Village of Elmwood Park and Town of Mt. Pleasant, respectively. The Town of Somers Sanitary District No. 1 purchases water wholesale from the Kenosha Water Utility, and the Sturtevant Water and Sewer Utility purchases water wholesale from the Racine Water Department. All four of the public utilities located in the watershed utilize Lake Michigan as the source of supply.

Electric Power Service and Gas Service: Electric power is available to all portions of the watershed, such power being supplied by the Wisconsin Electric Power Company. Natural gas service is also available to all portions of the watershed, such service being supplied by the Wisconsin Natural Gas Company.

Transportation

Arterial Streets and Highways: The Pike River watershed is served by the arterial street and highway system shown on Map 10. This arterial system provides ready access to all rural and urban land uses in the watershed, thus supporting those land uses, and facilitates rapid movement of persons and goods by automobile and motor truck throughout the watershed. The arterial system is so well developed that the urban development can be readily supported almost anywhere in the watershed. The arterial system, and related collector and land access streets, serving the land uses in the watershed is also important to the watershed planning effort because of associated potential adverse effects on surface water quality. For example, as discussed in Chapter VII of this report, rainfall or snowmelt induced washoff of substances from urban land surfaces, including streets and highways, may have harmful effects on the surface and ground waters of the watershed.

Bus Service: The transportation needs of the resident population of the watershed, largely determined by the distribution of residential development in relation to centers of employment, shopping, and other activities, together with the configuration of the arterial street and highway system of the watershed, have resulted in the development of two types of motor bus service: urban mass transit and intercity bus service. Urban mass transit service within the watershed is provided, as shown on Map 10, by the Belle Urban System, operated by the Racine Transit Commission, and by the urban mass transit system operated by the Kenosha Transit and Parking Commission, which provide service to the Racine and Kenosha areas, respectively.

Also as shown on Map 10, intercity bus service is provided throughout the watershed by Wisconsin Coach Lines, Inc., which operates a route connecting the central business district of Milwaukee with Racine and Kenosha, with a single stop located in the watershed at the intersection of STH 32 and Sheridan Road in the City of Kenosha.

Railroad Service: Railroad service in the watershed is limited to freight hauling, except for scheduled Amtrak passenger service over the line of the Chicago, Milwaukee, St. Paul & Pacific Railroad Company (The Milwaukee Road) between Milwaukee and Chicago with a stop in Sturtevant, and a commuter service from Kenosha to Chicago operated by the Chicago & North Western Transportation Company.

Freight service is provided in and through the watershed by the Milwaukee Road and the Chicago & North Western Transportation Company. As shown on Map 10, three railroad lines traverse the Pike River watershed in a north-south direction and a single railroad line in an east-west direction.

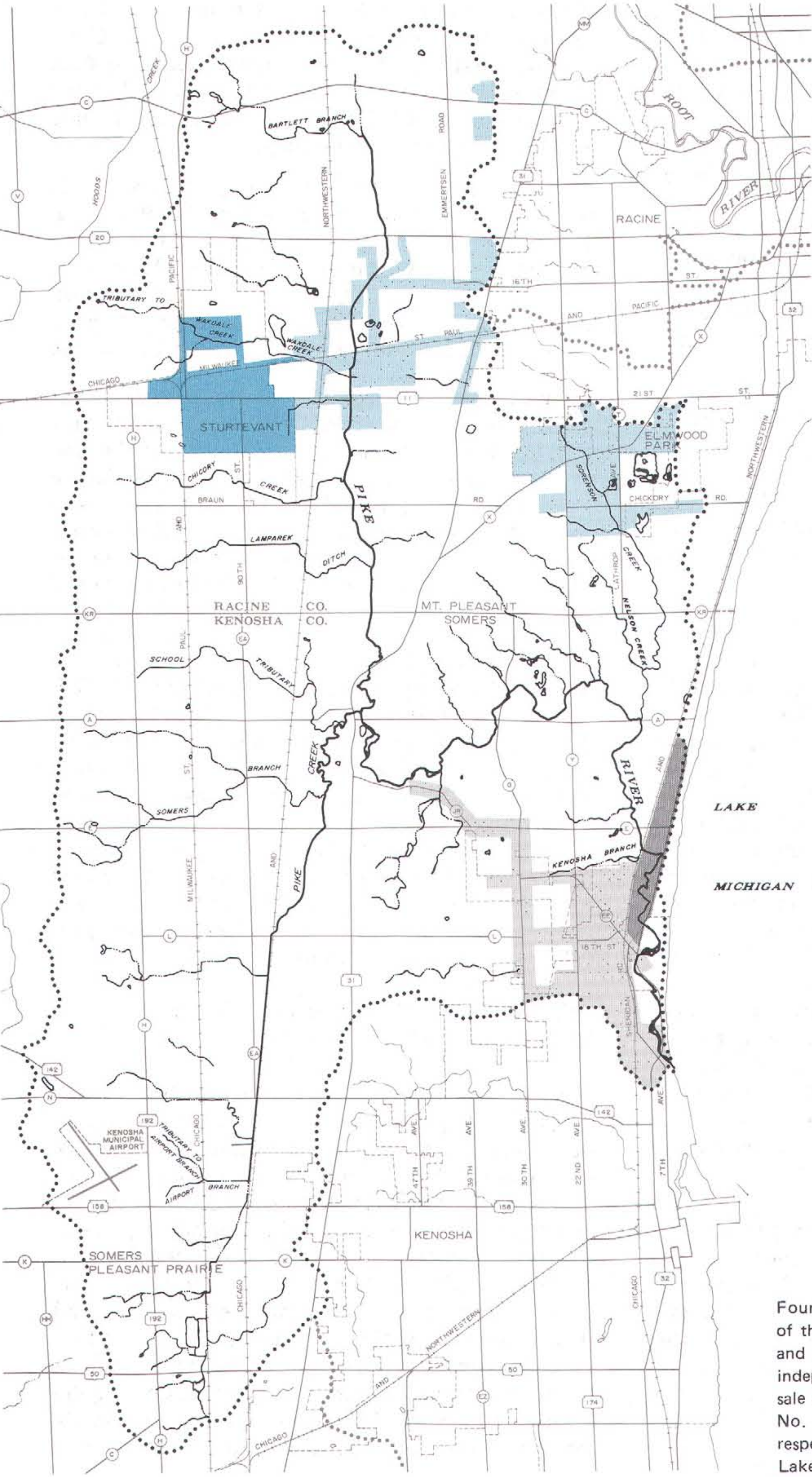
Airport: As shown on Map 10, Kenosha Municipal Airport, lying almost entirely within the Pike River watershed, is the only airport in the basin. The airport is owned by the City of Kenosha, and provides general aviation service.

DESCRIPTION OF THE WATERSHED: NATURAL RESOURCE BASE

The natural resource base is a primary determinant of the development potential of a watershed and of its ability to provide a pleasant and habitable environment for all forms of life. The principal elements of the natural resource base are climate, physiography, geology, soils, vegetation, water resources, and fish and wildlife resources. Without a proper understanding and recognition of elements comprising the natural resource base and their interrelationships, human use and alteration of the natural environment proceed at the risk of excessive costs in terms of both monetary expenditures and destruction of nonrenewable or slowly renewable resources. In this age of high resource

Map 9

PUBLIC WATER SUPPLY SERVICE AREAS IN THE PIKE RIVER WATERSHED: 1975

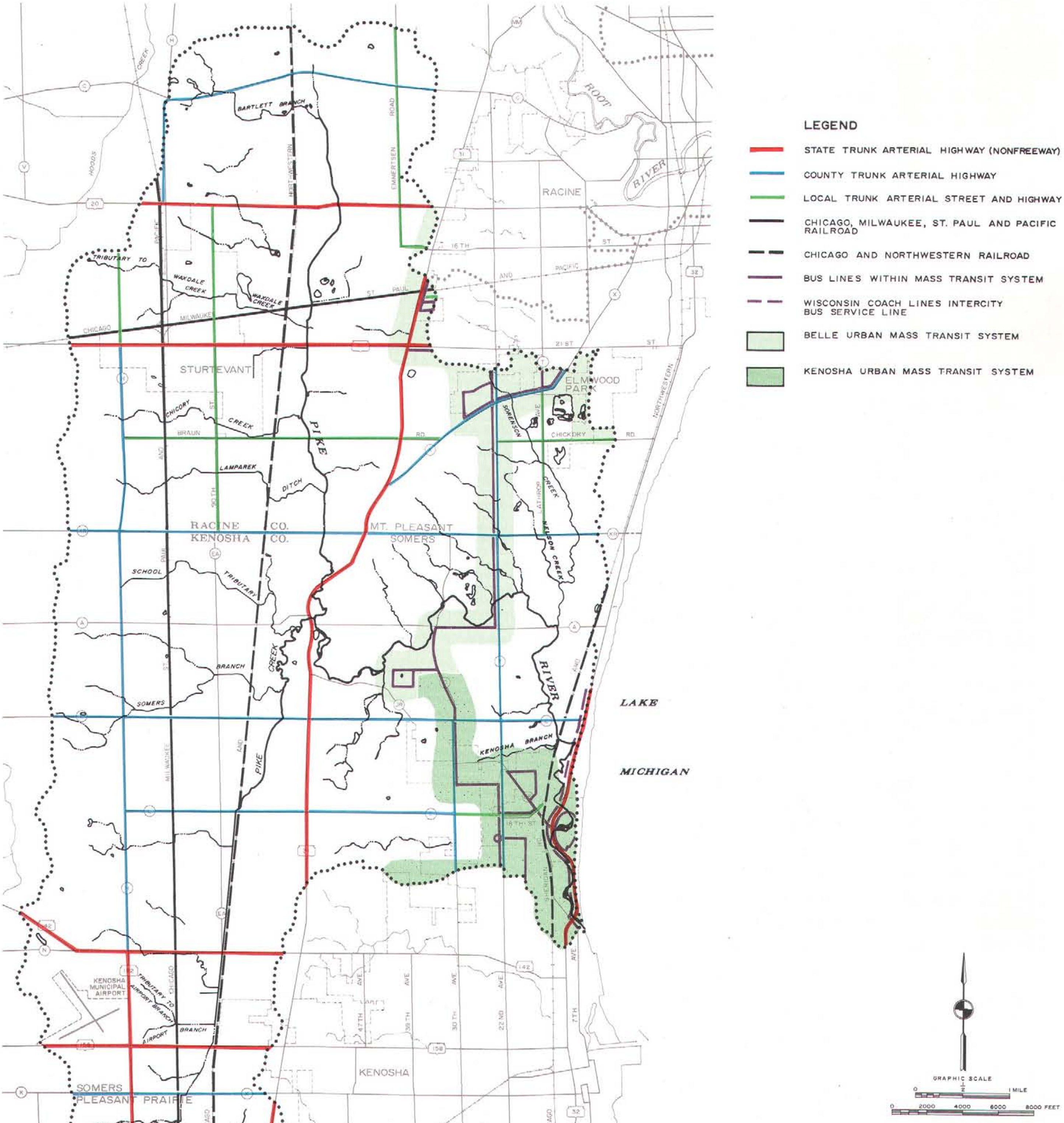


Four public water supply systems serve the urban areas of the Pike River watershed. The Kenosha Water Utility and Racine Water Department operate complete and independent water supply services, and provide wholesale service to the Town of Somers Sanitary District No. 1 and the Sturtevant Water and Sewer Utility, respectively. These four public water utilities utilize Lake Michigan as a source.

Source: SEWRPC.

Map 10

ARTERIAL STREET AND HIGHWAY AND TRUNKLINE RAILROAD FACILITIES IN THE PIKE RIVER WATERSHED: 1978



Source: SEWRPC.

The Pike River watershed is served by a well-developed surface transportation system. Passenger transportation is primarily by highway, with goods movement by both rail and highway. The Chicago, Milwaukee, St. Paul & Pacific Railroad traverses the watershed in both east-west and north-south directions, and the Chicago & North Western Railway traverses the basin in a north-south direction.

demand, urban expansion, and rapidly changing technology, it is especially important that the natural resource base be a primary consideration in any areawide planning effort, since these aspects of contemporary civilization make the underlying and sustaining resource base highly vulnerable to misuse and destruction.

This portion of this chapter identifies and describes the significant elements of the natural resource base of the watershed; indicates and quantifies the spatial distribution and extent of those resources; characterizes, where possible, the quality of each component element of the natural resource base; and seeks to identify those elements and characteristics of the natural resource base which must be considered in the watershed planning process. While all the aforementioned components of the natural resource base are described in this chapter in order to provide an overview of the watershed natural resource base, some are discussed in more detail, as needed, in later chapters. For example, this chapter includes an overview of the surface water resources of the watershed, while the findings of a hydrologic-hydraulic inventory are discussed in Chapter V, the results of a historic flooding inventory are set forth in Chapter VI, and the findings of water quality surveys are described in Chapter VII.

Climate[5]

General Climatic Conditions: The midcontinental location of the Southeastern Wisconsin Region, far removed from the moderating effect of the oceans, gives the Region and the watershed a typical continental type climate characterized primarily by a continuous progression of markedly different seasons and a large range in annual temperature. Low temperatures during winter are intensified by prevailing frigid northwesterly winds, while summer high temperatures are reinforced by the warm southwesterly winds common during that season. The Region and the watershed are positioned astride cyclonic storm tracks along which low pressure centers move from the west and southwest. The Region and the watershed also lie in the path of high pressure centers moving in a generally southeasterly direction. This location at the confluence of major migratory air masses results in the watershed as a whole being influenced by a continuously changing pattern of different air masses, and results in frequent weather changes being superimposed on the aforementioned large annual range in weather characteristics, particularly in winter and spring when distinct weather changes normally occur every three to five days. These temporal weather changes consist of marked variations in temperatures, type and amount of precipitation, relative humidity, wind speed and direction, and cloud cover.

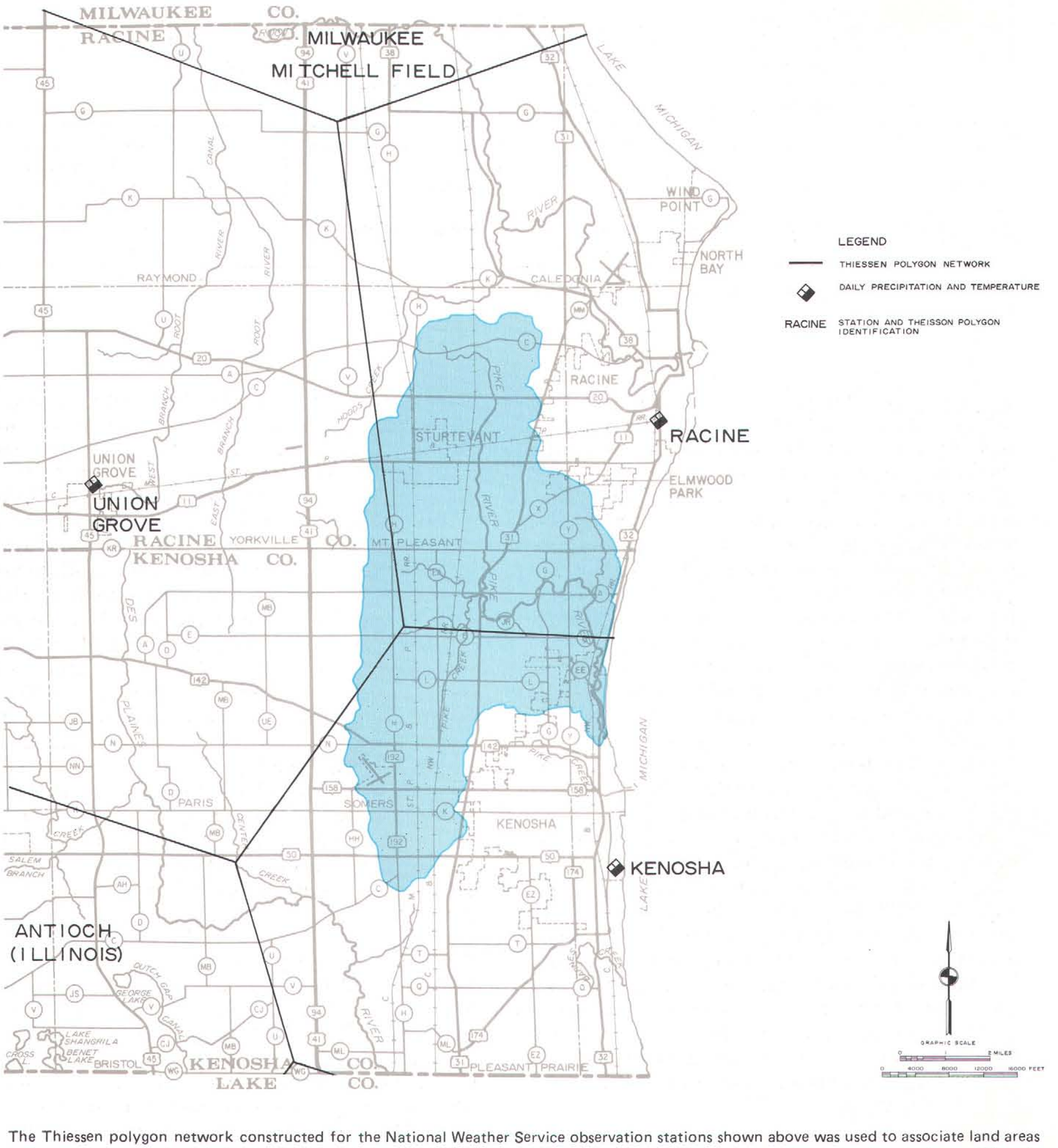
In addition to these distinct temporal variations in weather, the watershed—in spite of its relatively small size—exhibits spatial variations in weather due primarily to its proximity to Lake Michigan, particularly during the spring, summer, and fall seasons when the temperature differential between the lake water and the land air masses tends to be the greatest. During these periods, the presence of the lake tends to moderate the climate of the eastern border of the seven-county Southeastern Wisconsin planning region in general, and of portions of Pike River watershed in particular. It is common, for example, for midday summer temperatures in shoreline areas to drop abruptly to a temperature level 10°F lower than inland areas because of cooling lake breezes generated by air rising from the warmer land surfaces. This Lake Michigan temperature influence is, however, generally limited to that portion of the watershed lying within a few miles of the shoreline.

The location of three meteorological stations near the Pike River watershed as well as the types of precipitation recording equipment and the availability of temperature and other meteorological data are shown on Map 11 and Table 7. Additional information about selected stations is presented in Chapter VIII. These National Weather Service stations are located outside the limits of the basin at distances of 2.7 miles to the Racine, 3.5 miles to the Kenosha, and 6.1 miles to the Union Grove stations. Selected data from the meteorologic stations near the watershed were used in the development of the following discussion of basin temperature, precipitation, snow cover, frost depth, evaporation, wind, and sky cover characteristics.

[5] *Unless otherwise indicated, climatic and weather descriptions and data presented here are based on information extracted from various periodic publications of the National Weather Service, U. S. Department of Commerce, formerly known as the Weather Bureau, U. S. Department of Commerce.*

Map 11

METEOROLOGICAL STATIONS OF THE NATIONAL WEATHER SERVICE NEAR THE PIKE RIVER WATERSHED: 1980



The Thiessen polygon network constructed for the National Weather Service observation stations shown above was used to associate land areas with specific meteorological data in the watershed study. This was a necessary requirement for characterizing the meteorologic conditions in the Pike River watershed and for operating the water resources simulation model used to calculate streamflow and streamwater quality.

Source: SEWRPC.

Table 7

NATIONAL WEATHER SERVICE METEOROLOGICAL STATIONS NEAR THE PIKE RIVER WATERSHED

Station Identification		Location				
Name	National Weather Service Number	County	City or Village	Current Location	Year Began Operation	Data Recorded
Kenosha	4174	Kenosha	City of Kenosha	Sewage treatment plant	1945	Hourly precipitation, daily temperature
Racine	6922	Racine	City of Racine	Sewage treatment plant	1940	Hourly precipitation, daily temperature
Union Grove. . .	8723	Racine	Village of Union Grove	Sewage treatment plant	1945	Hourly precipitation, daily temperature

Source: National Weather Service and SEWRPC.

Temperature: Watershed temperatures, which exhibit a large annual range, are relevant to watershed planning. Seasonal temperatures determine the kinds and intensities of the recreational uses to which surface waters and adjacent riverine lands may be put, and consequently, the periods over which the highest levels of water quality should be maintained. More importantly, aerobic and anaerobic biochemical processes fundamental to the self-purification of streams are temperature dependent, since reaction rates approximately double with each $20^{O}F$ rise in temperature within the temperature range normally encountered in nature. The supply of oxygen available for such processes is a function of oxygen solubility in water, or the maximum concentration of oxygen that can be retained in solution, which is also highly dependent on temperature. For example, a stream at or near freezing temperatures can hold about 15 milligrams per liter (mg/l) of dissolved oxygen, but the surface waters of that same stream on a hot $80^{O}F$ day will have the dissolved oxygen solubility reduced by almost one-half. The summer period is, therefore, critical and limiting in both natural and artificially induced aerobic processes, since oxygen demands are at their annual maximum due to accelerated reaction rates, while the oxygen supply is at its annual minimum because of solubility limitations associated with those high temperatures.

Data for two selected air temperature observation stations near the Pike River watershed—Kenosha and Racine—are presented in Table 8. Monthly temperature data for the two stations are presented graphically in Figure 8. Air temperature and precipitation data used to develop the tables and figures presented in this and the subsequent sections of this chapter are for various periods of record ranging from 29 years to 38 years. Coincident periods of record were not used because of the widely varying periods of historic record available. Although noncoincident periods of record were used, the monthly and annual summary data presented in this chapter are judged to be sufficiently accurate to portray the spatial and temporal variations in watershed temperature and precipitation characteristics. These data indicate the temporal variations, and in some instances the spatial variations, in temperature and precipitation which may be expected to occur within or near the watershed. The temperature data also illustrate how watershed air temperatures lag approximately one month behind summer and winter solstices during the annual cycle, with the result that July is the warmest month in the watershed and January the coldest.

Summer air temperatures throughout the watershed, as reflected by monthly means at the Kenosha and Racine stations for July and August, are in the $70^{O}F$ to $73^{O}F$ range. Average daily maximum temperatures within the watershed for these two summer months are in the $79^{O}F$ to $84^{O}F$ range, whereas average daily minimum temperatures vary from $61^{O}F$ to $62^{O}F$. With respect to minimum daily temperatures, the meteorological station network is not sufficient to reflect all the effects of topography. During nighttime hours, cold air, because of its greater density, flows into low lying

Table 8

AIR TEMPERATURE CHARACTERISTICS AT SELECTED LOCATIONS NEAR THE PIKE RIVER WATERSHED

	Location											
	Kenosha (1948-1976)			Racine (1940-1977)			Union Grove (1964-1976)			Watershed Summary		
Month	Average Daily Maximum[a]	Average Daily Minimum[a]	Mean[b]	Average Daily Maximum[a]	Average Daily Minimum[a]	Mean[b]	Average Daily Maximum[a]	Average Daily Minimum[a]	Mean[b]	Average Daily Maximum[c]	Average Daily Minimum[c]	Mean
January	29.8	13.4	21.6	29.4	13.5	21.5	29.9	12.5	21.2	29.6	13.5	21.6
February	33.4	17.6	25.5	33.1	20.5	26.8	33.5	15.8	24.7	33.3	20.1	26.2
March	41.0	25.7	33.4	42.0	26.1	34.1	42.9	24.9	33.9	41.5	25.9	33.8
April	53.7	35.9	44.8	52.7	36.7	44.7	56.8	35.3	46.0	53.2	36.3	44.8
May	64.3	44.7	54.5	66.2	45.3	55.8	67.5	43.8	55.7	65.3	45.0	55.2
June	75.0	54.7	64.8	77.1	52.6	64.9	78.2	54.6	66.4	76.1	53.7	64.9
July	79.9	61.0	70.5	82.6	61.7	72.2	83.0	60.4	71.7	81.3	61.4	71.4
August	79.3	60.9	70.1	83.5	61.4	72.5	82.0	59.5	70.7	81.4	61.2	71.3
September	72.1	53.1	62.6	73.6	50.5	62.1	74.6	51.7	63.1	72.9	51.8	62.4
October	62.0	43.1	52.6	62.9	43.7	53.3	64.0	42.1	53.0	62.5	43.4	53.0
November	46.8	30.5	38.6	46.2	30.7	38.5	47.0	29.3	38.1	46.5	30.6	38.6
December	34.4	18.9	26.7	33.9	19.5	26.7	34.2	17.9	26.1	34.2	19.2	26.7
Year	56.0	38.3	47.1	56.9	38.5	47.7	57.8	37.3	47.6	56.5	38.5	47.5

[a] *The monthly average daily maximum temperature and the monthly average daily minimum temperature are obtained by using daily measurements to compile an average for each month in the indicated period of record; the results are then averaged for all months in the period of record.*

[b] *The mean monthly tempeature is the average of the average daily maximum temperature and daily minimum temperature for each month.*

[c] *Average of values for the Kenosha and Racine stations.*

Source: National Weather Service and SEWRPC.

areas. Because of this phenomenon, the average daily minimum temperatures in these topographically low areas, particularly during the summer months, will be less than those recorded by the meteorological stations.

Winter temperatures for the watershed, as measured by monthly means for January and February, are in the range of 21°F to 27°F. Average daily maximum temperatures within the watershed for these two winter months vary from 29°F to 33°F, whereas average daily minimum temperatures are in the 13°F to 21°F range. A comparison of temperature data for the Kenosha and Racine stations to the east, and the Union Grove station to the west of the Pike River watershed, suggests that this basin is positioned so that the eastern edge of the watershed has lakeshore temperature characteristics, whereas the western edge of the basin has inland temperature characteristics, as shown in Table 8 and Figure 8. The Kenosha and Racine stations, which are located within about one mile from the Lake Michigan shoreline, exhibit average daily maximum temperatures during the late spring and throughout summer that are about 1°F to 4°F lower—because of the cooling effect of Lake Michigan—than those recorded at the Union Grove station, which is located about 12 miles from Lake Michigan.

A comparison of air temperature data for the Kenosha and Racine stations and Union Grove station presented in Table 8 and Figure 8 also suggests the existence of an "urban heat island effect." Large urban complexes have been observed to exhibit higher air temperatures than surrounding rural areas. This temperature differential is partly attributable to the numerous heat sources within an urban environment. Another factor is the more gradual loss of this heat to the atmosphere because of the dense pattern of the urban structures emitting the heat in that they radiate heat towards each other rather than into the open atmosphere as in rural areas, and because of the presence of atmospheric contaminants which form a barrier to nighttime radiation from the earth back to the atmosphere.

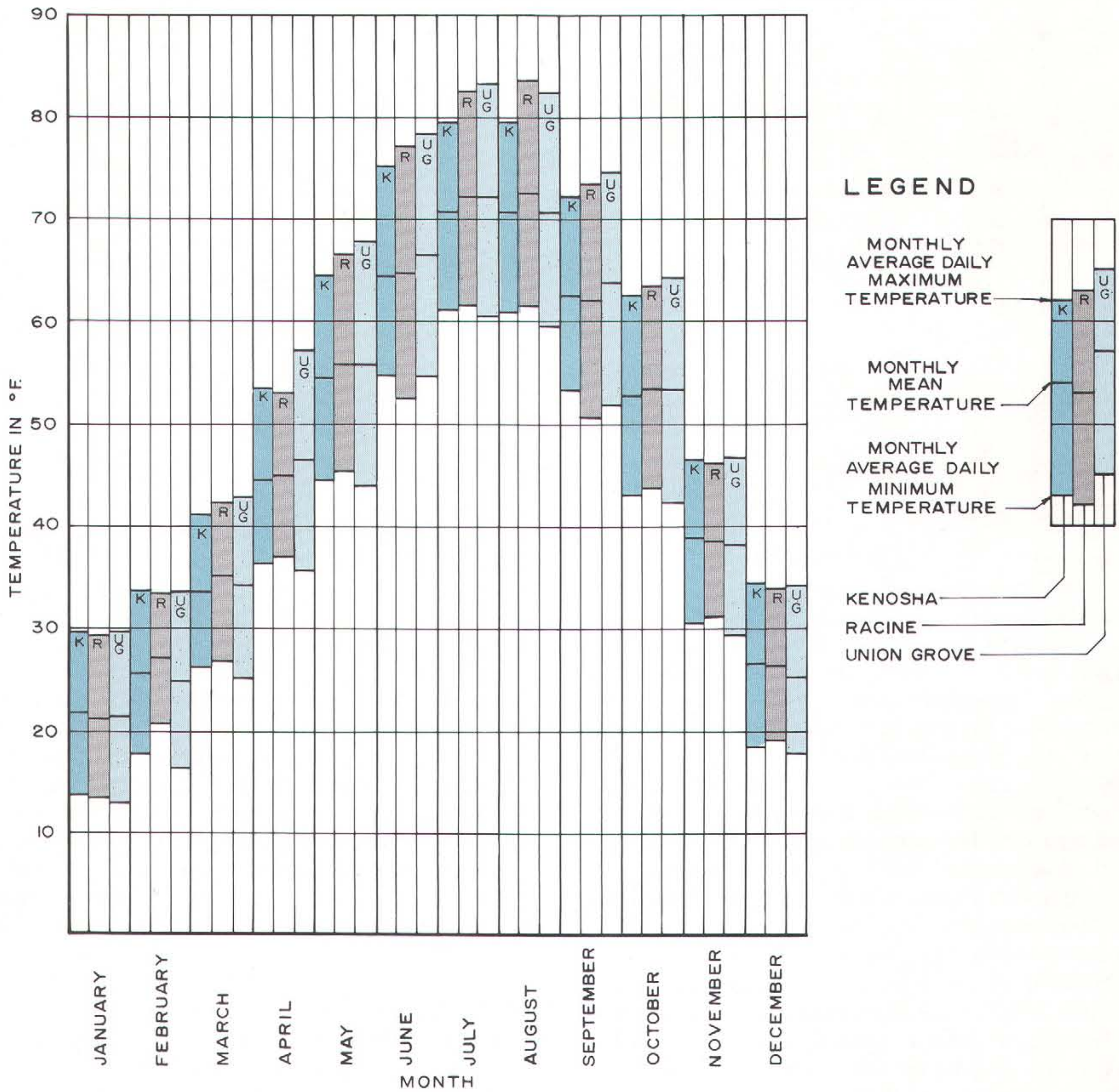
For all months of the year except June and September at the Racine station, the average daily minimum temperatures for the Kenosha and Racine stations, both located in urbanized areas, are 1°F to 5°F higher than average daily minimum temperatures at Union Grove, which is located near a rural area.

Extreme high and low temperatures for the watershed, based on 29 years or more of historic records at observation stations near the basin, range from a high of about 103°F to a low of about - 24°F. The growing season, which is defined as the number of days between the last 32°F frost in spring and the first freeze in the fall, averages about 180 days for the watershed. The last 32°F frost in the spring normally occurs near the end of April whereas the first freeze in the fall usually occurs during the latter half of October.

Precipitation: Precipitation within the watershed takes the form of rain, sleet, hail, and snow, and

Figure 8

AIR TEMPERATURE CHARACTERISTICS AT SELECTED LOCATIONS NEAR THE PIKE RIVER WATERSHED



Source: National Weather Service and SEWRPC.

ranges from gentle showers of trace quantities to destructive thunderstorms, as well as major rainfall-snowmelt events causing property damage, inundation of poorly drained areas, and stream flooding. Existing sewerage system problems such as overflows from combined sewers are the direct result of even small precipitation events. Rainfall events may also cause separate sanitary sewerage systems to surcharge and back up into basements and overflow into surface watercourses, and may require sewage treatment plants to bypass large volumes of partially treated or untreated sewage in excess of the hydraulic capacity of the plants. Such surcharging of separate sanitary sewerage sysems is caused by the entry of excessive quantities of rain, snowmelt, and groundwater into the sanitary sewers via manholes, building sewers, building downspouts, and foundation drain connections; and by infiltration through faulty sewer pipe joints, manhole structures, and cracked pipes.

Total precipitation as well as snowfall data for three observation stations near the Pike River watershed—Kenosha, Racine, and Union Grove—are presented in Table 9 and the location of each is shown on Map 11. Monthly total precipitation and snowfall observations for the three stations are presented graphically in Figure 9. The data illustrate the temporal variations in the type and amount of precipitation that normally occurs within or near the watershed.

The average annual total precipitation in the watershed and immediate surroundings, based on a numerical average of data for the Kenosha and Racine stations, is 32.3 inches, expressed as water equivalent, while the average annual snow and sleet measured as snow and sleet is 45.8 inches. The average annual total precipitation for the watershed itself as determined by the Thiessen Polygon Network method is 32.4 inches, while the average annual accumulation of snow and sleet is 46.3 inches.

Average total monthly precipitation for the watershed, based on the Thiessen Polygon Network method, ranges from a low of 1.27 inches in February to a high of 3.89 inches in June. The principal snowfall months are December, January, February, and March, when average monthly snowfalls are 10.1, 12.1, 10.2, and 9.5 inches, respectively, and during which time 91.0 percent of the average annual snowfall may be expected to occur. Snowfall is the predominant form of precipitation, totaling approximately 60 percent of the total precipitation expressed as water equivalent, during these months. Approximately 18 inches, or 60 percent of the average annual precipitation, normally occurs during the late April through mid-October growing season, primarily as rainfall. Assuming that 10 inches of measured snowfall is equivalent to one inch of water, the average annual snowfall of 46.3 inches is equivalent to 4.6 inches of water, and therefore only 14 percent of the average annual total precipitation occurs as snowfall. It is of interest to note that approximately one-half of the 32.4 inch average annual precipitation leaves the watershed as streamflow; the remaining one-half being lost from the watershed primarily as evapotranspiration.[6]

A comparison of precipitation data for the Kenosha and Racine stations to the east of the Pike River watershed and the Union Grove station to the west, suggests that the eastern edge of the watershed experiences higher average seasonal snow and sleet accumulations than does the western edge of the basin. As shown in Table 9 and Figure 9, the Kenosha and Racine stations, which are located within about one mile from the Lake Michigan shoreline, exhibit average seasonal snowfalls of 42.8 inches and 48.7 inches, respectively, which are higher than that recorded at the Union Grove station, which is located about 12 miles from Lake Michigan. The occurrence of somewhat higher seasonal snowfall amounts along the Lake Michigan shore is attributed to the availability of more moisture in the air mass immediately above the lake.

Based on the tabulated data, annual precipitation within the watershed and the immediate surroundings has varied from a low of approximately 17 inches, or about 53 percent of the area average, to a high of approximately 50 inches, or about 54 percent above the average. Annual seasonal snowfall has varied from a low of approximately five inches, or about 11 percent of the area average, to a high of approximately 109 inches, or about 135 percent above the average. The maximum monthly precipitation recorded at any of these three stations is 11.41 inches, recorded at Waukesha in July of 1952, and the maximum monthly snowfall is 56 inches, also measured at Waukesha in January 1918. The maximum 24-hour rainfall is 5.76 inches as recorded on June 22 and 23, 1917, measured at Milwaukee, while the maximum 24-hour snowfall is 30 inches measured at Racine on February 19 and 20, 1898.

Extreme precipitation event data through 1976 for three long-term stations—Milwaukee at Mitchell Field, Waukesha, and Racine—are presented in Table 10. Inasmuch as these long-term records are for stations located reasonably near to the Pike River watershed, data from these stations may be considered representative of the extreme precipitation events that have occurred within the watershed.

Snow Cover: The likelihood of snow cover and the depth of snow on the ground not only have a major effect on winter recreation, but are also important precipitation-related factors that influence the planning, design, construction, and maintenance of public utilities. Snow cover, particularly early in the winter season, significantly influences the depth and duration of frozen ground, which in turn affects engineered works involving extensive excavation and underground construction. Accumulated snow depth at a particular time and place is primarily dependent on antecedent snowfall, rainfall, and temperature characteristics, and the amount of solar radiation. Rainfall is relatively unimportant as a melting agent but can, because of compaction effects, significantly affect the depth of snow cover on the ground.

Snow depth as measured at Milwaukee for the 70-year period from 1900 through 1969 and published in "Snow and Frost in Wisconsin." a 1970 Wisconsin Statistical Reporting Service report, is

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[6] *Determined using the hydrologic-hydraulic model described in Chapter VIII.*

Table 9

PRECIPITATION CHARACTERISTICS AT SELECTED LOCATIONS NEAR THE PIKE RIVER WATERSHED

Month	Kenosha Average Total Precipitation (1945-1978)	Kenosha Average Snow and Sleet (1960-1977)	Racine Average Total Precipitation (1940-1977)	Racine Average Snow and Sleet (1957-1977)	Union Grove Average Total Precipitation (1945-1977)	Union Grove Average Snow and Sleet[a]	Watershed Summary Average Total Precipitation	Watershed Summary Average Snow and Sleet[b]	Watershed Summary Average Based on the Thiessen Polygon Method Total Precipitation	Watershed Summary Average Based on the Thiessen Polygon Method Snow and Sleet
January	1.53	11.10	1.87	13.21	1.39	8.44	1.70	12.16	1.71	12.05
February	1.02	10.00	1.45	10.60	1.17	8.17	1.24	10.30	1.27	10.18
March	2.22	8.20	2.90	10.30	2.39	9.55	2.56	9.25	2.61	9.46
April	3.38	1.80	3.43	1.67	3.22	1.59	3.41	1.74	3.39	1.71
May	3.19	- -	3.32	- -	3.19	- -	3.26	- -	3.26	- -
June	3.90	- -	3.86	- -	4.10	- -	3.88	- -	3.89	- -
July	3.58	- -	3.59	- -	3.56	- -	3.59	- -	3.58	- -
August	3.12	- -	3.19	- -	3.22	- -	3.16	- -	3.17	- -
September	3.24	- -	3.06	- -	3.07	- -	3.15	- -	3.13	- -
October	2.26	0.10	2.18	0.34	2.27	0.01	2.22	0.22	2.22	0.22
November	2.09	2.00	2.29	2.22	2.00	2.64	2.19	2.11	2.19	2.17
December	1.78	9.60	2.15	10.39	1.80	10.67	1.97	10.00	1.98	10.12
Year	31.31	42.80	33.29	48.73	31.38	41.07	32.33	45.78	32.40	46.33

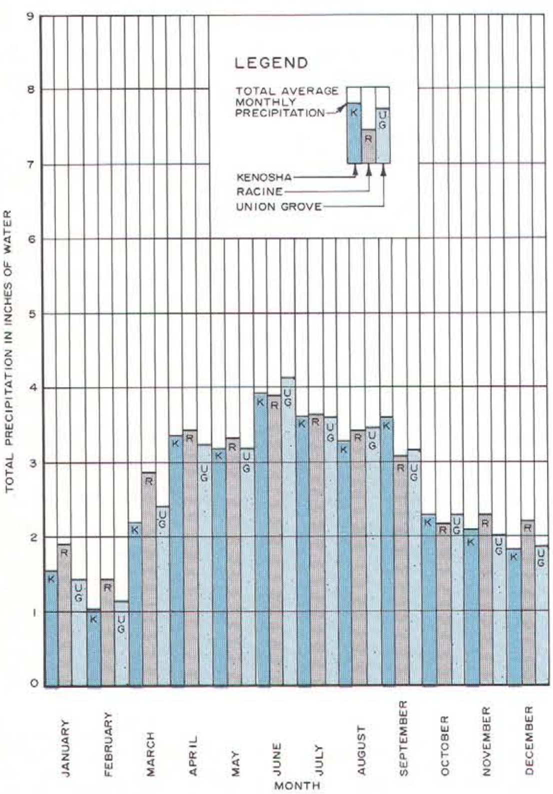
[a] *Snow and sleet data are not available at Union Grove. Therefore, approximations were made by taking proportional values of the average total precipitation, using the same proportion of snow and sleet to total precipitation, computed from recorded data at the Waukesha station which is located approximately the same distance from Lake Michigan.*

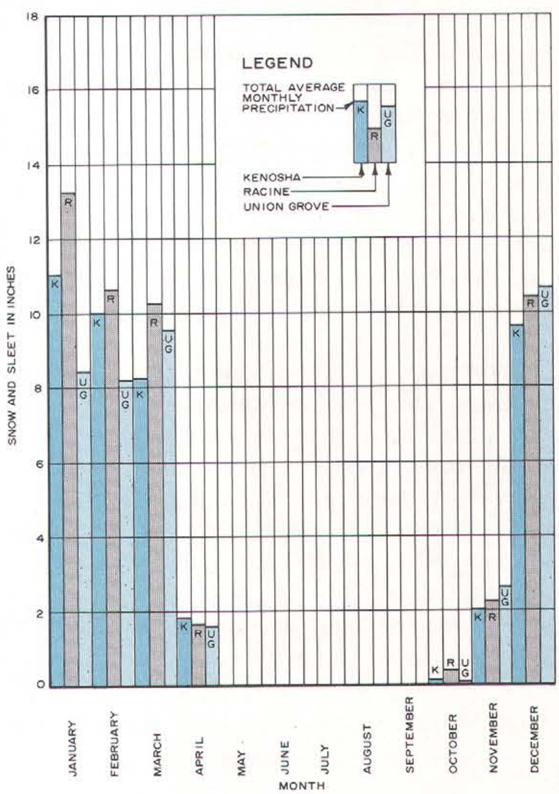
[b] *Average of values for the Kenosha and Racine stations.*

Source: National Weather Service and SEWRPC.

Figure 9

PRECIPITATION CHARACTERISTICS AT SELECTED LOCATIONS NEAR THE PIKE RIVER WATERSHED





Source: National Weather Service and SEWRPC.

Table 10

EXTREME PRECIPITATION EVENTS FOR SELECTED LONG-TERM STATIONS NEAR THE PIKE RIVER WATERSHED

Observation Station		Period of Precipitation Records Except Where Indicated Otherwise	Total Precipitation (water equivalent)											
			Maximum Annual		Minimum Annual		Maximum Monthly			Maximum Daily				
Name	County		Amount	Year	Amount	Year	Amount	Month	Year	Amount	Day	Month	Year	
Milwaukee	Milwaukee	1870-1976	50.36[a]	1876	18.69[a]	1901	10.03	June	1917	5.76[b]	22-23	June	1917	
Racine	Racine	1895-1976	48.33	1954	17.75	1910	10.98	May	1933	4.00	11	September	1933	
Waukesha	Waukesha	1892-1976	43.57	1938	17.30	1901	11.41	July	1952	5.09	18	July	1952	

Observation Station		Snowfall										
		Maximum Annual		Minimum Annual		Maximum Monthly			Maximum Daily			
Name	County	Amount	Year	Amount	Year	Amount	Month	Year	Amount	Day	Month	Year
Milwaukee	Milwaukee	109.0[c]	1885-1886	11.0[c]	1884-1885	52.6	January	1918	20.3[d]	4-5	February	1924
Racine	Racine	85.0	1897-1898	5.0[e]	1901-1902	38.0	February	1898	30.0[d]	19-20	February	1898
Waukesha	Waukesha	83.0[e]	1917-1918	9.1	1967-1968	56.0	January	1918	20.0[d]	5-6	January	1918

[a] *Based on the period 1841-1976.*

[b] *Maximum precipitation for a 24-hour period.*

[c] *Maximum and minimum snowfalls for a winter season.*

[d] *Maximum snowfall for a 24-hour period.*

[e] *Estimated from incomplete records.*

Source: National Weather Service, Wisconsin Statistical Reporting Service, and SEWRPC.

summarized and presented in Table 11. It should be emphasized that the tabulated data pertain to snow depth on the ground as measured at the place and time of observation, and are not a direct measure of average snowfall. Recognizing that snowfall and temperatures, and therefore snow accumulation on the ground, vary spatially within the watershed, the Milwaukee area data presented in Table 11 should be considered only as an approximation of conditions throughout the watershed. As indicated by the data, snow cover is most likely during the months of December, January, and February, during which at least a 0.39 probability exists of having one inch or more of snow cover at Milwaukee. Furthermore, during January and the first half of February, at least a 0.24 probability exists of having five or more inches of snow on the ground. During March, the month in which severe spring snowmelt-rainfall flood events are most likely to occur, at least a 0.33 probability exists of having one inch or more of snow on the ground during the first half of the month, while the probability of having that much snow cover diminishes to 0.07 by the end of the month.

The aforementioned table facilitates an estimation of the probability that a given snow cover will exist or be exceeded at any given time, and should, therefore, be useful in planning winter outdoor work and construction activities as well as in estimating runoff for hydrologic purposes. There is, for example, only a 0.07 probability of having one or more inches of snow cover on November 15 of any year, whereas there is a much higher probability, 0.61, of having that much snow cover on January 15.

Frost Depth: Ground frost or frozen ground refers to that condition in which the ground contains variable amounts of water in the form of ice. Frost influences hydrologic processes, particularly the proportion of rainfall or snowmelt that will run off the land directly to sewerage systems and to

Table 11

SNOW COVER PROBABILITIES AT MILWAUKEE BASED ON DATA FOR THE PERIOD 1900-1970

Date		Snow Cover[a]									
		1.0 Inch or More		5.0 Inches or More		10.0 Inches or More		15.0 Inches or More		Average (inches)	
Month	Day	Number of Occurrences[b]	Probability of Occurrence[c]	Number of Occurrences[b]	Probability of Occurrence[c]	Number of Occurrences[b]	Probability of Occurrence[c]	Number of Occurrences[b]	Probability of Occurrence[c]	Per Occurrence[d]	Overall[e]
November	15	5	0.07	0	0.00	0	0.00	0	0.00	1.2	0.09
	30	12	0.17	1	0.01	1	0.01	0	0.00	2.8	0.49
December	15	33	0.47	10	0.14	0	0.00	0	0.00	3.3	1.54
	31	32	0.46	9	0.13	1	0.01	0	0.00	3.6	1.66
January	15	43	0.61	17	0.24	4	0.06	2	0.03	4.9	2.94
	31	48	0.69	22	0.31	9	0.13	4	0.06	6.2	4.26
February	15	44	0.63	23	0.33	7	0.10	3	0.04	6.0	3.69
	28	27	0.39	8	0.11	3	0.04	1	0.01	4.5	1.69
March	15	23	0.33	6	0.09	4	0.06	0	0.00	3.9	1.21
	31	5	0.07	1	0.01	1	0.01	0	0.00	3.4	0.24

[a] *Data pertains to snow depth on the ground as it was measured at the time and place of observation, and is not a direct measure of average snowfall.*

[b] *Number of occurrences is the number of times during the 70 year period of record when measurements revealed that the indicated snow depth was equaled or exceeded on the indicated date.*

[c] *Probability of occurrence of a given snow depth and date is computed by dividing the number of occurrences by 70, and is defined as the probability that the indicated snow cover will be reached or exceeded on the indicated date.*

[d] *Average snow cover per occurrence is defined as the sum of all snow cover measurements in inches for the indicated date divided by the number of occurrences for that date; that is, the number of times in which 1.0 inch or more of snow cover was recorded.*

[e] *Overall average snow cover is defined as the sum of all snow cover measurements in inches for the indicated date divided by 70; that is, the number of observation times.*

Source: Wisconsin Statistical Reporting Service, "Snow and Frost in Wisconsin," June 1970.

surface watercourses in contrast to that which will enter and be temporarily detained in the soil. Anticipated frost conditions influence the design of engineered works in that structures and facilities are designed either to prevent the accumulation of water and, therefore, the formation of damaging frost as in the case of pavements and retaining walls, or the structures and facilities are designed to be partially or completely located below the frost susceptible zone in the soil, as in the case of foundations and water mains. For example, in order to avoid or minimize the danger of structural damage, foundation footings must be placed at a sufficient depth in the ground to be below that zone in which the soil may be expected to contract, expand or shift due to frost actions. A similar consideration exists in the design and construction of sanitary sewers.

Snow cover is a primary determinant of the depth of frost penetration and of the duration of frozen ground. The thermal conductivity of snow cover is less than one-fifth that of moist soil, so that heat loss from the soil to the cold atmosphere is greatly inhibited by an insulating snow cover. An early, major snowfall that is retained on the ground as a substantial snow cover will inhibit or prevent frost development in unfrozen ground and may even result in a reduction or elimination of frost in already frozen ground. If an early, significant snow cover is maintained by additional regular snowfall throughout the winter season, frozen ground may not develop at all or, at most, a relatively small frost penetration will occur. Frost depth is also dependent on vegetal cover and soil type. Assuming similar soil types, for example, frost will penetrate more deeply into bare, unprotected soil than into soil covered with an insulating layer of sod.

Frost conditions for the Region are available on a bi-monthly basis for the months of November to April as shown in Table 12 and are based upon data for an eight-year period of record extending

Table 12

AVERAGE FROST DEPTH IN THE PIKE RIVER WATERSHED NOVEMBER TO APRIL[a]

Month and Day	Nominal Frost Depth (inches)
November 30	1
December 15	3
December 31	3
January 15.	9
January 31.	12
February 15	15
February 28	15
March 15.	12
March 31.	6
April 15	1

[a] *Based on 1960-1968 frost depth data for cemeteries as reported by funeral directors and cemetery officials. Since cemeteries have soils that are overlain by an insulating layer of turf, the frost depths should be considered as minimum values.*

Source: *Wisconsin Statistical Reporting Service, "Snow and Frost in Wisconsin," June 1970.*

from 1961 through 1968, as set forth in the report "Snow and Frost in Wisconsin," published in 1970 by the Wisconsin Statistical Reporting Service. These data are provided for representative locations on a weekly basis by funeral directors and cemetery officials. Since cemetery soils are normally overlain by an insulating layer of turf, the frost depths shown in Table 12 should be considered minimum values. Frost depths in excess of four feet have been observed in southeastern Wisconsin. During the period that frost depth observations have been made in southeastern Wisconsin, one of the deepest regionwide frost penetrations occurred in early March 1963, when 25 to 30 inches of frost occurred throughout the planning region. Frost depths of over three feet were observed throughout the Region in January and February of 1977. The Milwaukee and West Allis City Engineers reported over five feet of frost beneath some city streets in January and February of 1977.

The data indicate that frozen ground is likely to exist throughout the watershed for approximately four months each winter season, extending from late November through March, with more than six inches of frost normally occurring during January, February, and the first half of March. Historical data indicate that the most severe frost conditions normally occur in Februaıy, when 15 or more inches may be expected.

Evaporation: Evaporation is the natural process in which water is transformed from the liquid or solid state to the vapor state and returned to the atmosphere. Total evaporation includes evaporation from water and snow surfaces and directly from the soil, and also includes evaporation of precipitation intercepted on or transpired by vegetation. The magnitude and annual variation in evaporation from water surfaces and the relation of the evaporation to precipitation is important because of the key role of this process in the hydrologic cycle of the Pike River watershed.

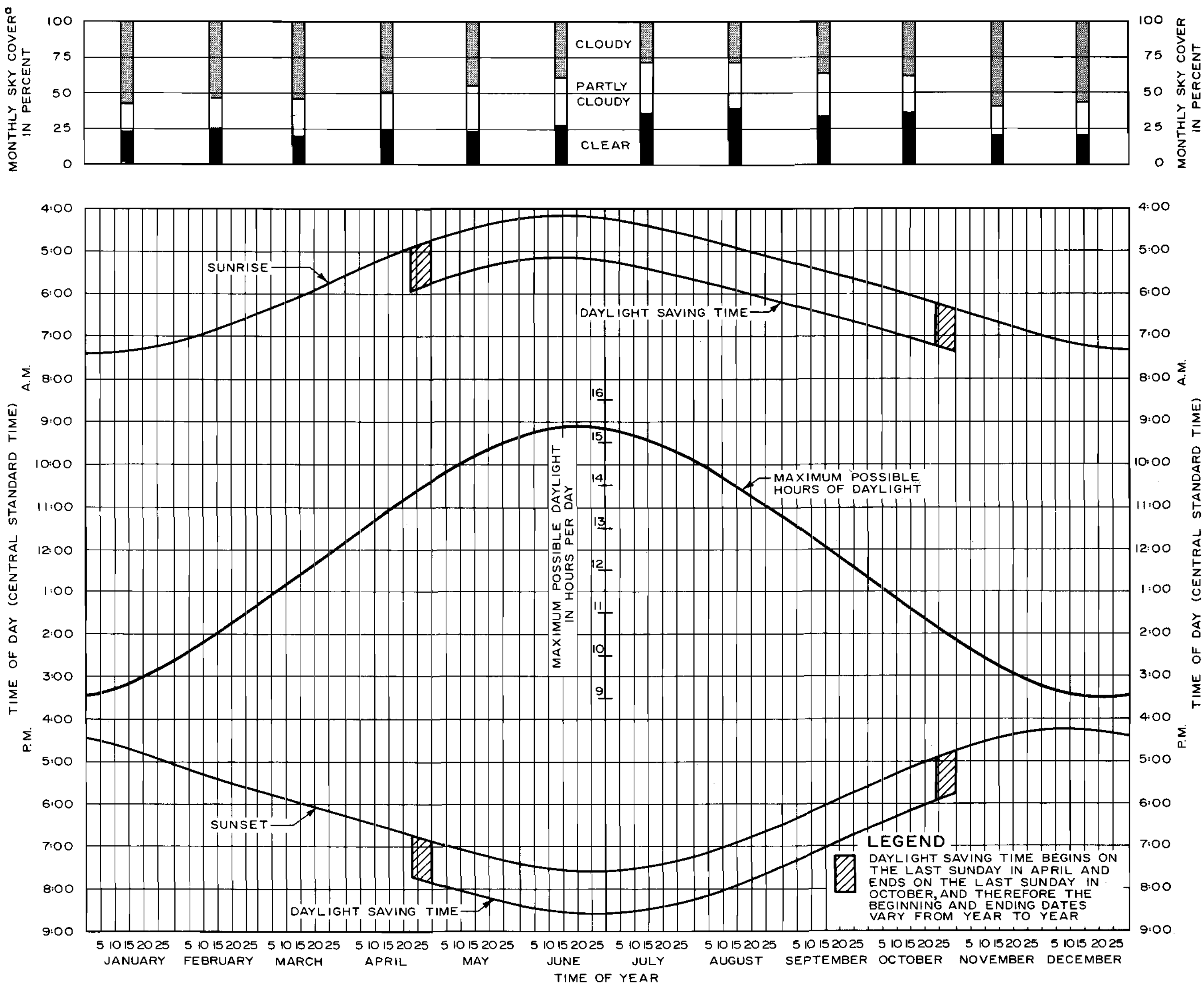
Limited pan evaporation data available for the watershed and environs average about 29 inches annually, with about 24 inches occurring during the period May through October. During this period, pan evaporation exceeds precipitation. Pan evaporation, however, is not indicative of total evaporation in the watershed because the area of surface waters in the watershed is much smaller than the total watershed area.

Wind: Prevailing winds in the Region follow a clockwise pattern in terms of the prevailing direction over the seasons of the year, being northwesterly in the late fall and winter, northeasterly in the spring, and southwesterly in the summer and early fall. Wind velocities in the Pike River watershed may be expected to be less than five miles per hour about 15 percent of the time, between 5 and 15 miles per hour about 60 percent of the time, and in excess of 15 miles per hour about 25 percent of the time.

Daylight and Sky Cover: The annual variation in the time of sunrise and sunset and the daily hours of sunlight for the watershed are presented in Figure 10. Expected sky cover information, in the form of the expected percent of clear, partly cloudy, and cloudy days each month, also is summarized in Figure 10. These daylight and sky cover data have some value in planning outdoor construction and maintenance work, and are also useful in analyzing and explaining diurnal changes in observed surface water quality. For example, marked changes in measured stream dissolved oxygen levels are normally correlated with the transition from daytime to nighttime conditions, when photosynthetic oxygen production by algae and aquatic plants is replaced by oxygen

Figure 10

SUNRISE, SUNSET, AND SKY COVER IN THE PIKE RIVER WATERSHED



[a]BASED ON MILWAUKEE SKY COVER DATA. THESE MONTHLY DATA ARE SIMILAR TO THOSE OBSERVED AT MADISON AND AT GREEN BAY, WHICH SUGGESTS THAT THERE IS VERY LITTLE VARIATION IN THIS MONTHLY DATA FOR THE LARGE GEOGRAPHIC REGION RELATIVE TO THE PIKE RIVER WATERSHED, REPRESENTED BY THESE THREE NATIONAL WEATHER SERVICE STATIONS. THEREFORE, THE MILWAUKEE DAYLIGHT AND SKY COVER MONTHLY DATA MAY BE CONSIDERED APPLICABLE TO THE WATERSHED. SKY COVER CONSISTS OF CLOUDS OR OBSCURRING PHENOMENA, AND IS EXPRESSED IN TENTHS. A DAY IS CLASSIFIED AS CLEAR IF THE SKY COVER DURING THE DAYLIGHT PERIOD IS 0-0.3, PARTLY CLOUDY IF THE SKY COVER IS 0.4-0.7, AND CLOUDY IF THE SKY COVER IS 0.8-1.0. MONTHLY SKY COVER INDICATES, BY MONTH, THE PERCENT OF DAYS THAT HISTORICALLY HAVE BEEN CLEAR, PARTLY CLOUDY, OR CLOUDY.

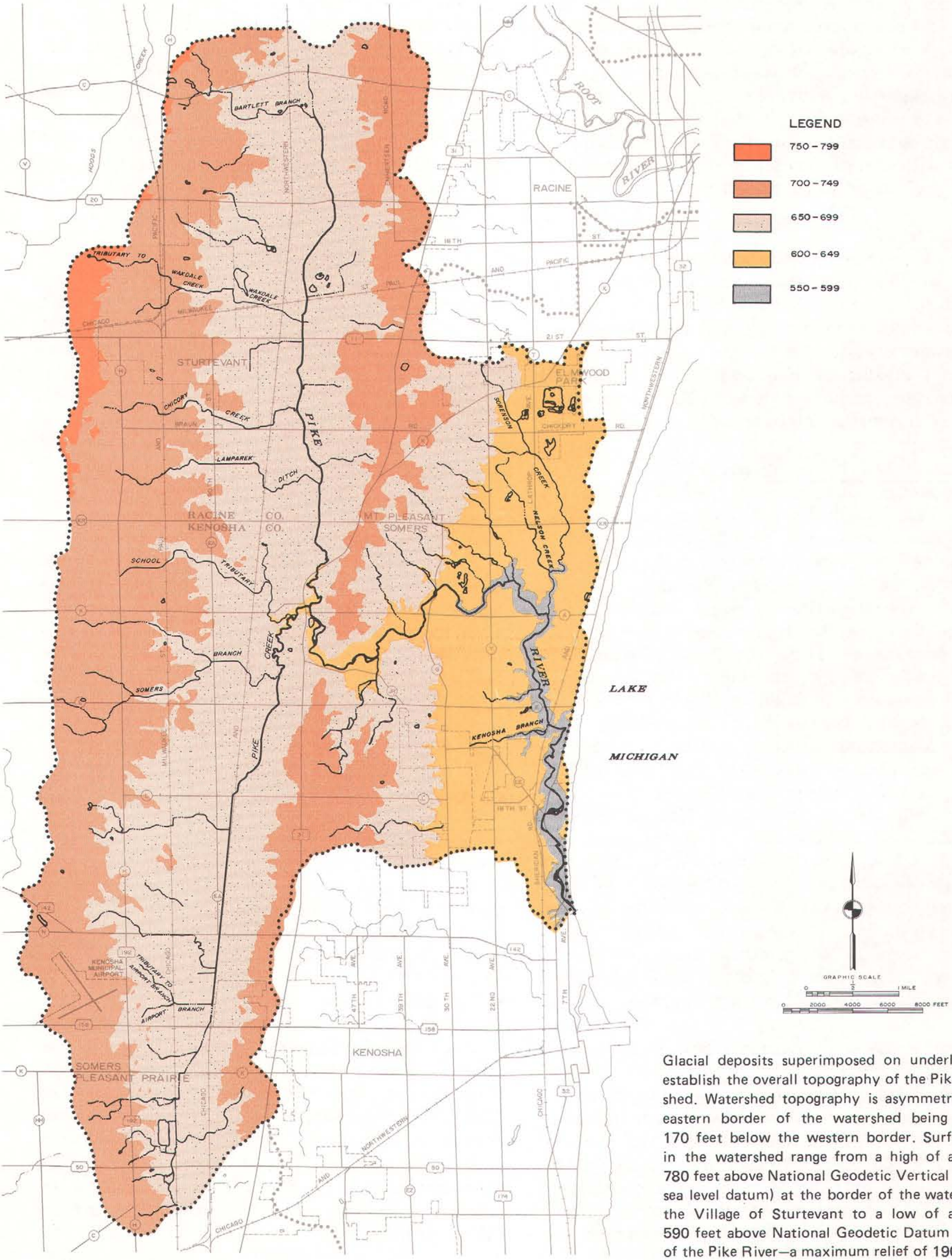
Source: Adapted by SEWRPC from National Weather and U. S. Naval Observatory Data.

utilization through respiration by those algae and aquatic plants. As illustrated in Figure 10, the duration of daylight ranges from a minimum of 9.0 hours on about December 22, the winter solstice, to a maximum of 15.4 hours on about June 21, the summer solstice.

Mean monthly sky cover for the sunrise to sunset period varies somewhat during the year. The smallest amount of daytime sky cover may be expected to occur during the four-month July through October period, when the mean monthly sky cover is at or slightly above 0.5. Clouds or other obscuring phenomena are most prevalent during the five months of November through March, when the mean monthly daytime sky cover is, about 0.7. The tendency for maximum average sky cover to occur in the winter and for minimum average sky cover to occur in the summer is also illustrated by examining the

Map 12

TOPOGRAPHIC CHARACTERISTICS OF THE PIKE RIVER WATERSHED



Source: SEWRPC.

Glacial deposits superimposed on underlying bedrock establish the overall topography of the Pike River watershed. Watershed topography is asymmetrical, with the eastern border of the watershed being about 80 to 170 feet below the western border. Surface elevations in the watershed range from a high of approximately 780 feet above National Geodetic Vertical Datum (mean sea level datum) at the border of the watershed west of the Village of Sturtevant to a low of approximately 590 feet above National Geodetic Datum at the mouth of the Pike River—a maximum relief of 190 feet.

expected relative number of days classified as clear, partly cloudy, and cloudy for months in each of those seasons. During the summer months, as shown in Figure 10, about one-third of the days may be expected to be categorized as clear, one-third as partly cloudy, and one-third as cloudy. Greater sky cover occurs in the winter, however, when over one-half of the days are classified as cloudy, with the remainder being approximately equally divided between partly cloudy and clear.

Physiography

The 51.54-square-mile Pike River watershed is an irregularly shaped basin with its major axis oriented in an approximately north-south direction. Its length—measured from the north to the south extremity of the basin—is approximately 13.3 miles, and its maximum width, which occurs approximately midway between the north and south extremities of the basin, is about 5.6 miles.

Topographic and Physiographic Features: Watershed topography or variation in elevation, is shown on Map 12. Watershed physiographic features, or surficial land forms, have been determined largely by the underlying bedrock and the overlying glacial deposits of the watershed. The Niagara cuesta on which the watershed lies is a gently eastward sloping bedrock surface. The topography in this section is asymmetrical as shown on Map 12, with the eastern border of the watershed being generally lower in elevation—about 80 to 170 feet—than the western border. Glacial deposits overlying the bedrock formations form the surface topography of the watershed consisting primarily of gently sloping ground moraine—heterogeneous material deposited on the glacial ice. Surface elevations within the watershed range from a high of approximately 780 feet above National Geodetic Vertical Datum (mean sea level datum) at the border of the watershed west of the Village of Sturtevant to approximately 590 feet above National Geodetic Vertical Datum at the mouth, a maximum relief of 190 feet. The areas of greatest local relief are located in the eastern half of the watershed.

Topography is an important consideration in watershed planning since it is one of the most important factors determining the hydrologic response of a watershed to rainfall and rainfall-snowmelt events, and since topographic considerations enter into the selection of sites and routes for public utilities and facilities such as sewerage and water supply systems, flood control facilities, and highways. Large-scale topographic mapping at a scale of 1" = 200' with a two-foot contour interval prepared to SEWRPC standards is available for the entire watershed. The mapping was prepared by Alster and Associates, Incorporated, beginning in 1966 and ending in 1979, for SEWRPC, Racine and Kenosha Counties, the Town of Somers, and the City of Kenosha. The above mapping, together with 1" = 400' scale aerial photographs were used extensively in the watershed planning process and should be equally valuable during implementation of the Pike River watershed plan.

Surface Drainage: The Pike River watershed drains in northerly, southerly, and easterly directions, discharging to Lake Michigan. Surface drainage within the watershed is diverse with respect to channel cross-sectional shape, channel slope, degree of stream sinuosity, and floodland shape and width. The heterogeneous character of the surface drainage system is due partly to the natural effects of glaciation superimposed on the bedrock and partly due to channel modifications and other results of urbanization in the basin.

The Pike River begins its 18.39-mile route to Lake Michigan from its origin near the intersection of Airline Road and CTH C in the northwest one-quarter of Section 10, Township 3 North, Range 22 East, in the Town of Mt. Pleasant. From its source, the river flows in a generally easterly direction for about one mile before turning south and flowing to Petrifying Springs Park in the Town of Somers in Kenosha County. From there, the river flows in a generally easterly direction to approximately one mile from the Lake Michigan shoreline, where it turns south and flows to its confluence with Lake Michigan. The Pike River acts as an estuary of Lake Michigan from its mouth to the lagoon located on the Carthage College Campus, a distance of about 1.4 miles. Pike Creek, the largest tributary to the Pike River, begins its 5.28-mile route to the Pike River from its point of origin near the intersection of the Chicago & North Western Railway and STH 158 in the northwest one-quarter of Section 33, Township 2 North, Range 22 East, in the Town of Somers. From there it flows in a north-northeasterly direction to its confluence with the Pike River in Petrifying Springs Park. Several other streams are tributary to the Pike River, including Bartlett Branch, Waxdale Creek, Chicory Creek, Lamparek Ditch, Sorenson Creek, School Tributary, and Somers Branch, all as shown on Map 3. The lengths of all perennial streams along with other detailed information are shown in Table 17.

Geology[7]

The geology of the Pike River watershed is a complex system of various layers and ages of rock formations. The type and extent of the various bedrock formations underlying the watershed was determined primarily by the environments in which the sediments forming the various rock layers were deposited. The surface of this varied system of rock layers was, moreover, eroded prior to being buried by a blanket of glacial deposits consisting of unconsolidated sand, silt, clay, gravel, and boulders. The bedrock formations underlying the Pike River watershed consist of, in ascending order, predominantly crystalline rocks of the Precambrian Era, Cambrian through Silurian Period sedimentary rocks of the Paleozoic Era, and unconsolidated surficial deposits. Only the glacial deposits are exposed in the watershed, there being no known bedrock outcrops in the basin.

Table 13, which summarizes the stratigraphy of the Pike River watershed, indicates that the unconsolidated surficial deposits have a thickness of 100 to 250 feet and that the underlying dolomite, shale, and sandstone bedrock attains a combined thickness in excess of 1,900 feet. Bedrock layers slope downward in an easterly direction at about 15 feet per mile (about 0.28 foot per 100 feet). The relationship between the geologic units and the three aquifer systems underlying the watershed is also set forth in Table 13.

Precambrian Rock Units: Precambrian crystalline rocks thousands of feet thick form the basement on which younger rocks were deposited. Little is known of their origin, but in wells near the watershed that reach the Precambrian basement, the rock types include quartzite and granite. The Precambrian rocks were extensively eroded to an uneven surface before the overlying sedimentary formations were deposited. Layered sedimentary rocks overlying the Precambrian rocks consist primarily of sandstone, shale, and dolomite. These rocks were deposited during the Cambrian, Ordovician, and Silurian geologic time periods, in seas that covered much of the present North American continent.

Cambrian Rock Units: Cambrian rocks in the watershed are primarily sandstone, but contain some siltstone, dolomite, and shale. The most dominant Cambrian rock units are the two lowermost units, the Mount Simon sandstone, which was deposited on the Precambrian surface, and the Eau Claire sandstone. The other Cambrian rock units in the watershed are the Galesville and Franconian undifferentiated sandstones and the Trempealeau dolomite formation, which are younger than the Mount Simon and Eau Claire sandstones. All five Cambrian rock units are present throughout the watershed. The Eau Claire sandstone has a thickness

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[7] *This summary of watershed geology is based on data and information presented in the following published reports:*

- *William J. Drescher, Frederick C. Dreher, and Paul N. Brown, "Water Resources of the Milwaukee Area, Wisconsin," U. S. Geological Survey Circular 247, Washington, D. C., 1953, 42 pp.*
- *F. C. Foley, W. C. Walton, and W. J. Drescher, "Ground-Water Conditions in the Milwaukee-Waukesha Area, Wisconsin," U. S. Geological Survey Water-Supply Paper 1229, Washington, D. C., 1953, 96 pp.*
- *J. H. Green and R. D. Hutchinson, "Ground-Water Pumpage and Water Level Changes in the Milwaukee-Waukesha Area, Wisconsin, 1950-61," U. S. Geological Survey Water-Supply Paper 1809-I, Washington, D. C., 1965, 19 pp.*
- *Martha J. Ketelle, "Hydrogeologic Considerations in Liquid Waste Disposal, With a Case Study in Southeastern Wisconsin," SEWRPC Technical Record, Vol. 3, No. 3, September 1971, 39 pp.*
- *Earl L. Skinner and Ronald G. Borman, "Water Resources of Wisconsin-Lake Michigan Basin," Hydrologic Investigations Atlas HA-432, U. S. Geological Survey, Washington, D. C., 1973.*
- *U. S. Geological Survey, Wisconsin Geological and Natural History Survey, and SEWRPC, Digital Computer Model of the Sandstone Aquifer in Southeastern Wisconsin, April 1976, 42 pp.*
- *R. D. Hutchinson, "Water Resources of Racine and Kenosha Counties, Southeastern Wisconsin," U. S. Geological Survey Water-Supply Paper 1878, Washington, D. C., 1970, 63 pp.*

Table 13

STRATIGRAPHY OF THE PIKE RIVER WATERSHED

System	Geologic Unit[a]	Nominal Thickness or Thickness Range (feet)	Dominant Lithology	Hydrologic Unit[b]
Quaternary	Holocene and Pleistocene Deposits	100-250	Clay, silt, sand, and gravel and boulders Possibly locally stratified	Sand and gravel aquifers (unconfined)
Silurian	Dolomite Undifferentiated	150-300	Dolomite	Dolomite Aquifer (unconfined)
Ordovician	Maquoketa Shale Undifferentiated	200	Shale	Confining bed
	Galena Dolomite, Decorah Formation, and Platteville Formation, Undifferentiated	300	Dolomite	Sandstone
	St. Peter Sandstone	100-150	Sandstone	
Cambrian	Trempealeau Formation	50-150	Dolomite	- -
	Galesville and Franconian Sandstone, Undifferentiated	200-250	Sandstone	
	Eau Claire Sandstone	350	Sandstone, siltstone and shale	
	Mount Simon Sandstone	600 +	Sandstone	
Precambrian	Undifferentiated	(thousands of feet)	Crystalline rocks including granite and quartzite	- -

[a]*Each geologic unit underlies or covers the entire watershed with the exception of holocene deposits which are found only in topographically low areas such as in streams and marshes.*

[b]*The combination of the unconfined sand and gravel and dolomite aquifers is sometimes referred to as the shallow aquifer whereas the confined sandstone aquifer is sometimes referred to as the deep aquifer.*

Source: U. S. Geological Survey and SEWRPC.

of about 350 feet, whereas the Mount Simon sandstone has a thickness in excess of 600 feet, with the total thickness being unknown because of the absence of fully penetrating wells or other bore holes.

Ordovician Rock Units: Ordovician rocks in the watershed consist of sandstone, dolomite, and shale. The St. Peter sandstone, which was deposited on an erosion surface cut into the underlying Cambrian formation, has a thickness of between 100 and 150 feet over the watershed. The Platteville formation, Decorah formation, and Galena dolomite, which were deposited in succession on top of the St. Peter sandstone but are not differentiated in the watershed, have a combined thickness of approximately 300 feet. Above these is the relatively impermeable Maquoketa shale, which has a thickness of about 200 feet throughout the watershed.

Silurian Rock Units: Silurian rocks consisting of undifferentiated dolomite strata and having a thickness of between 150 and 300 feet overlie the Maquoketa shale. They form the bedrock beneath the glacial deposits in all of the watershed. As shown on Map 13, which depicts the topography of the surface of the bedrock, the Silurian dolomite was eroded prior to deposition of the glacial till so as to exhibit an overall downward slope which generally follows the present drainage pattern of the watershed.

Quaternary Deposits: Unconsolidated deposits of boulders, gravel, sand, silt, and clay overlie the sedimentary rocks. These were deposited during the Pleistocene age by continental glaciers that last covered the wastershed about 11,000 years ago. The deposits can be classified according to their origin into till and stratified drift. Till, a heterogeneous mixture of clay, silt, sand, gravel, and boulders, was deposited from ice without the sorting action of water. Most of the watershed is overlain by till in the form of ground moraine. Stratified drift consists primarily of sand and gravel that were sorted and deposited as outwash of glacial meltwater. Local deposits of stratified drift may exist in the watershed in the form of sand and gravel. As shown on Map 14, the thickness of the unconsolidated deposits in the Pike River watershed is variable, ranging from 100 to 250 feet.

Holocene materials consist of recent alluvium and marsh deposits. They occur only along streams and in marshy areas and constitute a very small fraction of the unconsolidated deposits covering the watershed land surface.

Abandoned Sand and Gravel Pits and Quarries: Inactive sand and gravel pits and dolomite quarries, and more particularly the excavations left as a result of the mining operations, have the potential to serve a variety of needs in the ever-expanding urban area. The depressions may serve initially as solid waste disposal sites and, upon filling, serve residential, commercial, or industrial land uses. Lakes and ponds developed in the depressions left by sand, gravel, and dolomite operations could complement contiguous public recreational areas or private residential, commercial, or industrial development. Those depressions that are in an urban setting may also serve as storm water detention ponds. Carefully selected inactive sand and gravel pits and dolomite quarries could also be preserved, in whole or in part, as scientific sites, oriented to the study of glacial and bedrock geology, or as historic sites intended to inform visitors of the commercial activities of early inhabitants. There are no active sand and gravel pits or dolomite quarries in the Pike River watershed. There are only six small, abandoned sand and gravel pits in the watershed, all located near the Village of Elmwood Park.

Soils

The nature of the soils within the Pike River watershed has been determined primarily by the interaction of the parent glacial deposits covering the Region with topography, climate, plants, animals, and time. Within each soil profile, the effects of these soil forming factors are reflected in the transformation of soil material in place, chemical removal of soil components by leaching or physical removal by wind or water erosion, additions by chemical precipitation or by physical deposition, and transfer of some soil components from one part of the soil profile to another.

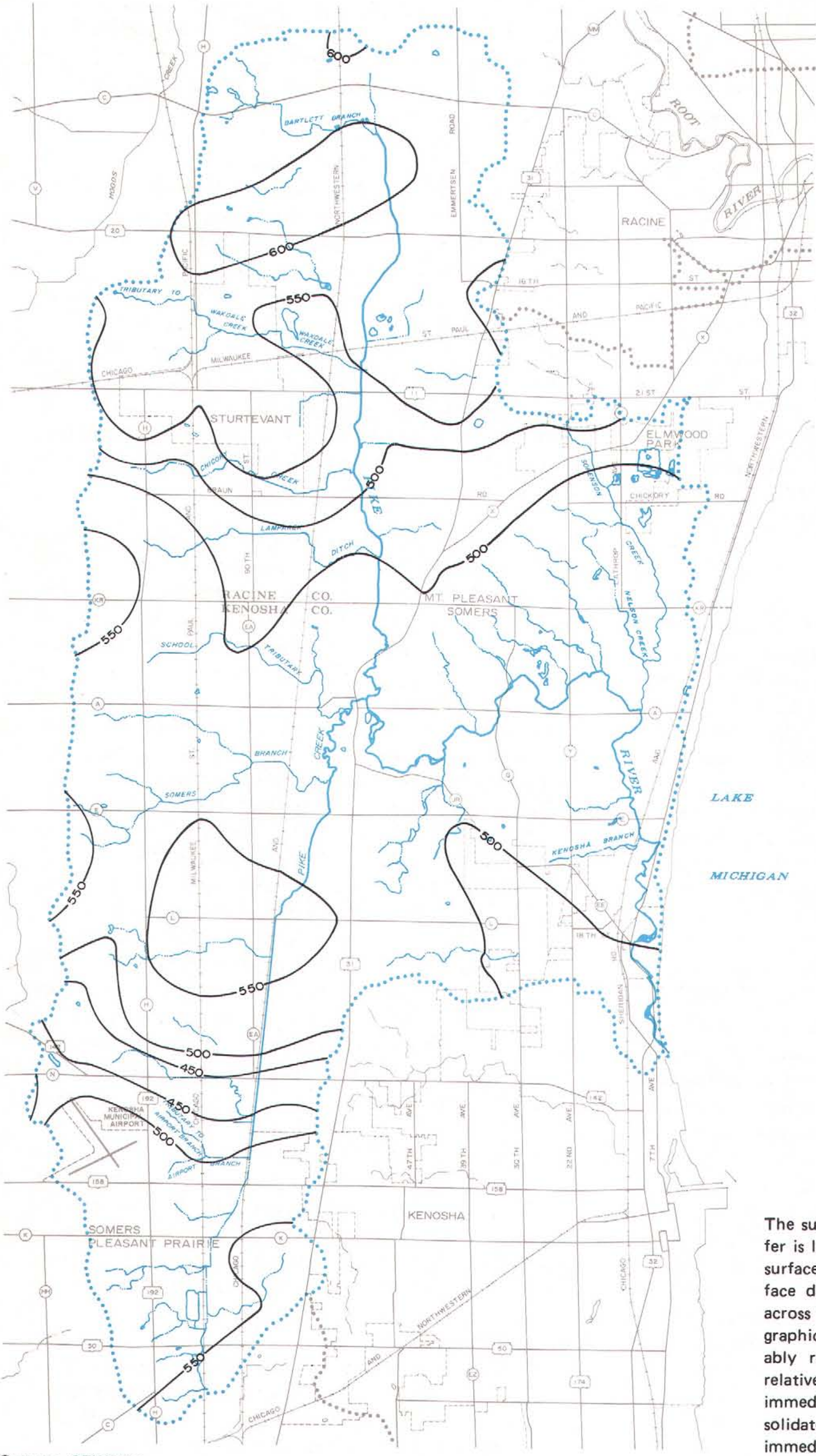
Soil forming factors, particularly topography and the nature of the parent glacial materials, exhibit wide spatial variations in southeastern Wisconsin, and therefore hundreds of different soil types have developed within the Pike River watershed and the Region. In order to assess the significance of these unusually diverse soil types to sound regional development, the Commission in 1963 negotiated a cooperative agreement with the U. S. Soil Conservation Service under which detailed operational soil surveys were completed for most of the Region. The results of the soil survey have been published in SEWRPC Planning Report No. 8, Soils of Southeastern Wisconsin. The regional soil survey has not only resulted in the mapping of soils within the Region in great detail and provided data on the physical, chemical, and biological properties of the soils, but has also provided interpretations of the soil properties for planning, engineering, agricultural, and resource conservation purposes. Detailed soils data are available for the entire area of the Pike River watershed. The detailed soils data were utilized in the watershed planning program in the hydrologic modeling, the identification of areas having limitations for urban development utilizing onsite waste disposal systems and for development utilizing public sanitary sewer service, the identification of prime agricultural lands, and delineation of primary environmental corridors.

Vegetation

Watershed vegetation at any given time is determined by, or is the result of, a variety of factors including climate, topography, occurrence of fire, soil characteristics, proximity of bedrock, drainage

Map 13

TOPOGRAPHY OF THE SURFACE OF THE BEDROCK IN THE PIKE RIVER WATERSHED



LEGEND

—600— CONTOURS ON BEDROCK SURFACE
CONTOUR INTERVAL 50 FEET
DATUM IS MEAN SEA LEVEL

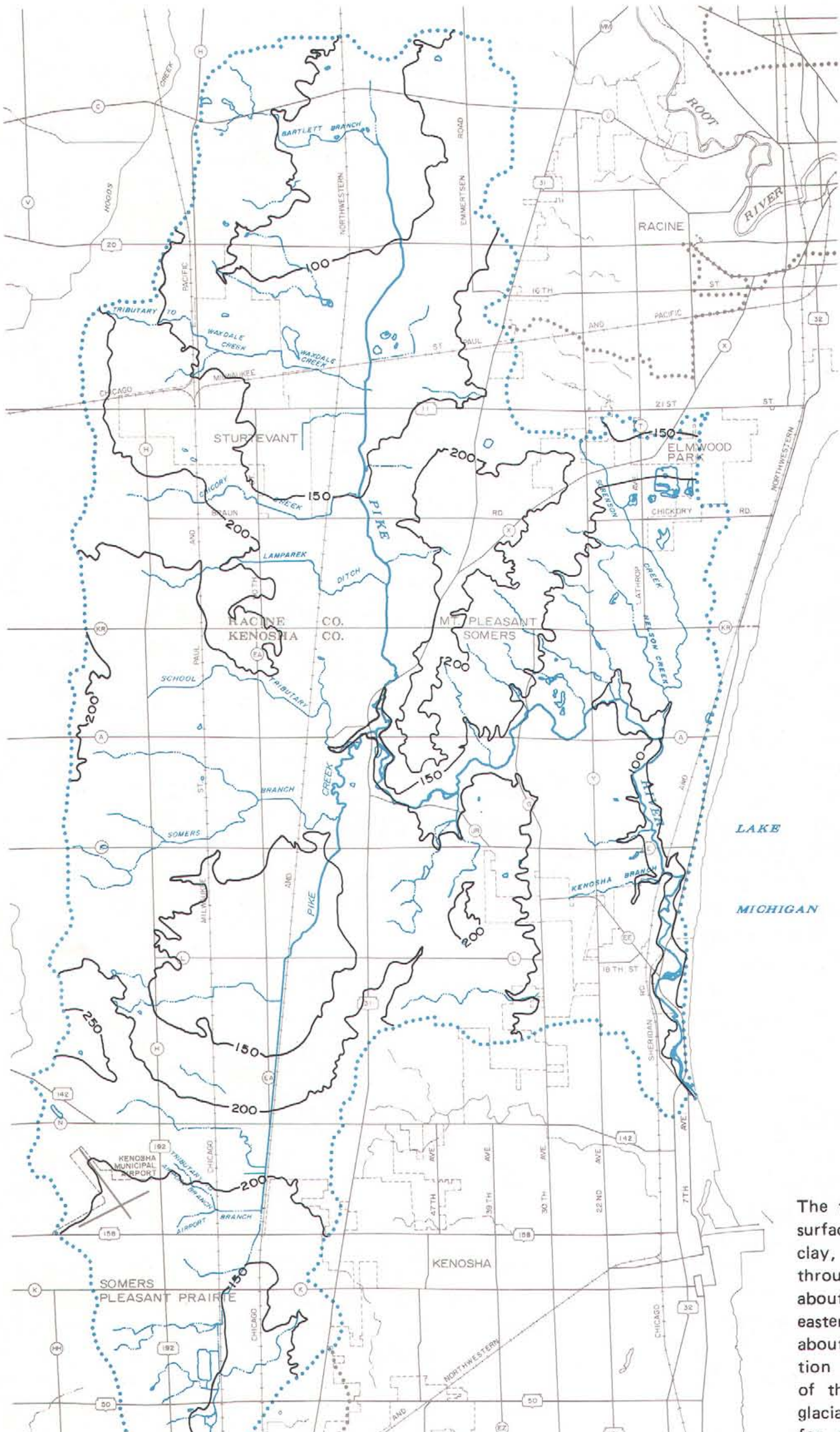
GRAPHIC SCALE
0 ½ 1 MILE
0 2000 4000 6000 8000 FEET

The surface of both the bedrock and the dolomite aquifer is located from 100 to 250 feet beneath the ground surface of the Pike River watershed. This bedrock surface dips generally downward in an easterly direction across the watershed at about 15 feet per mile. Topographic variations on the surface of the bedrock probably reflect preglacial water and wind erosion. The relatively impermeable Maquoketa shale is positioned immediately below the dolomite unit, whereas unconsolidated glacial till, drift, and alluvial deposits lie immediately above the unit.

Source: SEWRPC.

Map 14

THICKNESS OF GLACIAL DEPOSITS IN THE PIKE RIVER WATERSHED



LEGEND

—100— CONTOUR LINES REPRESENT EQUAL THICKNESS OF SAND AND GRAVEL DEPOSITS
CONTOUR INTERVAL IS 50 FEET
DATUM IS MEAN SEA LEVEL

GRAPHIC SCALE

0 1 MILE

0 2000 4000 6000 8000 FEET

The thickness of the glacial deposits which form the surface of the watershed and which are composed of clay, silt, sand, gravel, and boulders has been measured throughout the basin. Thickness varies from a low of about 100 feet, which occurs near the northern and eastern boundaries of the watershed, to a maximum of about 250 feet, which occurs in the southwestern portion of the watershed approximately one mile north of the Kenosha Municipal Airport. The thickness of glacial deposits is an important factor in the planning for and design of subsurface utilities and facilities because the thickness determines whether such facilities will be constructed above or within the underlying bedrock.

features, and, of course, the activities of man. Due to the temporal and spatial variability of these influencing factors and the sensitivity of vegetation to most of them, the watershed's vegetation has been a changing mosaic of different types.

The terrestrial vegetation in the watershed occupies sites which may be subdivided into two broad land classifications: wetland and woodland. Wetlands are defined as areas that are inundated or saturated by surface or groundwater at a frequency and with a duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adopted for life in saturated soil conditions and may represent a variety of stages in the natural filling of lake and pond basins as well as floodplain areas. Woodlands are defined as lands at least 20 acres in area which are covered by a dense, concentrated stand of trees and associated undergrowth.

The location, extent, type, and quality of wetland and woodland areas are key determinants of the watershed's environmental quality. Such areas can, for example, support a variety of outdoor recreational activities. They offer aesthetic values, including a contribution to the beauty and visual diversity of the environment and the potential for functioning as visual and acoustic shields or barriers. Such areas and the vegetation contained within them serve important ecological functions, since they are typically—on a unit area basis—the biologically most productive areas of the watershed; provide continuous wildlife range and sanctuary for native biota; and help to maintain surface water quality by functioning as sediment and nutrient traps. Finally, certain woodland and wetland areas can be excellent outdoor laboratories for educational and research activities.

Presettlement Prairies, Woodlands, and Wetlands: Prior to the arrival of European settlers, the vegetation of the watershed was predominantly prairie, oak savannah, mesic forest, and marsh and sedge meadow. The prairies were composed of a variety of grasses such as Indian grass, big bluestem, and prairie dropseed, with a variety of forb species such as prairie dock, lead plant, blazing star, and prairie bush clover. The oak savannah or oak opening was characterized by a parklike groundlayer of the drier prairie species such as little bluestem grass, side-oats gramma grass, prairie coreopsis, false boneset, purple prairie clover, and pasqueflower with scattered bur oak trees. The lower reaches of the Pike River watershed and the lands adjacent to the Sorenson Creek were characterized by mesic or moderately moist, forest composed of a variety of upland deciduous hardwoods such as sugar maple, basswood, red oak, and slippery elm. The headwater portions of Pike Creek contained marsh and sedge meadow which were composed of cattail, sedges, bluejoint grass, and cord grass.

The presettlement distribution pattern of plant communities in the Pike River watershed can be represented by five generalized categories as shown on Map 15. The map is based on information gathered as part of the U. S. Public Land Survey conducted within the watershed just prior to settlement of the watershed by Europeans in the 1830's. For example, a land surveyor's field notebook contains the following description of Township 2 North, Range 23 East—the watershed portion of which now contains the lower reaches of the Pike River: "This small fraction is of very good soil and timber, thoroughly watered by the Pike River."

These notes also provide the following description of Township 3 North, Range 22 East—the watershed portion of which now contains the Village of Sturtevant, Town of Mt. Pleasant, and parts of the City of Racine: "Nearly all good rolling prairie."

Based primarily on these and other U. S. Public Land Survey records, the five generalized categories of presettlement vegetation shown on Map 15 consisted of the following nine terrestrial and wetland plant community types with the prairie encompassing about 66 percent of the watershed area:

1. Dry upland forests as indicated by the presence of the more xeric, or dry, oaks including black and white oaks like the remnants now found in Campbell's or Fink's Hardwoods, located in the Town of Mt. Pleasant. Many of these dry upland forests located within the watershed may have been former oak openings on thin soils or dry slopes.

2. Dry-mesic upland hardwood forest similar to that now found in the Sander's Park State Scientific Area located in the Town of Mt. Pleasant.

3. Mesic upland hardwood forest containing sugar maple and basswood similar to that now found in hardwoods in Petrifying Springs Park located in the Town of Somers.

4. Small lowland zones of wet to wet-mesic hardwood forest containing American elm, silver maple, and green ash like that which still exists along the lower reaches of the Pike Creek at the Hawthorn Hollow Sanctuary in the Town of Somers.

5. Oak openings containing scattered bur oaks with a parklike ground layer which are no longer found within the watershed.

6. Prairies containing prairie dock, blazing star, compass plant, and big bluestem grass which are presently limited to the railroad rights-of-way similar to the Truesdell Prairie remnant located in the Town of Pleasant Prairie.

7. Small lowland areas of shrub carr containing red osier dogwood, willows, and other shrubs similar to that now found in the wetland south of the Truesdell marsh located in the Town of Pleasant Prairie.

8. Small lowland zones of southern sedge meadow like that now found in the wetland adjacent to the Sunnyside Acres Subdivision in the Town of Mt. Pleasant.

9. Small lowland zones of shallow marsh like that now found in the Truesdell marsh located in the Town of Pleasant Prairie.

The dry, dry-mesic, and mesic upland forests fall within the broad category of woodlands whereas the remaining four plant community types which still remain in the watershed—wet to wet-mesic hardwood forest, shallow marsh, southern sedge meadow, and shrub carr—may be categorized as wetlands.

Inventories, including onsite field inspection, of the remaining natural areas which contain examples of the presettlement landscape within the Pike River watershed were conducted by the Wisconsin Department of Natural Resources, Scientific Areas Preservation Council staff in 1973 for Kenosha, Racine, and Walworth Counties and again in 1976 for the coastal zone along Lake Michigan. In addition, the Commission staff conducted a systematic review of its files, the literature, and the 1975 large-scale aerial photography of the watershed as well as a poll of area biologists and resource managers to determine if any additional natural areas were located within the watershed. The findings of this natural area inventory effort are summarized below.

A total of two natural areas not already protected through public ownership encompassing 88 acres, or less than 0.3 percent of the total area of the watershed, and two natural areas presently protected by public ownership encompassing 95 acres, or less than 0.3 percent of the total area of the watershed, were identified and rated as shown on Map 16 and in Table 14. Based on the current condition each natural area was classified into one of the following four categories:

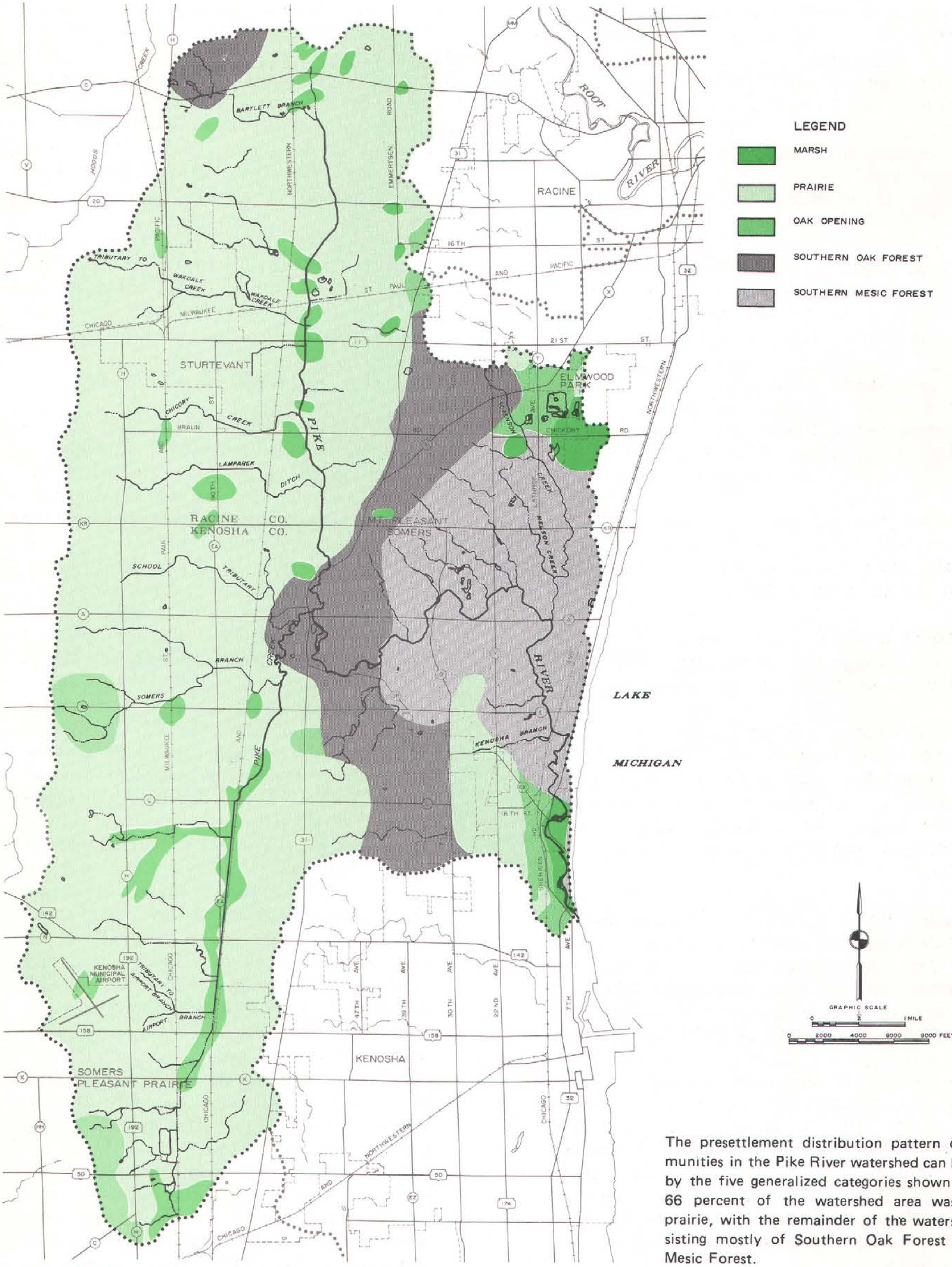
1. State Scientific Areas—State Scientific Areas are defined as those natural areas, geological sites, or archaeological sites identified as being of at least statewide significance and which have been so designated by the Wisconsin Department of Natural Resources, Scientific Areas Preservation Council.

2. Natural Areas of Statewide or Greater Significance—Natural areas of statewide or greater significance are defined as those natural areas which have not been significantly modified by man's activity, or have sufficiently recovered from the effects of such activity, so as to contain nearly intact native plant and animal communities which are believed to be representative of the presettlement landscape, but which have not as yet been classified as State Scientific Areas.

3. Natural Areas of Countywide or Regional Significance—Natural areas of countywide or regional significance are defined as those natural areas which have been slightly modified by man's activities or which have insufficiently recovered from the effects of such activity but still contain good examples of native plant and animal communities representative of the presettlement landscape. These natural areas are of lesser significance because the degree of their quality is less than what would be defined as ecologically ideal and there is evidence of past or present disturbances such as logging, grazing, water level changes as a result of ditching or filling, or pollution; the area may contain very common plant or animal community types in the Region, in which case only the best examples would qualify for state scientific area recognition; or the area may be of insufficient size. These natural areas may serve local communities as educational sites, passive recreation areas, and ecological zones which lend a degree of naturalness to their surroundings. In addition, these natural areas,

Map 15

PRESETTLEMENT VEGETATION IN THE PIKE RIVER WATERSHED

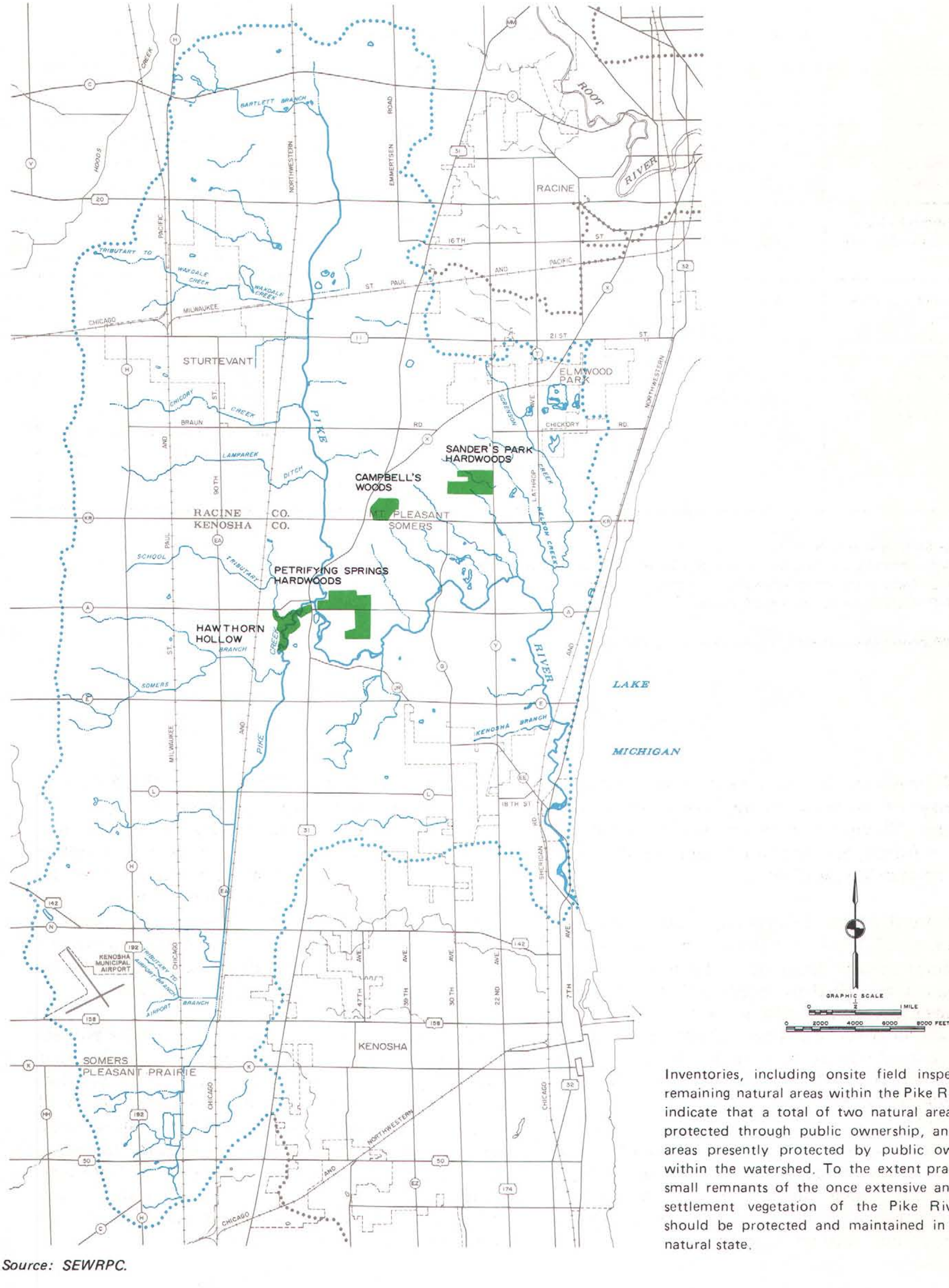


The presettlement distribution pattern of plant communities in the Pike River watershed can be represented by the five generalized categories shown above. About 66 percent of the watershed area was classified as prairie, with the remainder of the watershed area consisting mostly of Southern Oak Forest and Southern Mesic Forest.

Source: SEWRPC.

Map 16

KNOWN NATURAL AREAS IN THE PIKE RIVER WATERSHED: 1980



Source: SEWRPC.

Inventories, including onsite field inspection, of the remaining natural areas within the Pike River watershed indicate that a total of two natural areas not already protected through public ownership, and two natural areas presently protected by public ownership exist within the watershed. To the extent practicable, these small remnants of the once extensive and diverse presettlement vegetation of the Pike River watershed should be protected and maintained in an essentially natural state.

Table 14

KNOWN NATURAL AREAS IN THE PIKE RIVER WATERSHED: 1980

Name	Location by U. S. Public Land Survey	Owner	Acreage	Code	Description
Petrifying Springs Hardwoods (Kenosha County)	T2N, R22 E Sections 2 and 11	Kenosha County	65	NA-1	A mature mesic hardwood forest containing white oak, red oak, ash, sugar maple, and basswood
Hawthorn Hollow (Kenosha County)	T2N, R22E Section 10	Private	50	NA-3	A lowland hardwood forest bordering Pike Creek. Area includes a 10-acre prairie
Campbell's or Fink's Hardwoods (Racine County)	T3N, R22E Section 35	Private	38	NA-3	An upland hardwood forest dominated by red oak and shagbark hickory
Sanders Park Hardwood Forest (Racine County)	T3N, R22E Section 36	Racine County	30	SA	A rich upland oak forest located on one of Lake Michigan's ancient terraces. The forest is dominated by white and red oaks, black walnut, and white ash. In addition, the forest contains 89 species of wild flowers and ferns

Code - SA—State Scientific Area.
NA-1—Natural area of state or greater significance but not presently designated as a State Scientific Area.
NA-2—Natural area of countywide or regional significance.
NA-3—Natural area of local significance.

Source: Wisconsin Department of Natural Resources and SEWRPC.

if protected in an undisturbed condition, may be expected to increase in value over time. Therefore, some of these areas may, in the future, become natural or scientific areas of statewide significance.

4. Natural Areas of Local Significance—Natural areas of local significance are defined as those natural areas which have been significantly modified by man's activities but have nevertheless retained a modest amount of natural cover. Such natural areas are suitable for local educational use and their exclusion from a natural area survey would be considered an oversight. Natural areas of local significance may reflect the patterns of former vegetation or serve as examples of the influence of human settlement on vegetation. These natural areas may also be expected to increase in value if protected in an undisturbed condition.

Classification of an area into one of the foregoing categories is based upon consideration of the diversity of plant and animal species and community types present; the expected structure and integrity of the native plant or animal community; the extent of disturbance from man's activities such as logging, grazing, water level changes, and pollution; the commonness of the plant and animal communities present; any unique natural features within the area; size of the area; and educational value.

In addition to the type categorization, the natural areas in the Pike River watershed were classified by the dominant type or types of vegetation present in such areas. The nine categories used above to describe presettlement vegetation were used to classify the existing vegetation. Based on the vegetation classification, mesic and dry-mesic hardwood forest are the most dominant types of vegetation in the remaining natural areas of the watershed.

Map 16 indicates that all of the remaining unprotected natural areas in the watershed are located near the Kenosha/Racine County line. Two of the natural area sites are classified as being of local significance. Two natural areas are classified as being of statewide or greater significance, and one, the Sander's Park Hardwood Forest, has been designated as a State Scientific Area. In summary, only small remnants of the once extensive and diverse presettlement vegetation of the Pike River watershed still remain. To the extent practicable, these remnants should be protected and maintained in an essentially natural state.

Existing Woodlands: Woodlands in the Pike River watershed presently cover a total combined area of 758 acres, or approximately 2.3 percent of the total area of the watershed. Located primarily along the riverine portions of the watershed, these woodlands provide an attractive natural resource of immeasurable value. Not only is the beauty of the stream system and the topography of the watershed accentuated by woodlands, but these woodlands are also essential to the maintenance of the overall environmental quality of the watershed.

The woodlands of the watershed can be classified into five forest types: 1) dry hardwoods, 2) dry-mesic hardwoods, 3) mesic hardwoods, 4) wet-mesic hardwoods, and 5) wet hardwoods. The latter two forest types are wetlands and are considered in the following section dealing with wetlands. The location of the remaining dry, dry-mesic, and mesic hardwood forests located within the Pike River watershed are shown on Map 17. Natural stands of trees within the watershed consists largely of even age mature, or nearly mature, specimens with insufficient reproduction and saplings to maintain the stands when the old trees are harvested or die of disease or age. This lack of young growth is an unnatural condition brought about by mismanagement and is often associated with many years of extensive grazing by livestock.

From 1963 to 1975, the area devoted to woodlands within the watershed decreased from 818 to 758 acres, a 7.3 percent loss. Woodlands within the watershed are thus being lost at a rate of approximately five acres per year. These losses are due to conversion to urban use, land clearing for agricultural use, highway construction, the effects of diseases such as the dutch elm disease and oak wilt, and degeneration and neglect. These forces of destruction may be expected to rapidly and appreciably reduce the woodland acreage unless corrective measures are taken. Moreover, the present rate of loss may be expected to accelerate rapidly in the foreseeable future unless land management, balanced use, and sustained yield management are applied. The changes in woodland area within the watershed since 1963 are shown in Table 15.

Table 15

WOODLAND AREAS IN THE PIKE RIVER WATERSHED: 1963, 1970, AND 1975

Township/County	Woodland Area						Woodland Area Change			
	1963		1970		1975		1963 to 1975		1970 to 1975	
	Acreage	Percent of Total	Acreage	Percent of Total	Acreage	Percent of Total	Acreage	Percent	Acreage	Percent
Pleasant Prairie . .	19	2	19	3	7	--[a]	-12	-63.0	-12	-63.0
Somers	572	70	527	68	529	70	-43	-7.5	2	0.4
Kenosha County	591	72	546	71	536	71	-55	-9.3	-10	-2.0
Mt. Pleasant	227	28	226	29	222	29	-5	-2.2	-4	-2.0
Racine County	227	28	226	29	222	29	-5	-2.2	-4	-2.0
Total	818	100	772	100	758[b]	100	-60	-7.3	-14	-2.0

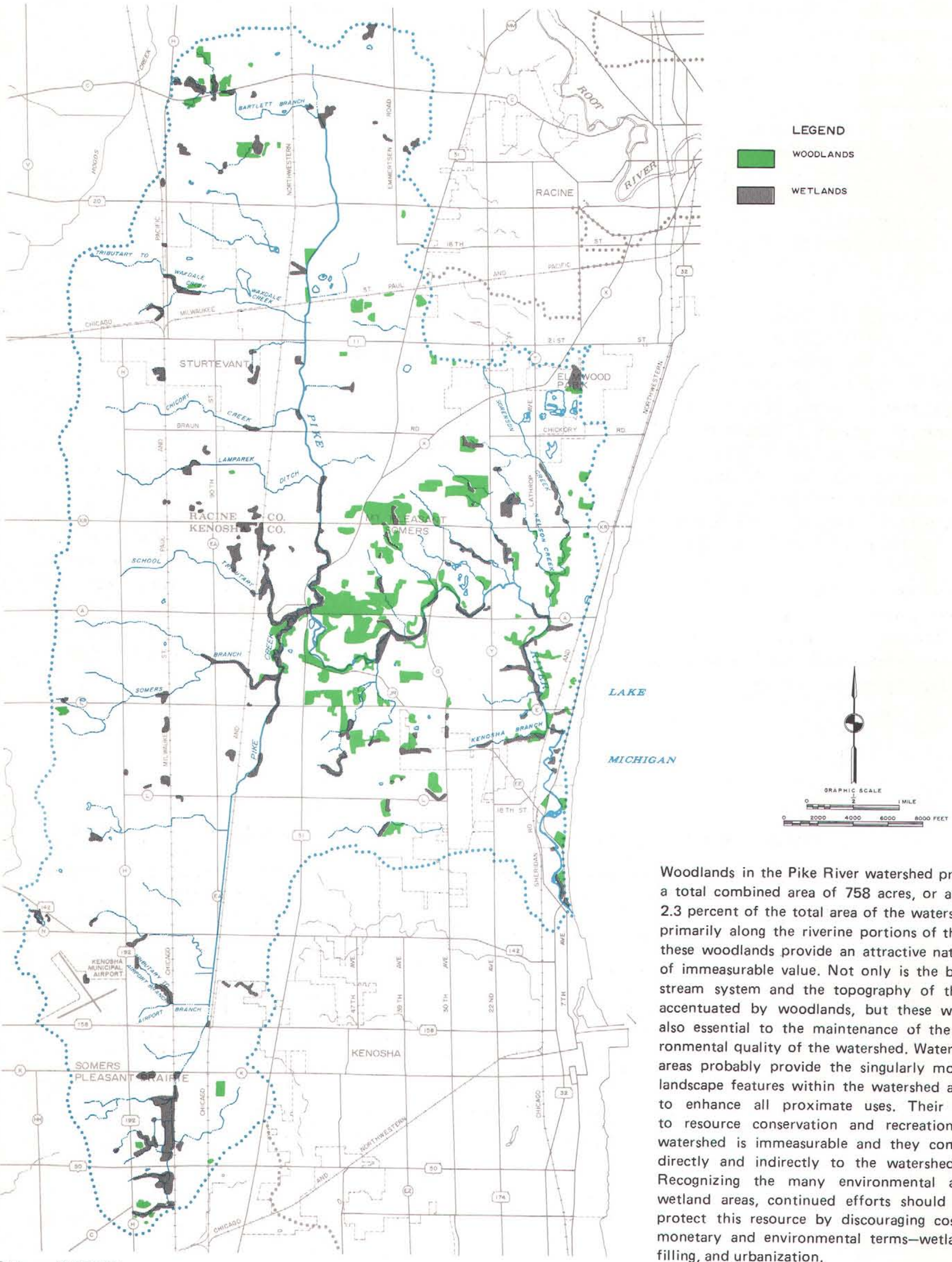
[a]Less than 1.0 percent.

[b]Total does not include 80 acres of pine plantation.

Source: SEWRPC.

Map 17

WOODLANDS AND WETLANDS IN THE PIKE RIVER WATERSHED: 1975



Source: SEWRPC.

Woodlands in the Pike River watershed presently cover a total combined area of 758 acres, or approximately 2.3 percent of the total area of the watershed. Located primarily along the riverine portions of the watershed, these woodlands provide an attractive natural resource of immeasurable value. Not only is the beauty of the stream system and the topography of the watershed accentuated by woodlands, but these woodlands are also essential to the maintenance of the overall environmental quality of the watershed. Water and wetland areas probably provide the singularly most important landscape features within the watershed and can serve to enhance all proximate uses. Their contribution to resource conservation and recreation within the watershed is immeasurable and they contribute both directly and indirectly to the watershed's economy. Recognizing the many environmental attributes of wetland areas, continued efforts should be made to protect this resource by discouraging costly—both in monetary and environmental terms—wetland draining, filling, and urbanization.

An increasing demand for woodland areas has arisen within the watershed especially for such areas located in and near riverine areas by persons who wish to live closer to nature. Real estate interests also have acquired scenic woodland areas for development and this trend may be expected to accelerate. Severe damage to wooded areas has resulted where developers have subdivided woodland tracts into small urban lots and removed trees to develop subdivisions. Remaining trees are often seriously weakened through the loss of a large portion of the root system. Woodlands may be substantially preserved during land subdivisions if lots are made five acres or larger in size and if careful attention is paid to construction practices as well as to the subdivision layout and design.

Whether the land values placed on woodlands in the watershed are economically sound or not, they do command respect in the current market place. A large and increasing portion of people in modern, affluent society, for various tangible or intangible reasons, are eager to own wooded land. These reasons include private recreation, bird and other wildlife watching, hunting, growing trees as a hobby as well as a business venture, or merely aesthetic appreciation.

It is becoming more apparent, particularly in the Pike River watershed, that the interaction between man and his environment is intensifying and becoming critical. The quality of life within an area is greatly influenced by the overall quality of the environment as measured in terms of clean air, clean water, scenic beauty, and natural diversity. In addition to contributing to clean air and water, the maintenance of woodlands within the watershed can contribute to the maintenance of a diversity of plant and animal life in association with human life. The existing woodlands of the watershed which required a century or more to develop can be destroyed through mismanagement within a comparatively short period of time. A new dimension in woodland management is needed to retain the woodlands of the Pike River watershed as an essential element of the natural resource base.

Existing Wetlands: Wetlands are defined as areas that are inundated or saturated by surface or groundwater at a frequency and with a duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions and may represent a variety of stages in the natural filling of lake and pond basins as well as floodplain areas. Wetlands are generally unsuited for most agricultural uses requiring cultivation. Wetlands are covered by organic soils, silts, and marl deposits. Included in the composition of wetlands are areas covered by various types of semi-terrestrial and emergent aquatic vegetation, the dominant plant species of which help to further classify these areas.

Wetlands within the Pike River watershed have been identified by the Southeastern Wisconsin Regional Planning Commission and are shown on Map 17. There are eight major classes of wetlands within the Pike River watershed. They include deep and shallow marsh, southern sedge meadow, shrub carr, fresh (wet) meadow, low prairie, and southern wet and wet-mesic hardwood forests.

Water and wetland areas probably provide the singularly most important landscape features within the watershed and can serve to enhance all proximate uses. Their contribution to resource conservation and recreation within the watershed is immeasurable and they contribute both directly and indirectly to the watershed's economy. Recognizing the many environmental attributes of wetland areas, continued efforts should be made to protect this resource by discouraging costly—both in monetary and environmental terms—wetland draining, filling, and urbanization. Wetlands have an important set of common natural functions that make them ecologically and environmentally valuable resources. The resource values of wetlands may be summarized as follows:

1. Wetlands affect the quality of water. Aquatic plants change inorganic nutrients such as phosphorus and nitrogen into organic material, storing it in their leaves or in the peat which is composed of plant remains. The stems, leaves, and roots of these plants also slow the flow of water through the wetland, allowing the silt and other sediment to settle out as well as catching some of the sediment on themselves. Wetlands, thus, protect the downstream or offshore water resources from siltation and pollution.

2. Wetlands also influence the quantity of water. They act to retain water during dry periods and to hold it back during wet weather, thereby stabilizing streamflows and controlling flooding. At a depth of 11 inches an acre of marsh is capable of holding 300,000 gallons of water and, thus, helps protect communities against flooding.

3. Wetlands which are located around the shoreland of lakes act to absorb storm impact thereby protecting the shoreline from erosion.

4. Wetlands may serve as groundwater recharge and discharge areas.

5. Wetlands are important resources for overall ecological health and diversity. They provide essential breeding, nesting, resting, and feeding grounds and provide escape cover for many forms of fish and wildlife. The water present in the wetland is also attractive to upland birds and other animals. These functions give wetlands recreational, research, and educational values; support activities such as trapping, hunting, and fishing; and add aesthetic value to the community.

From 1963 to 1975, the area within the watershed devoted to wetlands decreased from 722 to 665 acres, or by 7.9 percent. Thus, wetlands within the watershed are presently being lost at the rate of about five acres per year. Most of the loss in wetland area has been the result of conversion to agricultural uses through extensive drainage ditching. Other reclaimed areas have been developed for urban and recreational uses. The changes in wetland area within the watershed since 1963 are shown in Table 16.

Water Resources

Surface water resources, consisting of streams and associated floodlands, form the singularly most important element of the natural resource base of the watershed. Their contribution to the economic development, recreational activity, and aesthetic quality of the watershed is immeasurable. The groundwater resources of the Pike River watershed are hydraulically connected to the surface water resources, inasmuch as they provide the base flow of streams. The groundwater resources, along with Lake Michigan, constitute the major sources of supply for domestic, municipal, and industrial water users. Indeed, together with the abatement of flooding, the protection, enhancement, and proper development of these invaluable water resources constitute the basis for mounting the Pike River watershed study.

Surface Water Resources: The surface water resources of the watershed as identified in 1975—in the form of ponds, lakes, and wetlands—are far less abundant comparatively than those of the Region as a whole. The total surface area of the

Table 16

WETLAND AREAS IN THE PIKE RIVER WATERSHED: 1963, 1970, AND 1975

Township/County	Wetland Area						Wetland Area Change			
	1963		1970		1975		1963 to 1975		1970 to 1975	
	Acreage	Percent of Total	Acreage	Percent of Total	Acreage	Percent of Total	Acreage	Percent	Acreage	Percent
Pleasant Prairie . .	13	2	25	4	42	6	29	223.1	17	68.0
Somers	433	60	412	58	366	55	-67	-15.5	-46	-11.2
Kenosha County	446	62	437	62	408	61	-38	- 8.5	-29	- 6.6
Mt. Pleasant	276	38	270	38	257	39	-19	- 6.9	-13	- 4.8
Racine County	276	38	270	38	257	39	-19	- 6.9	-13	- 4.8
Total	722	100	707	100	665	100	-57	- 7.9	-42	- 5.9

Source: SEWRPC.

63 ponds within the watershed is approximately 153 acres, or about 0.5 percent of the total watershed area, compared to 2.2 percent for the Region as a whole.[8] The watershed is markedly void of lakes, and except for the six-acre impoundment in Petrifying Springs County Park, the remaining surface water area consists of wetlands and perennial streams. The total surface area of the few remaining wetlands within the watershed is about 665 acres, or 2.1 percent of the total watershed area, compared to 10.5 percent for the Region as a whole. The lack of large inland lakes and attendant recreational opportunities is offset by the proximity of the watershed to Lake Michigan, an enormous body of fresh water with great recreational potential.

Streams: One of the most interesting, variable, and occasionally unpredictable features of the watershed is its river and stream system with its ever changing, sometimes widely fluctuating, discharges and stages. The stream system of the watershed receives a relatively uniform flow of water from the shallow groundwater reservoir underlying the watershed. This groundwater discharge constitutes the baseflow of the streams. Agricultural drain tiles also contribute to this base flow. The streams also periodically receive surface water runoff from rainfall and snowmelt. This runoff, superimposed on the baseflow, sometimes causes the streams to leave their channels and occupy the adjacent floodplains. The volume of water drained annually from the watershed by the stream system is equivalent to about 11.2[9] inches of water spread over the watershed, amounting to about one-third of the average annual precipitation.

Perennial streams are defined herein as those streams which maintain at least a small continuous flow throughout the year except under unusual drought conditions. Perennial streams, unlike the other surface water systems of the watershed, are as abundant comparatively as those of the Region and the State as a whole. The total surface area of the perennial streams within the watershed is approximately 89 acres, or about 0.3 percent of the total watershed area, as compared to about 0.02 percent of the Region as a whole. There are 40.65 lineal miles of such perennial streams, as listed in Table 17.

The Pike River and its tributaries form an integral part of the major storm water drainage system for the most rapidly urbanizing areas of Racine and Kenosha Counties. The river has not been extensively channelized, but ditching and drainage of the land tributary to Pike Creek and to that portion of the Pike River north of Petrifying Springs County Park has changed the flow regimen of the River. The detailed study of portions of the perennial stream system within the watershed comprises an important element of the watershed planning effort, and subsequent chapters of this report will develop and describe the important interrelationships between the stream system and other natural and man-made elements of the watershed.

Floodlands: The natural floodplain of a river is a wide, flat to gently sloping area contiguous with and usually lying on both sides of the channel. The floodplain, which is normally bounded on its outer edges by higher topography, is gradually formed over a long period of time by the river during flood stage as that river meanders in the floodplain, continuously eroding material from concave banks of meander loops while depositing it on the convex banks. A river or stream may be expected to occupy and flow on its floodplain on the average of approximately once every two years, and therefore the floodplain should be considered as an integral part of a natural stream system.

How much of the natural floodplain will be occupied by any given flood will depend upon the severity of that flood, and more particularly, upon its elevation or stage. Thus, an infinite number of outer limits of the natural floodplain may be delineated, each related to a specified flood recurrence interval. The Southeastern Wisconsin Regional Planning Commission recommends, therefore, that the natural floodplains of a river or stream be more specifically defined as those cor-

[8] *An inventory was conducted of storm water detention ponds constructed since 1975, which revealed two such ponds. One is located in Section 15, T3N, R22E, in the Town of Mt. Pleasant south of STH 20 and west of Willow Road, and the other is located at the Wood Creek apartment complex at the intersection of 30th Avenue and 15th Place. All detention ponds considered to have a significant effect on downstream flood stages are incorporated into the hydrologic model of the watershed.*

[9] *Determined using the hydrologic-hydraulic model described in Chapter VIII.*

Table 17

PERENNIAL STREAMS IN THE PIKE RIVER WATERSHED

Perennial Stream	Tributary To	Source by U. S. Public Land Survey	Length[a] (miles)	Civil Division or Divisions in Which Stream is Located
Pike River	Lake Michigan	T3N, R22E, NW1/4, Section 10	15.89	Town of Mt. Pleasant Town of Somers City of Kenosha
Bartlett Branch	Pike River	T3N, R22E, SW1/4, Section 11	1.42	Town of Mt. Pleasant
Waxdale Creek (Worthington Lateral)	Pike River	T3N, R22E, NW1/4, Section 21	1.95	Town of Mt. Pleasant
Chicory Creek	Pike River	T3N, R22E, SW1/4, Section 28	1.89	Town of Mt. Pleasant
Lamparek Ditch	Pike River	T3N, R22E, NE1/4, Section 32	2.94	Town of Mt. Pleasant
Unnamed Tributary	Pike River	T2N, R22E, NE1/4, Section 2	0.17	Town of Somers
Sorenson Creek	Pike River	T3N, R23E, SW1/4, Section 30	3.49	Town of Mt. Pleasant Town of Somers
Nelson Creek	Sorenson Creek	T2N, R23E, SE1/4, Section 6	0.80	Town of Somers Town of Mt. Pleasant
Pike Creek	Pike River	T2N, R22E, NE1/4, Section 33	5.63	Town of Pleasant Prairie Town of Somers
School Tributary	Pike Creek	T2N, R22E, SE1/4, Section 5	3.10	Town of Somers
Somers Branch	Pike Creek	T2N, R22E, SW1/4, Section 9	2.38	Town of Somers
Unnamed Tributary	Pike Creek	T2N, R22E, NE1/4, Section 20	0.63	Town of Somers
Unnamed Tributary	Pike Creek	T2N, R22E, NE1/4, Section 29	0.17	Town of Somers
Unnamed Tributary	Pike Creek	T2N, R22E, SE1/4, Section 28	0.19	Town of Somers
Total	- -	- -	40.65	- -

[a] *Total perennial stream length as determined from SEWRPC large-scale topographic maps and U. S. Geological Survey quadrangle maps.*

Source: SEWRPC.

responding to a flood having a recurrence interval of 100 years, with the natural floodlands being defined as consisting of the river channel plus the 100-year floodplain.

A floodway is that designated portion of the regulatory floodlands required to convey the 100-year recurrence interval flood discharge. The floodway, which includes the channel, is that portion of the floodlands not suited for human habitation. All fill, structures, and other development that would impair floodwater conveyance by adversely increasing flood stages or velocities, or would itself be subject to flood damage, should be prohibited in the floodway.

The floodplain fringe is that portion of the regulatory floodplain lying outside of the floodway. Floodwater depths and velocities are small in this regulatory area relative to the floodway and, therefore, in a developed urban area further development may be permitted, although restricted and regulated so as to minimize flood damage. Because the regulatory floodway may result in increases in the stage of the regulatory flood relative to that which would occur under natural conditions, the floodplain fringe may include at its edges areas that would not be subject to inundation under natural conditions, but would be subject to inundation under regulatory floodway conditions.

The delineation of the natural floodlands in rural or largely undeveloped watersheds is extremely important to sound planning and development. Flood hazard delineations have many practical uses including identification of areas not well suited to urban development but possible prime locations for needed park and open space areas, identification of flood hazard areas possibly requiring structural or nonstructural floodland management measures, delination of hazard areas for flood insurance purposes, and provision of stage and probability data needed to quantify flood damages in monetary terms.

The problems of flooding and attendant damages in the Pike River watershed have been a matter of concern for many years. Several single-purpose studies have been conducted in an effort to document the flooding problem of the Pike River watershed and to delineate its floodlands. One such study, performed by the Soil Conservation Service of the U. S. Department of Agriculture,[10] was made to provide data for increased public and private awareness of the need for regulating land use and development in the floodprone areas. None of these studies have, however, included the development of alternative and recommended flood control plans for the watershed as a whole. It is, therefore, the purpose of this comprehensive watershed study to define the precise nature of the existing and probable future flood control problems of the watershed, identify the causes of those problems, propose alternative solutions thereto, and recommend the best solution from among the alternatives, together with the most effective means for carrying out that solution.

Existing flood problems can be best described in terms of information describing reported historic floods. Such information valuable to problem definition is presented in Chapter VI. Floodland management alternatives from which an integrated water resource management plan for the watershed can be synthesized are presented in Chapter XII, which includes a review and evaluation including the technical, economic, financial, legal, and administrative feasibility and political acceptability of each alternative. The recommended floodland management element of the comprehensive plan for the Pike River watershed along with the basis for the plan synthesis and an analysis of the attendant costs is presented in Chapter XIV.

[10] *This study entitled Flood Hazard Study, Pike River, Racine and Kenosha Counties, Wisconsin, December 1978, was performed by the Soil Conservation Service of the U. S. Department of Agriculture in cooperation with the Wisconsin Department of Natural Resources, the Racine and Kenosha County Soil and Water Conservation Districts, Racine and Kenosha Counties, and the City of Racine.*

Groundwater Resources: The Pike River watershed is richly endowed with groundwater resources. In the still rural portions of the watershed, the domestic water supply is provided by the groundwater reservoir. Public water supply is provided to the urban areas of the watershed with Lake Michigan as the source. Gradual discharge from the groundwater reservoir supplies the baseflow to the Pike River and its tributaries.

Rock units that yield water in usable amounts to pumped wells and in important amounts to lakes and streams are called aquifers. The aquifers beneath the watershed differ widely in water yield capabilities and extend to great depths, probably attaining a thickness in excess of 1,500 feet in portions of the watershed. Three major aquifers exist in the Pike River watershed. These are, in order from land surface downward: 1) the sand and gravel deposits in the glacial drift; 2) the shallow dolomite strata in the underlying bedrock; and 3) the Cambrian and Ordovician strata, composed of sandstone, dolomite, siltstone, and shale. Because of their relative nearness to the land surface, the first two aquifers are sometimes called the "shallow aquifers" and the latter the "deep aquifer." Wells tapping these aquifers are referred to as shallow or deep wells, respectively.

The occurrence, distribution, movement, use, and quality of groundwater resources and their relationship with surface water resources and other elements of the planning study are discussed in subsequent chapters of this report.

Fish and Wildlife Resources

Fish and wildlife are desirable because of their educational and aesthetic value, their importance in the ecological system, and their enhancement of certain recreational activities. The location, extent, and quality of fishery and wildlife areas and the type of fish and wildlife characteristic of those areas are, therefore, important determinants of the overall quality of the environment in the watershed.

Fishery: The distribution and abundance of fish in rivers and streams may be used as an indication of both short- and long-term changes in water quality and general instream ecological conditions. There are several advantages to using fish life as an indicator of the water quality and general ecological health of a stream system. First, fish occupy the top of the aquatic food chain and their presence, therefore, implies the presence of many other types of plants and animals upon which they feed. Second, fish live continuously for generations in a water body and, therefore, over time come to reflect the condition of that water body. Finally, fish have been well studied; therefore, accurate identification of species and more complete descriptions of their life histories are available than for other aquatic species, permitting relationships between fish and their environment to be well assessed.

In using information about the specific population of fish in a stream system as an indicator of water quality and ecological conditions, that information must be compared to information concerning the natural population of fish in a clean and ecologically sound stream system. Several characteristics of the fish population of a clean and sound environment are important in such a comparison. These characteristics include the presence of fish species from all parts of the food chain including the herbivorous or forage fish and several levels of predator fish; the presence of a high diversity of species; and a distribution of age classes reflecting a viable breeding population. Particular aquatic habitats should contain representative fish species—e.g., riffle areas should contain some combination of darters, daces, and certain species of minnows. The fish species should be spread among the pollution intolerant, tolerant, and very tolerant, with the intolerant species dominating in the clean water conditions. Knowing these characteristics of the natural fish population, which may be expected to exist in a clean and healthy environment, one may make comparisons with existing and historic populations and thereby assess the degree of deviation from the undisturbed native condition. Thus, typically, a natural undisturbed fish population has species in each of the three classifications with the intolerant species, however, being the most numerous. Any deviation may be attributed to the physical and water quality alterations in the habitat caused by the activities of man in the watershed tributary to the stream channel system, as well as to man-made changes on the stream channel system itself.

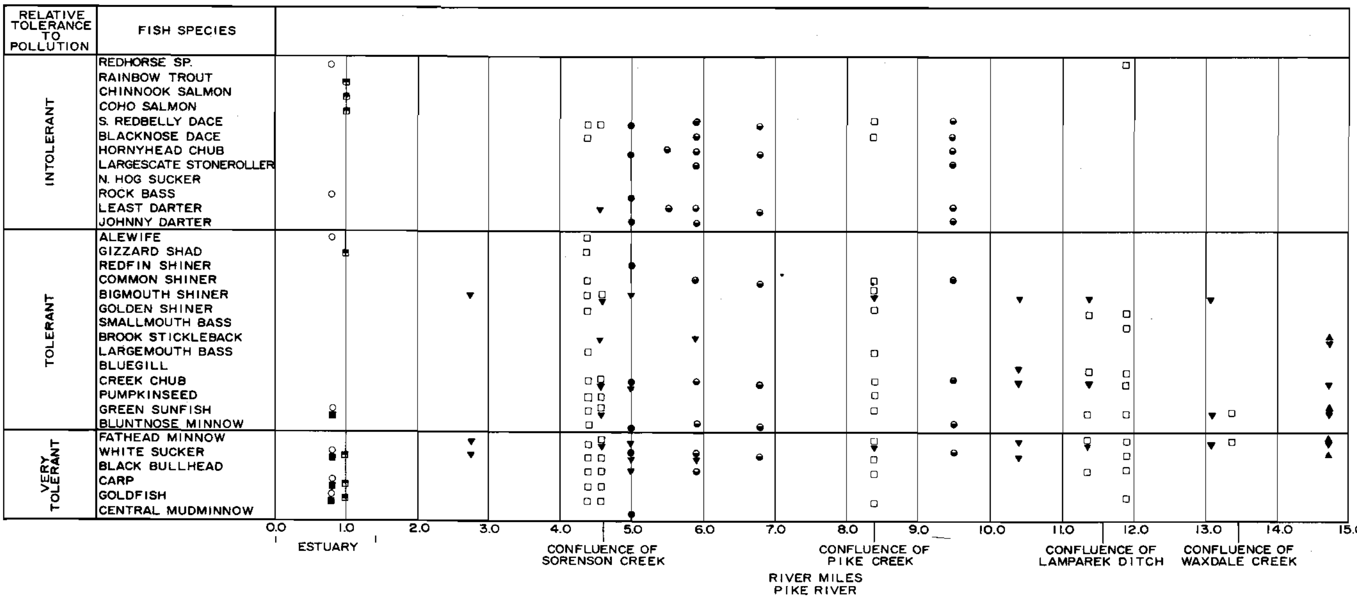
The use of fish as indicators of prevailing water quality conditions has been an important analytical tool for water quality evaluation in past watershed studies. Fish species may be categorized on the basis of their tolerance to pollution. However, the ranking of fish species on a pollution tolerance scale does not provide a precise species-by-species hierarchy of pollution tolerance and, therefore, an indication of water quality conditions. Rather, such a ranking is intended to generally group species according to their tolerance to pollution. Generally, this pollution tolerance is related to dissolved oxygen concentrations, although turbidity, siltation, temperature, pH, and toxic substances such as ammonia and pesticides are also important factors in determining tolerance. Fish classified as very tolerant can withstand large variations in water quality conditions and may, therefore, be expected to be found in both clean and in even heavily polluted waters. Fish classified as tolerant can withstand smaller variations in water quality conditions than very tolerant fish, and may, therefore, be expected to be found in clean and moderately polluted waters. Fish classified as intolerant are, relative to other categories, very restricted in the range of water quality conditions in which they can exist and, therefore, may be expected to inhabit only clean waters. Generally, the presence of intolerant fish species indicates good water quality conditions, with high dissolved oxygen levels, low turbidity, pH values within a 6.0 to 9.0 standard units range, water temperatures which do not exceed the natural daily and seasonal fluctuations, and no toxic substances present. In so far as a stream network is a dynamic system and fish are mobile animals, less tolerant fish species occasionally may find and temporarily reside in localized niches that are of higher quality than the overall quality of a particular reach of a stream system.

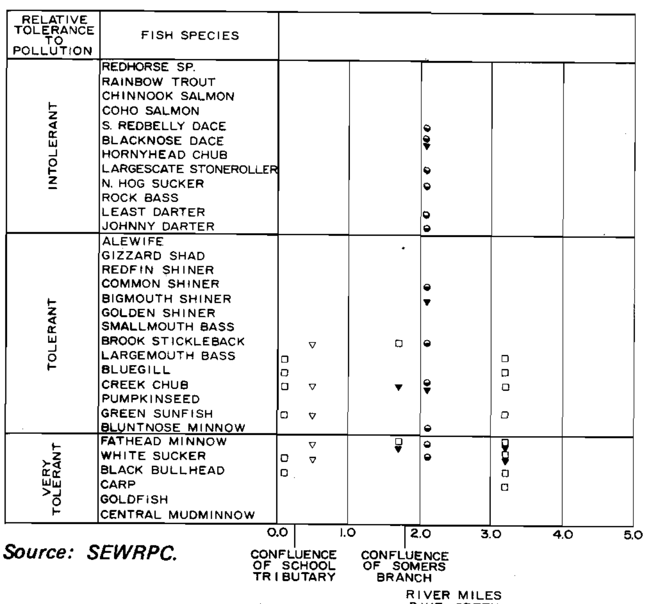
Historic Findings: Data from historic fish surveys of the Pike River system are useful in assessing the overall change in the fish populations and, therefore, in water quality conditions. In most cases where tolerant fish species have been significantly reduced or eliminated, significant alteration in the stream habitat may be assumed, such as channelization; draining of connected wetlands; runoff of fertilizers, sediment, pesticides and other toxic substances from both rural and urban lands; and the discharge of both municipal and industrial wastes.

Historic data from nine fishery surveys were evaluated and used to assess the changes over time that have occurred in the fishery of the Pike River watershed. Table 18 contains a list of the fish species and shows the number of individual species collected in the watershed since 1906. Figure 11 illustrates the spatial distribution of these species at each collecting site on the stream system.

Figure 11

HISTORIC SPATIAL DISTRIBUTION OF FISH IN THE PIKE RIVER WATERSHED: 1906-1979





LEGEND

DATE OF SURVEY

- ● JUNE 29, 1906
- ○ JULY 8-9, 1924
- ◒ JUNE 23, 1966
- ■ MARCH 19, 1969
- □ MAY 1, 1975
- ◘ SEPTEMBER 3-4, 1975
- ▲ MAY 9, 1978
- △ MAY 9, 1979
- ▼ AUGUST 20-27, 1980

Source: SEWRPC.

The earliest recorded fish survey of the Pike River watershed was conducted by George E. Wagner of the University of Wisconsin on June 29, 1906 in the vicinity of Lathrop Avenue in the Town of Somers. At that time nine species of fish were collected of which four were found to be intolerant—southern redbelly dace, Johnny darter, hornyhead chub, and rock bass, three tolerant—creek chub, bluntnose minnow, and redfin shiner, and two very tolerant—white sucker and central mudminnow. In July 1924, five additional sites were sampled. Fourteen fish species were collected of which seven were found to be intolerant—southern redbelly dace, Johnny darter, hornyhead chub, stoneroller, least darter, blacknose dace, and northern hog sucker, four tolerant—creek chub, bluntnose minnow, common shiner, and brook stickleback, and three very tolerant—white sucker, black bullhead, and fathead minnow. These early surveys were conducted for the purposes of collecting museum specimens as well as providing fish distribution records. These fish specimens are presently preserved in the collection of the University of Michigan at Ann Arbor, Michigan. The early fish surveys provide the best available appraisal of the native fish population in the Pike River watershed.

In May 1957 the Wisconsin Department of Natural Resources conducted a fish shocking survey of the Pike River to determine the potential for future sport fish management. Three additional species previously not recorded in the Pike River watershed were collected. They include the spottail shiner, brown bullhead, and white crappie. These three fish species were judged to be temporary migrants into the Pike River system from Lake Michigan and were not considered to represent a breeding population. As a result of that 1957 survey, several conclusions were developed by the Wisconsin Department of Natural Resources concerning the significance of the Pike River as a potential sport fishery. The report stated that Pike Creek, or the south branch of the Pike River, "has all the characteristics of a drainage ditch in the section that was shocked. In addition, the stream bottom was covered with refuse from

Table 18

HISTORICAL FISH SURVEYS CONDUCTED IN THE PIKE RIVER WATERSHED: 1906-1979

Fish Species According to Their Relative Tolerance to Pollution	Date of Survey							
	June 29, 1906	July 8-9, 1924	June 23, 1966	March 19, 1969	May 1, 1975	September 3-4, 1975	May 9, 1978	May 9, 1979
Very Tolerant								
Central mudminnow (Umbra limi)	X	--	--	--	--	--	--	--
Goldfish[a] (Carassius auratus)	--	--	X	X	X	X	--	--
Carp (Cyprinus carpio)	--	--	X	X	X	X	--	--
Black bullhead (Ictalurus melas)	--	X	--	--	--	X	--	--
White sucker (Catostomus commersonni)	X	X	X	X	X	X	X	X
Fathead minnow (Pimephales promelas)	--	X	--	--	--	X	X	X
Tolerant								
Bluntnose minnow (Pimephales notatus)	X	X	--	--	--	X	--	--
Green sunfish (Lepomis cyanellus)	--	--	X	X	--	X	X	X
Pumpkinseed (Lepomis gibbosus)	--	--	--	--	--	X	--	--
Creek Chub (Semotilus atromaculatus)	X	X	--	--	--	X	--	X
Bluegill (Lepomis macrochirus)	--	--	--	--	--	X	--	--
Largemouth bass (Micropterus salmoides)	--	--	--	--	--	X	--	--
Brook stickleback (Culaea inconstans)	--	X	--	--	--	X	X	X
Smallmouth bass (Micropterus dolomieui)	--	--	--	--	--	X	--	--
Golden shiner (Notemigonus chrysoleucas)	--	--	--	--	--	X	--	--
Bigmouth shiner (Notropis dorsalis)	--	--	--	--	--	X	--	--
Common shiner (Notropis cornutus)	--	X	--	--	--	X	--	--
Redfin shiner (Notropis umbratilis)	X	--	--	--	--	--	--	--
Gizzard shad[b] (Dorosoma cepedianum)	--	--	--	--	X	X	--	--
Alewife[a,b] (Alosa pseudoharengus)	--	--	X	--	--	X	--	--
Intolerant								
Johnny darter (Etheostoma nigrum)	X	X	--	--	--	--	--	--
Least darter (Etheostoma microperca)	--	X	--	--	--	--	--	--
Rock bass (Ambloplites rupestris)	X	--	--	--	--	--	--	--
Northern hog sucker (Hypentelium nigricans)	--	X	--	--	--	--	--	--
Largescale stoneroller (Campostoma oligolepis)	--	X	--	--	--	--	--	--
Hornyhead chub (Nocomis biguttatus)	X	X	--	--	--	--	--	--
Blacknose dace (Rhinichthys atratulus)	--	X	--	--	--	X	--	--
Southern redbelly dace (Chrosomus erythrogaster)	X	X	--	--	--	X	--	--
Coho salmon[a,b] (Oncorhynchus kisutch)	--	--	--	--	X	--	--	--
Chinook salmon[a,b] (Oncorhynchus tshawytscha)	--	--	--	--	X	--	--	--
Rainbow trout[a,b] (Salmo gairdneri)	--	--	--	--	X	--	--	--
Redhorse (Moxostoma sp.)	--	--	X	--	--	--	--	--

[a] *Introduced fish species.*

[b] *Anadromous fish species from Lake Michigan.*

Source: SEWRPC.

a local dump and the water smelled of pollution." Referring to the lower reaches of the Pike River in August 1953, Wisconsin Department of Natural Resources personnel observed that "much of the stream bed is dry" and on that basis recommended that because of "the intermittent nature of the water flow, management of this stream for smallmouth bass or any game fish is certainly questionable."

During the summer of 1966, the Wisconsin Department of Natural Resources, as part of the DDT residue studies in fish occurring in state waters, included the Pike River as one of their fish sampling sites. During this survey, the lower reaches of the Pike River, within one mile of the confluence with Lake Michigan, were sampled for fish. Seven fish species were collected during this survey of which one was found to be intolerant—rock bass, three tolerant—green sunfish, alewife, and gizzard shad, and three very tolerant—white sucker, carp, and goldfish. The rock bass, alewife, and gizzard shad were probably Lake Michigan migrants and as such did not represent local breeding populations within the lower reaches of the Pike River.

In March 1969, the Department of Natural Resources again conducted a survey of the lower reaches of the Pike River in the vicinity of the Alford Park-Carthage College area. The purpose of this survey was to determine if this portion of the river was used by trout from Lake Michigan for spawning. No game fish were collected during the survey. However, the four species of fish that were collected—green sunfish and white sucker, carp and goldfish—are classified, respectively, as being tolerant and very tolerant to polluted water quality conditions. The field report stated that this reach of the Pike River "appears to be very polluted by refuse of all kinds."

Two fish surveys were conducted in 1975 by the Wisconsin Department of Natural Resources and these surveys provide the most complete record of fish collected in the watershed prior to 1980. One survey conducted on May 1, 1975 in the lower reach of the Pike River between the mouth and Carthage College identified six fish species present including coho salmon and rainbow trout fingerlings. The second survey conducted on September 3 and 4, 1975 by the Wisconsin Department of Natural Resources as part of a fish distribution study established nine survey sites—one each on Lamparek Ditch, Somers Branch , Sorenson Creek, and Waxdale Creek, two on Pike Creek, and three on the Pike River—in the watershed. Two additional sites on the Pike River and School tributary were added in 1978 and 1979, respectively. The results of that survey appear in Table 18.

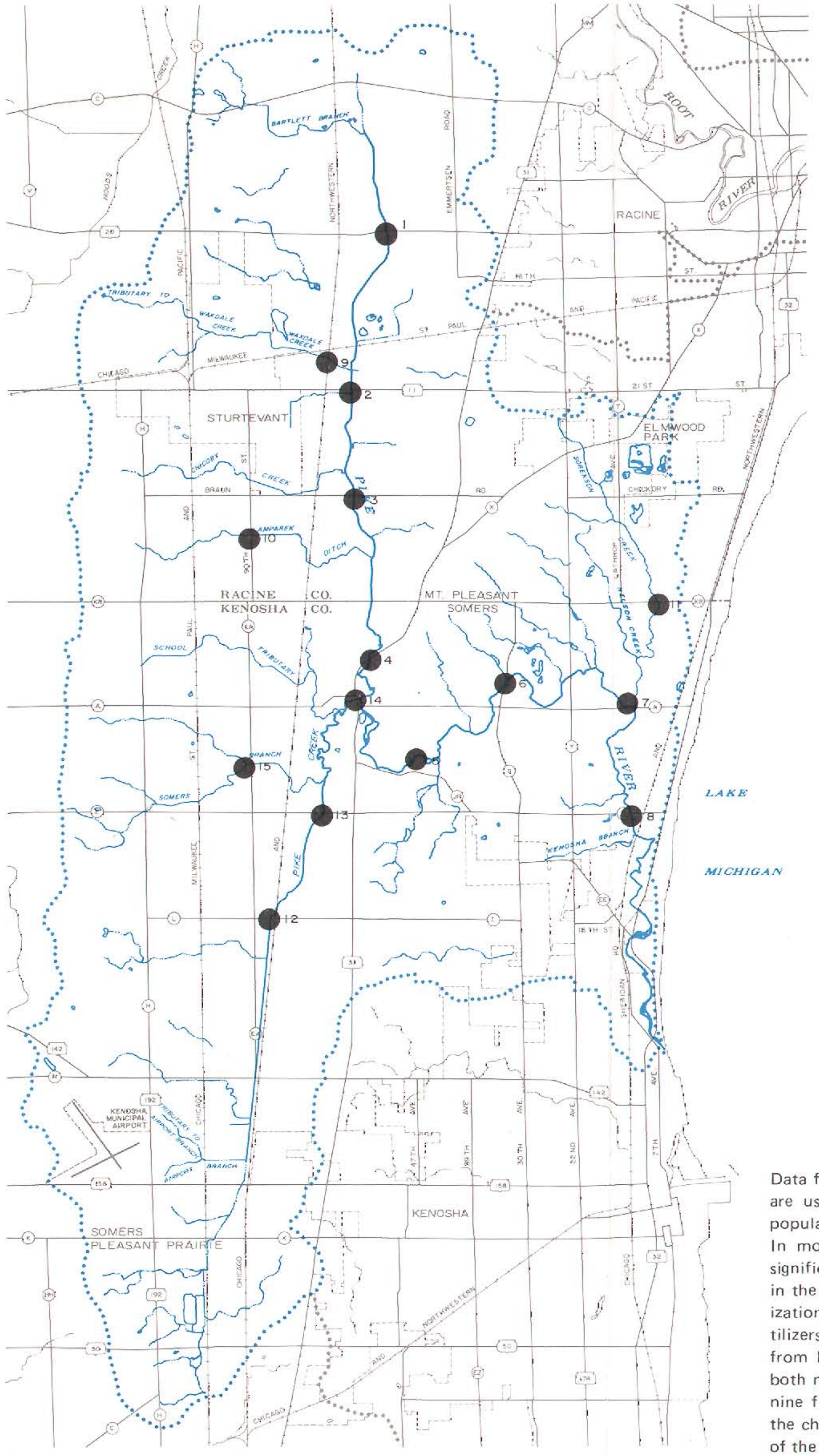
Two documented fish kills have occurred in the Pike River watershed. On July 6, 1979 a major fish kill occurred between the Kenosha Country Club and through Petrifying Springs County Park. Game fish, rough fish, and forage fish as well as crayfish and frogs were reported dead as a result of this fish kill. Oxygen depletion due to excessive decomposition of accumulated organic matter was postulated as being the cause of this particular fish kill. The reach of the Pike River between Petrifying Springs County Park and the Kenosha Country Club is impounded and water movement was slight at the time of the fish kill. A second fish kill occurred near the mouth of the Pike River on August 22, 1979. Both carp and bullheads were found dead as a result of this fish kill. Water quality data collected by the Commission from the lower reaches of the Pike River between 1966 and 1976 indicated that 21 percent of the samples analyzed in this reach had a dissolved oxygen content of less than 5.0 milligrams per liter. Both of these fish species are identified as being very tolerant to polluted water quality conditions and as such would have had to experience nearly anoxic water quality conditions in order to have been killed.

Existing Fisheries: Commission personnel inventoried the fish population of the Pike River watershed stream system in August 1980 in order to determine the current status of the watershed fishery. These field studies were intended to provide a basis for analyzing the potential for further fishery development within the watershed stream system.

Survey Procedure: The fish survey was accomplished using a one-quarter-inch mesh seine at each of 15 stations distributed throughout the watershed surface water system. The fish survey stations were selected to be representative of the major streams in the watershed, to encompass the full spectrum of natural to channelized conditions, and to provide a basis with which historic fish collections could be compared. The locations of the 15 fish survey stations are shown on Map 18. Information concerning the stations such as channel width, flow, depth, and water conditions is provided in Table 19.

Map 18

FISHERY RESOURCES IN THE PIKE RIVER WATERSHED: AUGUST 1980



LEGEND

FISH SURVEY STATION

7 STATION NUMBER

FISH SPECIES AND THEIR IDENTIFICATION NUMBERS LISTED IN ORDER OF DECREASING TOLERANCE TO POLLUTION

VERY TOLERANT

1 BLACK BULLHEAD

2 WHITE SUCKER

3 FATHEAD MINNOW

TOLERANT

4 GREEN SUNFISH

5 CREEK CHUB

6 BLUEGILL

7 BROOK STICKLEBACK

8 BIGMOUTH SHINER

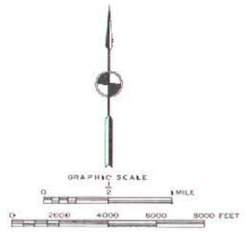
INTOLERANT

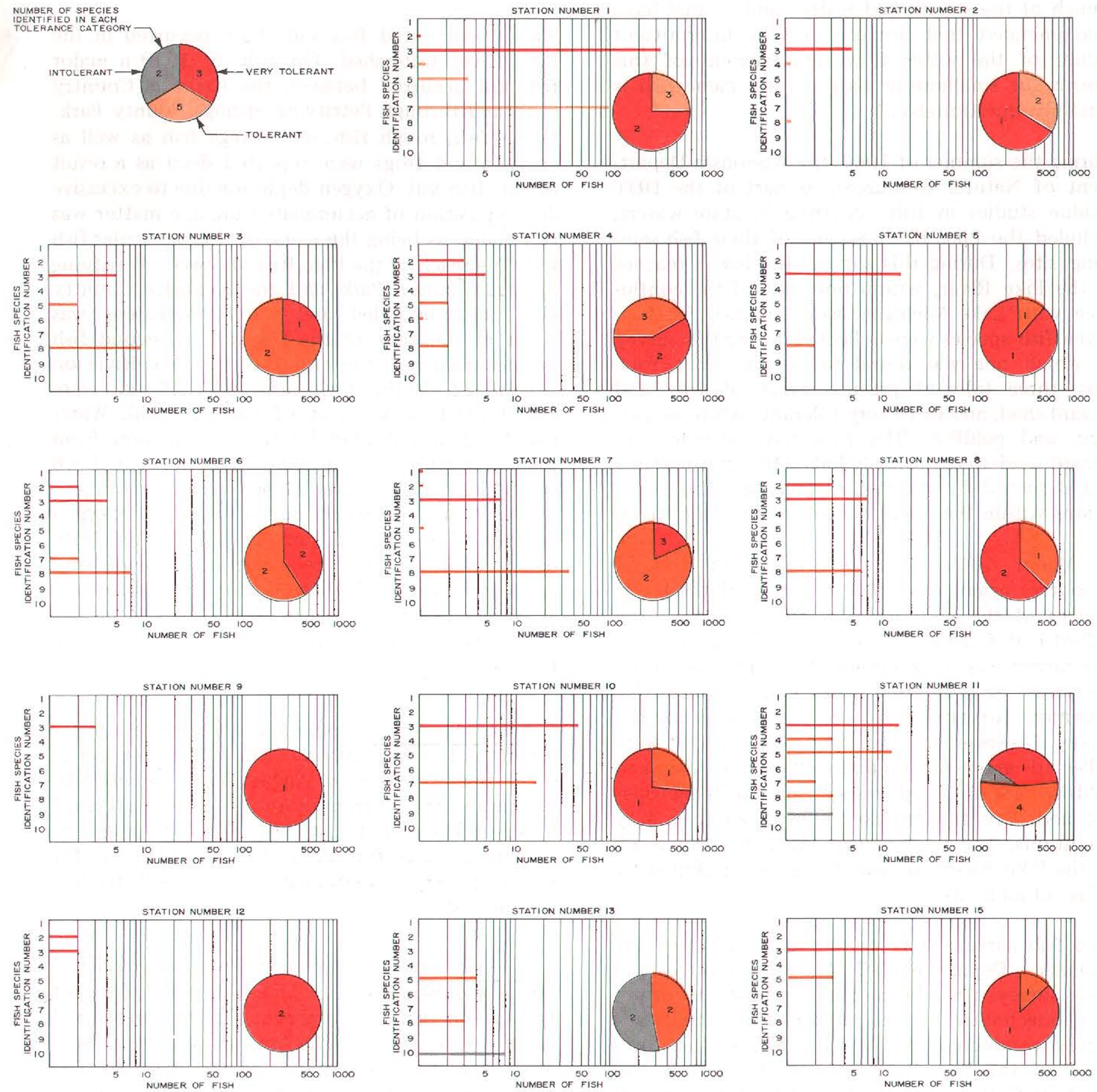
9 LEAST DARTER

10 BLACK-NOSED DACE

NOTE: EACH CIRCLE REPRESENTS THE TOTAL NUMBER OF FISH COLLECTED AT EACH FISH SURVEY STATION

NOTE: A SUMMARY GRAPH WAS OMITTED FOR FISH SURVEY STATION NUMBER 14 AT WHICH NO FISH WERE OBTAINED





Data from historic fish surveys of the Pike River system are useful in assessing the overall change in the fish populations and, therefore, in water quality conditions. In most cases where intolerant fish species have been significantly reduced or eliminated, significant alteration in the stream habitat may be assumed, such as channelization; draining of connected wetlands; runoff of fertilizers, sediment, pesticides and other toxic substances from both rural and urban lands; and the discharge of both municipal and industrial wastes. Historic data from nine fishery surveys were evaluated and used to assess the changes over time that have occurred in the fishery of the Pike River watershed.

Source: SEWRPC.

Table 19

FISH SURVEY STATIONS IN THE PIKE RIVER WATERSHED

Watercourse	Civil Division	Station Number	Stream Crossings at or Near Station: Name	Stream Crossings at or Near Station: River Mile	Vegetal Condition: On Banks	Vegetal Condition: Instream	Channel Width (feet)	Current	Temperature (^{o}F)	Channel Bottom Conditions	Observed Water Quality
Pike River main stem	Town of Mt. Pleasant	1	Washington Avenue (STH 20)	14.94	Overhanging grasses, ditched	Manna grass, sparse	6	Moderate to fast	64	Muck over gravel	Very turbid
Pike River main stem	Town of Mt. Pleasant	2	Racine Avenue (STH 11)	13.29	Manna grass and reed canary grass, ditched	Manna grass and water-plantain, sparse	8	Moderate	69	Gravel and muck	Slightly turbid
Pike River main stem	Town of Mt. Pleasant	3	Braun Road	12.23	Manna grass, ditched	Potamogeton sp., sparse	9	Slow to moderate	69	Clay and muck	Turbid, evidence of sewage
Pike River main stem	Town of Somers	4	Green Bay Avenue (STH 31)	10.38	Japanese bamboo and reed canary grass	None (shaded)	12	Moderate	- -	Muck and gravel	Very turbid
Pike River main stem	Town of Somers	5	Petrifying Springs County Park—south entrance bridge	8.26	Park lawn, overhanging trees and reed canary grass	None (shaded)	24	Moderate to fast	68	Gravel and rocks	Very turbid
Pike River main stem	Town of Somers	6	30th Avenue (CTH G)	6.60	Overhanging willows, weeds, and grasses	Elodea, Myriophyllum, Potamogeton sp., all sparse	25	Moderate to fast	69	Gravel and rocks	Turbid
Pike River main stem	Town of Somers	7	Lathrop Avenue (CTH T)	4.79	Overhanging trees, weeds and reed canary grass	Elodea and Potamogeton sp., all sparse	26	Moderate to fast	68	Gravel and rocks	Slightly turbid
Pike River main stem	Town of Somers	8	12th Street (CTH E)	3.27	Reed canary grass	None (shaded)	22	Moderate	69	Clay and rocks	Very turbid, erosion from bridge embankment
Waxdale Creek	Town of Mt. Pleasant	9	Airline Road	0.29	Weedy, ditched	None (shaded)	9	Moderate to slow	72	Muck over gravel	Very turbid and milky
Lamparek Ditch	Town of Mt. Pleasant	10	90th Street	1.56	Reed canary grass, hawthorn, ditched	Dense reed *canary grass*	6	Moderate	66	Muck over gravel	Very turbid
Sorenson Creek	Town of Mt. Pleasant	11	County Line Road (CTH KR)	1.56	Grazed pasture, grasses, and weeds	Water cress, Potamogeton spp., cat-tail, reed canary grass	10	moderate	70	Muck over gravel	Turbid
Pike Creek	Town of Somers	12	18th Street (CTH L)	3.34	Shrubs and grasses, ditched	None (shaded)	12	Moderate to fast	67	Muck and gravel	Very turbid
Pike Creek	Town of Somers	13	12th Street (CTH E)	2.13	Overhanging box elder	None (shaded)	20	Moderate to fast	67	Gravel	Turbid
Pike Creek	Town of Somers	14	Green Bay Avenue (STH 31)	0.05	Mesic forest	None (shaded)	32	Fast	66	Gravel	Very turbid
Somers Branch	Town of Somers	15	72nd Avenue (CTH EA)	1.11	Weedy	Emergents, cat-*tail, arrowhead,* reed canary grass, bulrush	8	Moderate	66	Bedrock	Very turbid

Source: SEWRPC.

Table 20

RESULTS OF FISH SURVEY IN THE PIKE RIVER WATERSHED: AUGUST 1980

Stream	Number of Stations	Population and Number of Species According to Relative Tolerance to Organic Pollution						Subtotal				Ratios of Very Tolerant, Tolerant, and Intolerant Populations
		Very Tolerant		Tolerant		Intolerant						
		Species	Population	Species	Population	Species	Population	Number of Species	Species Per Station	Population	Population Per Station	
Upper Pike River . . .	4	2	350	5	118	- -	- -	7	1.75	468	117	- -
Lower Pike River . . .	4	3	40	3	53	- -	- -	6	1.50	93	23	- -
Pike Creek	3	2	4	2	7	1	8	5	1.67	19	6	0.50:0.88:1.00
Waxdale Creek.	1	1	3	- -	- -	- -	- -	1	1.00	3	3	- -
Lamparek Ditch. . . .	1	1	44	1	16	- -	- -	2	2.00	60	60	- -
Sorenson Creek	1	1	15	4	20	1	3	6	6.00	38	38	5.00:6.67:1.00
Somers Branch Tributary	1	1	20	1	3	- -	- -	2	2.00	23	23	- -
Watershed Total	15	3	476	5	217	2	11	10	0.67	704	47	43.27:19.73:1.00

Source: SEWRPC.

The fish survey process proceeded in an upstream direction and the fish were netted after disrupting the bottom habitat and stream bank vegetation. All of the fish captured at each fish survey station were identified by species and counted. All of the captured fish are preserved as a part of the collection of the University of Wisconsin-Waukesha Center.

Inventory Findings: As indicated in Table 20 and Appendix B, a total of 704 fish representing 10 species were taken at the 15 stations during the fish survey which was carried out on August 20 through 27, 1980. The five most common species found in order of decreasing abundance were the fathead minnow, brook stickleback, bigmouth shiner, creek chub, and white sucker. Figure 12 indicates, in summary form, the fish species captured, the number of each species, and the approximate position of each species on a pollution tolerance scale for the 15 fish survey stations.

Of the total 704 fish, 476, or 68 percent, were classified as being very tolerant to pollution, 217, or 31 percent, were classified as being tolerant, and the remaining 11, or 1 percent, were considered intolerant. There were almost 65 times as many pollution tolerant and very tolerant fish taken in the survey as there were pollution intolerant fish.

A healthy fishery should contain a diversity of species similar to that found in the Pike River watershed in the 1906 and 1924 surveys. The converse presently exists in the Pike River watershed. Insofar as the fish population serves as an index of streamwater quality condition, the dominance of very tolerant and tolerant fish in the watershed stream system is a manifestation of the poor water quality conditions that generally exist in the watershed as documented in Chapter VII of this volume.

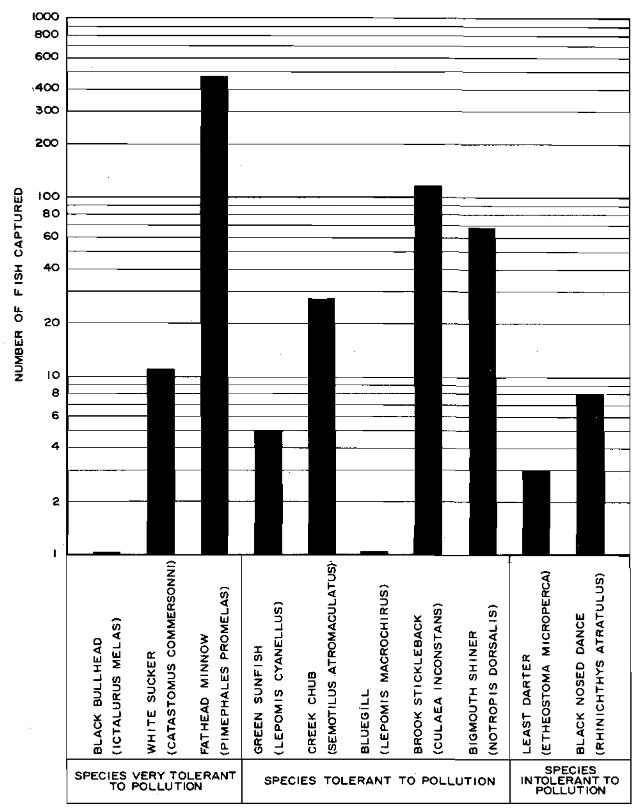
Of the 10 species of fish captured at the 15 instream stations, only the following three species are considered to be of any sport fishing value: black bullhead, green sunfish, and bluegill. Considering the watershed as a whole, fish of these three species amounted to only 1 percent of the total number of fish that were captured during the instream fish survey. This clearly indicates that the Pike River stream system—exclusive of the Lake Michigan estuary portion—presently supports no significant recreational fishery.

Although fish sampling stations were rather uniformly distributed over the watershed, the number of fish captured at the stations was not uniformly distributed. For example, of the 704 fish taken at the 15 instream stations, 435—or 63 percent—were collected at one station—Fish Survey Station Number 1 located at Washington Avenue and the Pike River. The relatively large number of fish captured at this station does not, however, mean that a desirable fishery exists in that portion of the watershed, since about 77 percent of the fish taken at this station were categorized as being very tolerant to pollution.

A reach-by-reach comparison of the number and type of fish captured during both present and past fish surveys indicates a striking spatial and temporal variation in fishery characteristics. The upper

Figure 12

RESULTS OF FISH SURVEY CONDUCTED IN THE PIKE RIVER WATERSHED: AUGUST 1980



Source: SEWRPC.

Pike River, which is defined as that portion of the main stem of the Pike River above its confluence with Pike Creek including Waxdale Creek and Lamparek Ditch, yielded between 435 fish at Fish Survey Station Number 1 to six fish at Fish Survey Station Number 2 along the main stem. Waxdale Creek and Lamparek Ditch yielded 3 to 60 fish, respectively. Examination of Figure 11 indicates that this section of the watershed lacks fish survey records prior to 1975. This lack of information prohibits a thorough analysis of the chronological changes that have occurred in a fish population. However, data are available to assess the recent status of this segment. Figure 11 indicates that this upper section of the Pike River watershed has been dominated by species of fish either tolerant or very tolerant to pollution. A single intolerant species, the southern redbelly dace, was reported in the 1975 survey near Braun Road. However, this fish species was not collected during August 1980. Because of the present habitat conditions, it is doubtful that a breeding population of smallmouth bass exists in the upper reaches of the Pike River watershed.

Waxdale Creek was found to contain only two species of fish, green sunfish and fathead minnow, which are classified as tolerant and very tolerant to pollution, respectively. The Lamparek Ditch contains a similar fishery in that it also contains only two species of fish, brook stickleback and fathead minnow which are classified as tolerant and very tolerant to pollution, respectively. However, a much larger fish population—60 fish—was found at the Lamparek Ditch station.

In general, the fish population of the upper portion of the Pike River watershed does not support the diversity of fish and numbers of intolerant species which are expected in the headwaters of typical southeastern Wisconsin streams. Most of the species collected during the 1975 and 1980 surveys were small forage fish. No large predator species were found. The population is obviously unbalanced in favor of the pollution-tolerant species indicating significant habitat alteration and poor water quality conditions. The drainage of wetlands, ditching of the stream channels, siltation, use of pesticides and fertilizers on agricultural lands, industrial waste spills, and organic pollution may all have contributed to the decline of the fish population in this portion of the Pike River watershed. There also exists the potential for toxic leachates from the Oakes Landfill site located in the east one-half of Section 23, Township 3 North, Range 22 East, in the Town of Mt. Pleasant, to enter the Pike River and further affect the fish populations in the event of failure of the leachate collection system of the landfill.

A similar conclusion regarding the deterioration of the upper reaches of the Pike River watershed was drawn from a survey of benthic organisms—organisms that inhabit the bottom sediments of surface waters such as tubifex worms, midges, dragonfly nymphs, and mayfly nymphs—conducted by the Wisconsin Department of Natural Resources in 1966. Using the species diversity and population of benthic organisms as indicators of water quality it was concluded that, at best, this portion of the Pike River watershed must be classified as severely polluted to septic.

Water quality data collected by the Commission in the lower reach of this portion of the Pike River watershed clearly indicate that low dissolved oxygen concentrations occurred frequently over the 10-year period between 1966 and 1976. Approximately 64 percent of the dissolved oxygen concentrations recorded during this period were below 5.0 milligrams per liter. Dissolved oxygen concentrations below 5.0 milligrams per liter cause intolerant fish species and benthic organisms to experience severe physiological stress, which causes the species to eventually be extirpated. There is little doubt that low dissolved oxygen concentrations have been a major factor in the loss of many of the more desirable fish species in this portion of the watershed.

The lower Pike River, which is defined as that portion of the main stem which encompasses all of the main stem of the Pike River downstream of Pike Creek and Sorenson Creek, yielded between 44 fish at Fish Survey Station Number 7 and 15 fish at Fish Survey Station Number 6, while the Sorenson Creek Fish Survey Station yielded 38 fish. Figure 11 indicates that historical records for this portion of the Pike River watershed date back to 1906. Since 1906, 26 species of fish were recorded as present in the lower reaches of the Pike River. In 1924, 15 species of fish were added to the 1906 list: three very tolerant species—carp, goldfish, fathead minnow; eight tolerant species—green sunfish, pumpkinseed, brook stickleback, golden shiner, largemouth bass, bigmouth shiner, gizzard shad, and alewife, and four intolerant species—coho and chinook salmon, rainbow trout, and redhorse. However, three intolerant species—hornyhead chub, stoneroller, and Johnny darter, one tolerant species—redfin shiner, and one very tolerant species—central mudminnow, have not been collected from this reach since 1924. The loss of these five species, particularly the three intolerant fish species, may be assumed to reflect an alteration of conditions which favor more tolerant fish species and which have caused an unnatural condition in the species balance. It should also be noted that some of the native species added to the original list may also have been present in 1906. However, no sampling sites were established in those portions of the lower reaches of the stream system where many of these additional species were collected later.

The presence of the three salmonids in the lower reach of the Pike River is due to the migratory nature of these lake dwelling species, which causes them to move into the river during the spawning season. Spawning, however, is unsuccessful because of the poor water quality conditions in the upper reaches of the watershed, such as excessive water temperatures and lack of suitable spawning habitat. In order for salmon to reproduce successfully, spawning streams must contain gravel bottom riffle zones which receive groundwater discharges. The discharge of ground water through the gravel substrate suspends the salmon eggs keeping them well oxygenated and removing metabolic wastes and silt from the habitat. In the fall coho and chinook salmon form a sport fishery in the lower reaches of the Pike River, while in spring the fishery include rainbow trout and white suckers. Young largemouth bass have been collected in the lower reaches of the Pike River but do not contribute significantly to the fishery as no adults have been reported. Netting of white sucker has been particularly successful between CTH E and the Kenosha Country Club, and salmon movement has been reported as far upstream as the impoundment located in Petrifying Springs County Park. The intolerant salmonids are apparently able to survive in the river temporarily during the fall when water levels and dissolved oxygen concentrations are relatively high. However, complaints from property owners concerning illegal trespass has prompted the Wisconsin Department of Natural Resources to establish a temporary weir under the first bridge upstream from the mouth of the river—the Sheridan Road bridge—to prevent the larger salmon from moving beyond that point. Fish snagging has been permitted below the weir between October 1 and January 31 of each year.

As noted above, two major fish kills occurred in 1979. These two fish kills may account, in part, for the large difference in the number of species collected in this reach between 1975 and 1980. Specifically, in 1975, 17 fish species were collected at CTH A, while in 1980 only five species were collected at Lathrop Avenue, both stations being located immediately downstream from the Kenosha Country Club. A good indication of the expected natural fish population within this reach of the Pike River is given by the 1924 survey taken at CTH G, when 11 species were collected: five intolerant, four tolerant, and two very tolerant. In 1980, the same site was found to contain only one tolerant and one very tolerant fish species, a significant change in the condition of the fish population.

It would appear that the natural immigration of fish back into this reach of the Pike River has barely begun and in fact, the stream may never return to its 1924, or for that matter, 1975 diversity, because of a lack of sufficient diversity of fish species in either the upstream or downstream reaches. While migrant species from Lake Michigan may reach this area, most are transient and spend only a small portion of the year in the river. In addition, the presence of a spillway near the Kenosha Country Club and a dam at the Petrifying Springs County Park inhibits the migration of fish, particularly the smaller forage species that are typical of the Pike River. The larger and stronger species such as salmon and white sucker may be able to negotiate the spillway and possibly even the dam. However, these two species comprise only a small component of the compliment of fish needed to return the stream to its former diversity.

Sorenson Creek enters the main stem of the Pike River downstream from the Kenosha Country Club and may serve as a potential source of some species of fish. The fish surveys conducted in 1975 and 1980 indicate a moderate diversity of fish life in Sorenson Creek. The presence of an intolerant fish species—least darter; four tolerant fish species—green sunfish, creek chub, brook stickleback, and bigmouth shiner; and a very tolerant fish species—fathead minnow; implies that stream conditions are of a higher quality than those occurring in the main stem and that a good variety of fish may yet exist in Sorenson Creek. However, Sorenson Creek may be too small in size to function as a reservoir for the entire Pike River fishery. It is, however, important that every effort be used to maintain the good water quality and habitat conditions in Sorenson Creek in order to protect the existing fish population, particularly the least darter population. This small fish has been identified as a "watch list" species in Wisconsin because of its significant statewide decline.[11] It should be noted that the least darter was formerly found at several locations along the Pike River but is now apparently confined to Sorenson Creek.

The sampling of the Pike Creek portion of the Pike River watershed yielded 19 fish and that of Somers Branch 23 fish. It should be noted that all of the fish species captured in this portion of the Pike River watershed were classified as tolerant or very tolerant to pollution, with the exception of one intolerant fish species—the blacknose dace—which was captured at Fish Survey Station Number 13 located at CTH E and Pike Creek.

Fortunately, historic records for Pike Creek include a survey conducted in 1924 and this provides a basis for comparison with the more recent surveys. Figure 11 indicates that the July 1924 survey identified six intolerant fish species—southern redbelly dace, blacknose dace, Johnny darter, least darter, stoneroller, and northern hog sucker—while the fish survey conducted in 1980 found but a single intolerant fish species—blacknose dace. In addition to the six intolerant fish species, four tolerant—creek chub, brook stickleback, common shiner, and bluntnose minnow—and two very tolerant—white sucker and fathead minnow—fish species were collected during the July 1924 survey for a total of 12 species at the single survey station, located at CTH E and Pike Creek. The 1975 and 1980 surveys identified one intolerant—blacknose dace, five tolerant—creek chub, green sunfish, bluegill, largemouth bass, and bigmouth shiner, and four very tolerant—white sucker, fathead minnow, black bullhead, and carp—fish species for a total of 10 fish species for the entire Pike Creek. The known diversity, then, has been reduced by two species of fish since 1924. However, it should be noted that this comparison involves three survey locations along the Pike Creek in 1975 and 1980, and a single survey location in 1924. It is likely that additional collection sites during the July 1924 survey would have recovered additional species. In addition, the number of very tolerant species has increased by two. Clearly, the shift in the fishery has been from a near natural fish population in 1924, with a significant proportion of fish—six species—in the intolerant category, to a population dominated by very tolerant species in 1975 and 1980. During the approximately 50-year interval between the 1924 and 1975 surveys significant habitat alterations have occurred in Pike Creek. It is also apparent that a significant change has occurred in the fishery during the five-year period between 1975 and 1980 as six fish species failed to be recaptured at the two sites located at CTH L and STH 31. In the 1980 fish survey no fish were collected after two extensive attempts approximately one week apart on Pike

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[11] *The Wisconsin Department of Natural Resources has assigned a watch status to those plants and animals which have a suspected, but not proven, problem with their abundance or distribution within the State. The purpose of this informal, nonlegal category is to focus attention on certain plants and animals before they become threatened or endangered.*

Creek near its confluence with the Pike River. The cause of this condition is unknown as the habitat conditions appear to be quite good. The best fishery within Pike Creek appears to exist in the vicinity of CTH E upstream from the confluence with the Somers Branch Tributary. This fish survey site supports a good population of the intolerant blacknose dace.

In general, Pike Creek lacks the compliment of intolerant species normally occurring in natural waters. While Pike Creek was found to possess a variety of forage fish and a single predator species—young largemouth bass—in 1975, it is not known whether this represents fish migration from other areas or a true local breeding population. Most of these species were not encountered during the 1980 survey. The loss of the intolerant fish species in Pike Creek as well as the low diversity of other fish species is probably due to a combination of factors including ditching, loss of wetland spawning areas, turbidity, siltation, use of pesticides and fertilizers in the tributary drainage areas, and organic enrichment from a sewage treatment plant located on the Somers Branch.

It should be further noted that the presence of a landfill site near Pike Creek and CTH L was reported by the Wisconsin Department of Natural Resources in 1957 and inspection of the stream bottom at that time noted the presence of refuse along the stream bottom as well as a polluted odor in the water. The possibility does exist that toxic leachates from this landfill site have entered and may be continuing to enter the stream and affect the fish populations in this reach. This landfill site is presently used as a solid waste transfer site by the Town of Somers.

During the 1980 survey, a local resident indicated that a canning company spilled a toxic chemical into the stream approximately a decade ago. This resident reported that the fish population was killed off and has never recovered since that event.

The findings of the benthic organism survey conducted by the Wisconsin Department of Natural Resources in 1966, correspond with the findings of the recent fish surveys. The benthic organisms survey reflects a decline from clean water to septic water quality conditions in the 2.1 mile reach of Pike Creek between CTH E and STH 31. Although this survey was conducted approximately 14 years ago, the results support the poor water quality conditions of Pike Creek in the 1975 and 1980 fish surveys.

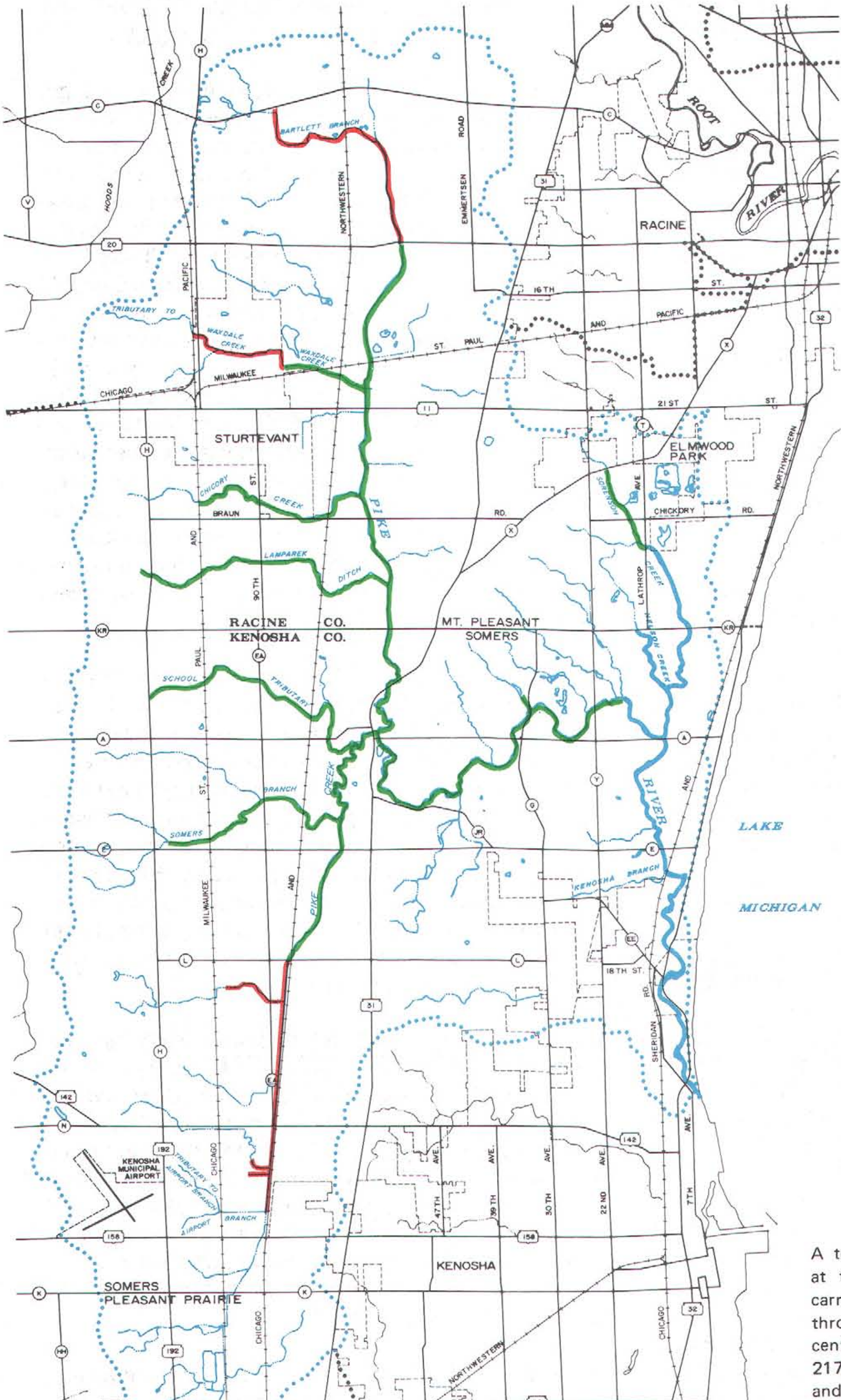
Water quality data collected by the Commission for Pike Creek demonstrate that low dissolved oxygen concentrations have occurred occasionally during the 10-year period from 1966 to 1976. Approximately 7 percent of the dissolved oxygen concentrations recorded during the 1966 to 1976 period were below 5.0 milligrams per liter. These occasional low dissolved oxygen concentrations may account for the lower diversity of fish life evident in Pike Creek. However, other water quality problems, such as toxic substances, are probably more significant contributors to the decline in the Pike Creek fishery.

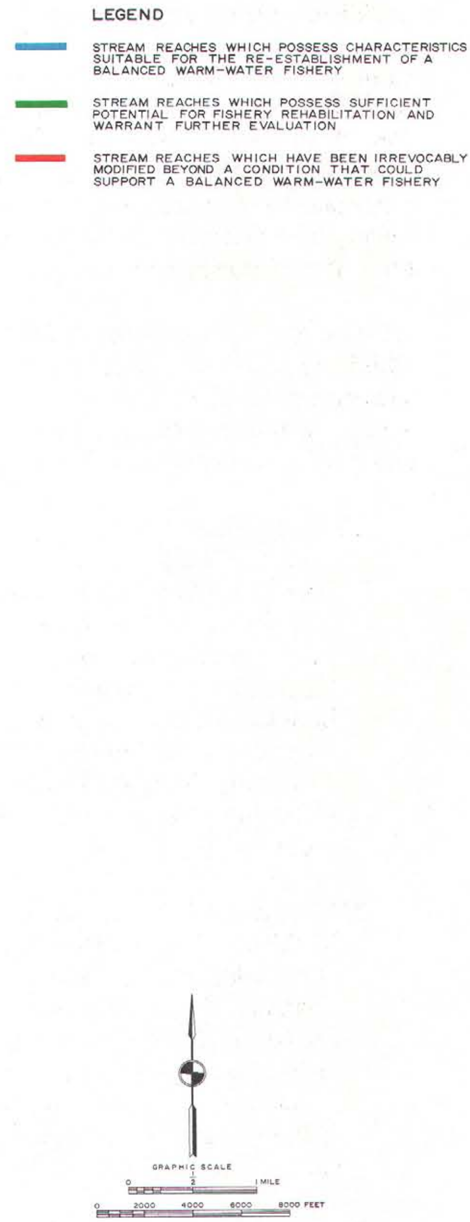
Concluding Remarks: For purposes of evaluating the general biological condition of the Pike River and its tributaries, a fishery survey was conducted as a part of the Pike River watershed study together with a review of historical fisheries data. Ten species distributed among 704 individuals were collected in the survey at 15 stations located throughout the Pike River watershed. Survey results indicated that 693 fish, or 99 percent of the fishery, consisted of tolerant and very tolerant species, indicating the generally degraded conditions of the water quality itself and of the fishery habitat of the approximately 40.7 miles of the perennial streams in the watershed. Based on the survey results, it was concluded that, as shown on Map 19, 6.8 miles, or 17 percent of the total stream system, have been irrevocably modified beyond a condition that could support a balanced warm-water fishery. It was further concluded that about 8.2 miles, or about 20 percent of the total stream system, still possessed the basic characteristics which would permit a balanced warm-water fishery, and that these reaches should be protected by proper land and water management. Finally, it was concluded that the remaining 25.7 miles, or about 63 percent of the total stream system, were found to possess sufficient potential for fishery rehabilitation to warrant further evaluation in the alternative plan development process. Of special note is that reach of the Pike Creek near its confluence with the Pike River in which good fishery habitat conditions were found but in which the fishery survey found a complete absence of the species normally present under such conditions. This absence could not be explained except on the basis of the possible presence of toxic substances.

Wildlife Habitat: Since the settlement of the Pike River watershed by Europeans, there has been a sharp decrease in the variety and quantity of

Map 19

EXISTING FISHERY CONDITIONS IN THE PIKE RIVER WATERSHED: 1980





Source: SEWRPC.

A total of 704 fish representing 10 species were taken at the 15 stations during the fish survey which was carried out by Commission personnel on August 20 through 27, 1980. Of the total 704 fish, 476, or 68 percent, were classified as being very tolerant to pollution, 217, or 31 percent, were classified as being tolerant, and the remaining 11, or 1 percent, were considered intolerant. There were almost 70 times as many pollution tolerant and very tolerant fish taken in the survey as there were pollution intolerant fish. Of the 10 species of fish captured at the 15 instream stations, only three species are considered to be of any sport fishing value.

wildlife. This is a loss not only to hunters and other sportsmen, but to the health and diversity of the total environment. Wildlife habitat areas were initially inventoried for the Commission by the Wisconsin Department of Natural Resources, Bureau of Research, personnel in 1963, and this initial inventory was updated in 1970. In addition to providing a qualitative and quantitative description of the existing wildlife resources of the watershed, this inventory was intended to provide a basis for identifying those wildlife habitat areas that should, under the land use element of both the regional land use plan and the Pike River watershed plan, be preserved and protected. The findings of the wildlife inventory are summarized below.

A total of 1,363 acres of wildlife habitat was identified within the watershed and value rated as shown on Map 20. Based on current condition, each wildlife habitat area was categorized into one of the following three value rating categories:

1. High-Value Wildlife Habitat Areas—High-value wildlife habitat areas contain a good diversity of wildlife, are of adequate size to meet all of the habitat requirements for the species concerned, and are generally located in proximity to other wildlife habitat areas. Campbell's or Fink's Hardwoods in the Town of Mt. Pleasant and the Truesdale Marsh located in the Town of Pleasant Prairie are examples of high-value wildlife habitat areas.

2. Medium-Value Wildlife Habitat Areas—Medium-value wildlife habitat areas generally lack one of the three aforementioned criteria for a high-value wildlife habitat. However, they do still retain a good plant and animal diversity. The Sander's Park State Scientific Area located in the Town of Mt. Pleasant is an example of a medium-value habitat area.

3. Low-Value Wildlife Habitat Areas—Low-value wildlife habitat areas are remnant in nature in that they generally lack two or more of the three aforementioned criteria for a high-value wildlife habitat, but may, nevertheless, be important if located in close proximity to other medium- and/or high-value wildlife habitat areas, if they provide corridors linking higher value wildlife habitat areas, or if they provide the only available range in the area. The riverine area along the Pike Creek near its confluence with the Pike River is typical of a low-value wildlife habitat area.

The factors considered in assigning value ratings to wildlife habitat areas were: diversity of animal and plant species, territorial requirements of the species, vegetative composition and structure, proximity to other wildlife habitat areas, and disturbance. In addition to the value rating categorization, the wildlife habitats in the Pike River watershed were classified according to the principal wildlife type to which the habitats were suited. The wildlife types include deer, pheasant, waterfowl, muskrat-mink, songbird, squirrel or mixed habitat. These designations were applied to help characterize a particular wildlife habitat area as meeting the particular requirements of the indicated species. This classification does not, however, imply that the named species is the only or even the most numerous or most important species in that particular habitat. For example, an area designated as a deer habitat may also provide squirrel and songbird habitat as well.

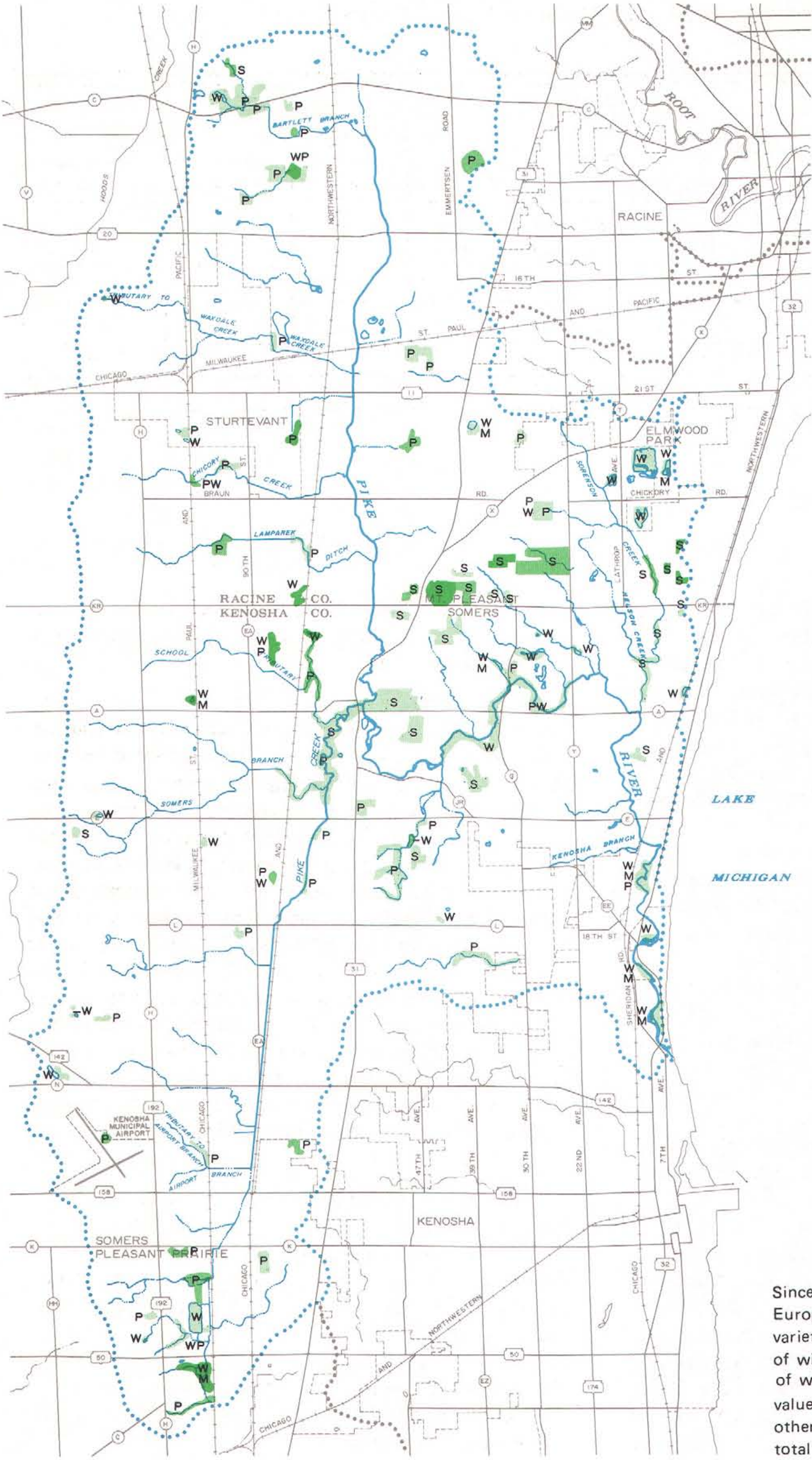
Table 21 indicates that 997 acres, or about 73 percent, of the wildlife habitat areas remaining in the Pike River watershed are in the low-value category. A total of 18 medium-value wildlife habitat areas, encompassing a total area of 236 acres, remain in the watershed located predominantly in the headwater portions of the Pike Creek and along the Racine/Kenosha County line. Twelve high-value wildlife habitat areas, encompassing a total area of 130 acres, remain in the Pike River watershed, of which nine are located within one mile of the Racine/Kenosha County line.

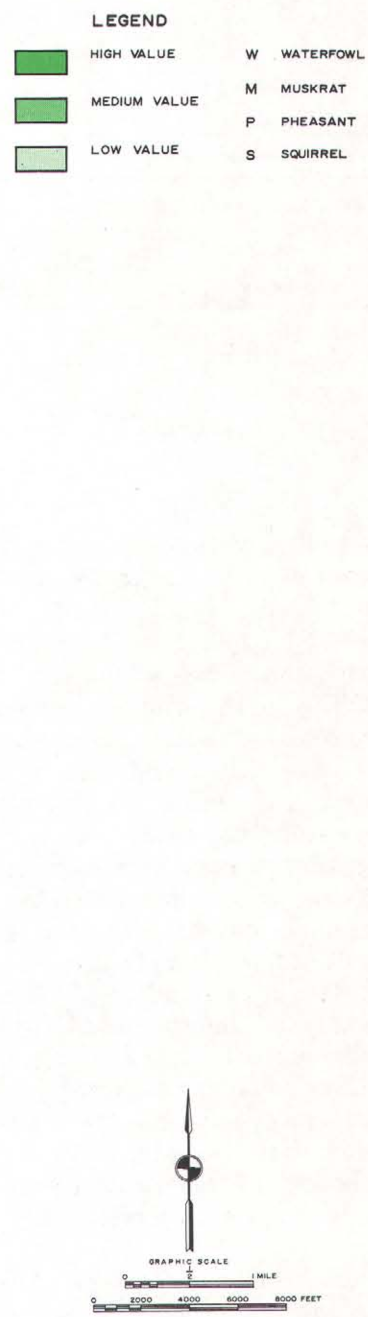
Game and Nongame Wildlife Species: The foregoing section described the quantity and quality of the remaining wildlife habitat in the Pike River watershed. The following section explicitly describes the remaining wildlife of the watershed. The wildlife population of the watershed consists of fish, amphibians, reptiles, birds and mammals. Each of these classes of the animal kingdom as represented in the watershed is described below, with the exception of the fish, which were described in a foregoing section of this chapter.

Although a field inventory of amphibians, reptiles, birds, and mammals was not conducted as a part of the Pike River watershed study, it is possible by using existing information such as the records of the Milwaukee County Public Museum and

Map 20

WILDLIFE HABITAT IN THE PIKE RIVER WATERSHED: 1980





Since the settlement of the Pike River watershed by Europeans, there has been a sharp decrease in the variety and quantity of wildlife. A total of 1,363 acres of wildlife habitat were identified within the watershed, of which 997 acres, or about 73 percent, are in the low-value category. This is a loss not only to hunters and other sportsmen, but to the health and diversity of the total environment.

Source: SEWRPC.

Table 21

WILDLIFE HABITAT AREAS IN THE PIKE RIVER WATERSHED: 1975

Township/ County	Wildlife Habitat (acres)						Township/ County Total
	High Value (acres)	Percent of Total	Medium Value (acres)	Percent of Total	Low Value (acres)	Percent of Total	
Pleasant Prairie	87	67	153	65	232	23	472
Somers	18	14	39	16	709	71	766
Kenosha County	105	81	192	81	941	94	1,238
Mt. Pleasant	25	19	44	19	56	6	125
Racine County	25	19	44	19	56	6	125
Watershed Total	130	100	236	100	997	100	1,363

Source: SEWRPC.

by polling naturalists and wildlife managers familiar with the watershed to complete a list of amphibians, reptiles, birds, and mammals which should be found in the watershed under existing conditions. The technique used in collating the wildlife data involved obtaining lists of those amphibians, reptiles, birds, and mammals known to have existed and known to exist in the two counties in which the Pike River watershed lies; associating these lists with the historic and remaining habitat areas, as inventoried; and then projecting the appropriate amphibian, reptile, bird, and mammal species into the watershed. The net result of the application of this technique is a better understanding of which species were once present in the watershed, which species are normally present under existing conditions, and which species could be expected to be lost as urbanization proceeds within the watershed. It should be noted that this procedure does not result in the inclusion of transient species which would be found in the watershed only on rare occasions.

Amphibians and Reptiles: Although often unseen and unheard, amphibians and reptiles are vital components of the ecologic system of an environmental unit like the Pike River watershed. Examples of amphibians native to the watershed include frogs, toads, and salamanders. Turtles and snakes are examples of reptiles common to the Pike River watershed. Table 22 presents a summary of the 14 amphibian and 16 reptile species normally present in the Pike River watershed under present conditions and identifies those species most sensitive to urbanization.

Most amphibians and reptiles have definite habitat requirements which are adversely affected by certain agricultural land management practices as well as by advancing urban development. One of the major detriments to the maintenance of amphibians in a changing environment is the destruction of breeding ponds. Frogs and salamanders often return to the same breeding site year after year, even if the pond is not there, in which case they cannot breed. When an area is being filled and developed some ponds must be selectively saved if amphibians are to be maintained. Toads are somewhat of an exception in this respect in that they can better adapt to the changes in environment which normally accompanies urbanization than can other species of amphibians.

Another major consideration in the preservation of both amphibians and reptiles is the maintenance of migration routes. Many species annually transverse distances of a mile or more from wintering sites to breeding sites to summer foraging grounds. The same pathways are used each year, and if species are to be maintained in the watershed, these pathways must be preserved. Protection of the environmental corridors of the watershed can assist materially in this respect.

Table 22

AMPHIBIANS AND REPTILES IN THE PIKE RIVER WATERSHED: 1980[a]

Scientific (family) and Common Name	Species Reduced or Dispersed with Full Watershed Urbanization	Species Lost With Full Watershed Urbanization
Amphibians		
Necturidae		
Mudpuppy	X	--
Ambystomatidae		
Blue-spotted salamander	--	X
Spotted salamander[a]	--	X
Eastern tiger salamander	X	--
Salamandridae		
Central Newt	X	--
Bufonidae		
American toad	X	--
Hylidae		
Blanchard's cricket frog	X	--
Northern spring peeper	--	X
Eastern gray treefrog	--	X
Western chorus frog	X	--
Ranidae		
Bull frog	--	X
Green frog	X	--
Wood frog	--	X
Northern leopard frog	--	X
Reptiles		
Chelydridae		
Common snapping turtle	X	--
Kinosternidae		
Musk turtle (stinkpot)	X	--
Emydidae		
True map turtle	--	X
Midland painted turtle	X	--
Blanding's turtle[a]	--	X
Colubridae		
Northern water snake	X	--
Northern brown snake	X	--
Red-bellied snake	X	--
Eastern garter snake	X	--
Chicago garter snake	X	--
Prairie (Plains) garter snake	X	--
Butler's garter snake	X	--
Eastern hognose snake	--	X
Eastern smooth green snake	--	X
Western fox snake	--	X
Eastern milk snake	--	X

NOTE: The technique used in collating the amphibian and reptile species involved the association of known county records with the historic and remaining habitat areas in the watershed.

[a]Identified as threatened in Wisconsin.

Source: SEWRPC.

Certain amphibians and reptiles are particularly susceptible to changes in food sources brought about by urbanization. The Western fox snake and Eastern milk snake, for example, are very likely to be lost over time to the watershed because of the reduction of rodents, their potential prey.

Birds: A large number of birds, ranging in size from large game birds to small song birds, are found in the Pike River watershed. Table 23 lists those birds that normally occur in the watershed. Each bird is classified as to whether it breeds within the watershed, only visits the watershed during the annual migration periods, or only visits the watershed on rare occasions.

Game birds which are found in the watershed include the pheasant, Hungarian (gray) partridge, woodcock, jacksnipe, rails, dabbling ducks, diving ducks, coots, and geese. Pheasant and Hungarian partridge are upland game birds and provide some opportunities for hunting. Although the watershed lies within the Mississippi flyway, opportunities for waterfowl hunting are now limited because of habitat deterioration and urbanization. The fall pheasant population within the watershed is irregularly distributed but fair populations live in the larger existing habitats. In areas actively hunted adjacent to the watershed, harvests may reach 20 or more cocks per square mile. Wintering flocks may reach 50 to 100 birds. Flocks of that size require good cover interspersed with fields containing waste grain such as corn from farming operations. Supplemental feeding of such flocks will greatly aid in their survival during severe winters.

There is a significant population of waterfowl in the watershed especially the mallards and teals. Larger numbers move through during migration when most of the regional species may be present except those requiring large lakes such as loons and scoters. Other species of water-based birds within the watershed include herons, sandpipers, gulls, plovers, and terns. Most of the waterfowl, shore birds, and wading birds may be expected to occur in and adjacent to the Pike River estuary.

Because of the mixture of lowland and upland woodlots, meadows, prairie, and agricultural lands still present in the watershed, along with the favorable summer climate, the watershed supports many other species of birds. Hawks and owls function as major rodent predators within the ecosystem. Swallows, whip-poor-wills, woodpeckers, nuthatches, and flycatchers, as well as several other species, serve as major insect predators. In addition to their ecological roles, birds such as robins, redwing blackbirds, orioles, cardinals, kingfishers, and mourning doves serve as subjects for bird watchers and photographers.

Table 23

BIRDS IN THE PIKE RIVER WATERSHED

Scientific (family) and Common Name	Birds			
	Migrant	Breeder	Forager	Rare
Gaviidae				
Common Loon	X	--	--	X
Podicipedidae				
Horned Grebe	X	--	--	--
Pied-Billed Grebe	--	X	--	--
Phalaerocoracidae				
Double-Crested Cormorant	X	--	--	X
Ardeidae				
Great Blue Heron	--	--	X	--
Great Egret	--	--	--	X
Green Heron	--	--	X	X
Black-Crowned Night Heron	--	--	--	X
American Bittern	--	--	X	--
Least Bittern	--	--	X	--
Anatidae				
Whistling Swan	X	--	--	X
Canada Goose	X	--	--	--
Mallard	--	X	--	--
Black Duck	--	X	--	--
Gadwall	X	--	--	--
Pintail	--	X	--	--
Green-Winged Teal	--	--	X	--
Blue-Winged Teal	--	X	--	--
American Wigeon	X	--	--	--
Northern Shoveler	--	--	X	--
Wood Duck	--	--	X	--
Redhead	X	--	--	--
Ring-Necked Duck	X	--	--	--
Canvasback	X	--	--	--
Lesser Scaup	X	--	--	--
Common Goldeneye	X	--	--	--
Bufflehead	X	--	--	--
Ruddy Duck	X	--	--	--
Hooded Merganser	X	--	--	--
Red-Breasted Merganser	X	--	--	--
Cathartidae				
Turkey Vulture	--	--	X	--
Accipitridae				
Sharp-Shinned Hawk	X	--	--	--
Cooper's Hawk	--	--	--	X
Red-Tailed Hawk	--	X	--	--
Red-Shouldered Hawk	--	--	X	X
Broad-Winged Hawk	X	--	--	--
Rough-Legged Hawk	X	--	--	--
Bald Eagle	X	--	--	X
Marsh Hawk	--	--	X	--
Pandionidae				
Osprey	X	--	--	X
Falconidae				
American Kestrel	--	X	--	--

Table 23 (continued)

Birds				
Scientific (family) and Common Name	Migrant	Breeder	Forager	Rare
Phasianidae				
Ring-Necked Pheasant (Introduced)	--	X	--	--
Gray Partridge (Introduced)	--	X	--	--
Rallidae				
Virginia Rail	--	X	--	--
Sora	--	X	--	--
Common Gallinule	--	X	--	--
American Coot	--	X	--	--
Charadriidae				
Semipalmated Plover	X	--	--	--
Killdeer	--	X	--	--
American Golden Plover	X	--	--	--
Piping Plover	X	--	--	X
Black-Bellied Plover	X	--	--	--
Ruddy Turnstone	X	--	--	--
Scolopacidae				
Woodcock	--	X	--	--
Common Snipe	X	--	--	--
Upland Sandpiper	--	--	X	--
Spotted Sandpiper	--	X	--	--
Greater Yellowlegs	X	--	--	--
Lesser Yellowlegs	X	--	--	--
Pectoral Sandpiper	X	--	--	--
White-Rumped Sandpiper	X	--	--	--
Least Sandpiper	X	--	--	--
Dunlin	X	--	--	--
Short-Billed Dowitcher	--	--	--	X
Long-Billed Dowitcher	--	--	--	X
Semipalmated Sandpiper	X	--	--	--
Sanderling	X	--	--	--
Laridae				
Herring Gull	--	--	X	--
Ring-Billed Gull	X	--	--	--
Bonaparte's Gull	X	--	--	--
Common Tern	X	--	--	X
Black Tern	--	--	X	X
Columbidae				
Mourning Dove	--	X	--	--
Rock Dove (Introduced)	--	X	--	--
Cuculidae				
Yellow-Billed Cuckoo	--	X	--	--
Black-Billed Cuckoo	--	X	--	--
Strigidae				
Screech Owl	--	X	--	--
Great-Horned Owl	--	X	--	--
Snowy Owl	X	--	--	X
Barred Owl	--	X	--	--
Short-Eared Owl	X	--	--	--
Saw-Whet Owl	--	--	--	X
Caprimulgidae				
Whip-Poor-Will	--	X	--	--
Common Nighthawk	--	X	--	--
Apodidae				
Chimney Swift	--	X	--	--
Trochilidae				
Ruby-Throated Hummingbird	--	X	--	--
Alcedinidae				
Belted Kingfisher	--	X	--	--

Table 23 (continued)

Scientific (family) and Common Name	Birds: Migrant	Breeder	Forager	Rare
Picidae				
Common Flicker	--	X	--	--
Pileated Woodpecker	X	--	--	--
Red-Bellied Woodpecker	--	X	--	--
Red-Headed Woodpecker	--	X	--	--
Yellow-Bellied Sapsucker	--	X	--	--
Hairy Woodpecker	--	X	--	--
Downy Woodpecker	--	X	--	--
Tyrannidae				
Eastern Kingbird	--	X	--	--
Great Crested Flycatcher	--	X	--	--
Eastern Phoebe	--	X	--	--
Yellow-Bellied Flycatcher	--	--	--	X
Arcadian Flycatcher	--	X	--	--
Alder Flycatcher	--	X	--	--
Willow Flycatcher	--	X	--	--
Least Flycatcher	--	X	--	--
Eastern Wood Pewee	--	X	--	--
Alaudidae				
Horned Lark	--	X	--	--
Hirundinidae				
Tree Swallow	--	X	--	--
Bank Swallow	--	X	--	--
Rough-Winged Swallow	--	X	--	--
Barn Swallow	--	X	--	--
Cliff Swallow	--	--	--	X
Purple Martin	--	X	--	--
Corvidae				
Blue Jay	--	X	--	--
Common Crow	--	X	--	--
Paridae				
Black-Capped Chikadee	--	X	--	--
Tufted Titmouse	--	X	--	--
Sittidae				
White-Breasted Nuthatch	--	X	--	--
Red-Breasted Nuthatch	X	--	--	--
Certhiidae				
Brown Creeper	X	--	--	--
Troglodytidae				
House Wren	--	X	--	--
Winter Wren	X	--	--	--
Long-Billed Marsh Wren	--	X	--	--
Short-Billed Marsh Wren	--	X	--	--
Mimidae				
Gray Catbird	--	X	--	--
Brown Thrasher	--	X	--	--
Turdidae				
American Robin	--	X	--	--
Wood Thrush	--	X	--	--
Hermit Thrush	X	--	--	--
Swainson's Thrush	X	--	--	--
Veery	--	X	--	--
Eastern Bluebird	--	X	--	--
Sylviidae				
Blue-Gray Gnatcatcher	--	--	--	X
Golden-Crowned Kinglet	X	--	--	--
Ruby-Crowned Kinglet	X	--	--	--

Table 23 (continued)

	Birds			
Scientific (family) and Common Name	Migrant	Breeder	Forager	Rare
Motacillidae				
Water Pipit	X	--	--	--
Bombycillidae				
Cedar Waxwing	--	X	--	--
Laniidae				
Northern Shrike	X	--	--	--
Loggerhead Shrike	X	--	--	X
Sturnidae				
Starling (Introduced)	--	X	--	--
Vireonidae				
Yellow-Throated Vireo	--	X	--	--
Red-Eyed Vireo	--	X	--	--
Warbling Vireo	--	X	--	--
Parulidae				
Black-and-White Warbler	--	X	--	--
Golden-Winged Warbler	--	X	--	--
Blue-Winged Warbler.	--	X	--	--
Tennessee Warbler	X	--	--	--
Orange-Crowned Warbler	X	--	--	--
Nashville Warbler.	--	X	--	--
Northern Parula Warbler	X	--	--	--
Yellow Warbler.	--	X	--	--
Magnolia Warbler.	X	--	--	--
Cape May Warbler	X	--	--	--
Yellow-Rumped Warbler	X	--	--	--
Black-Throated Green Warbler	X	--	--	--
Chestnut-Sided Warbler	--	X	--	--
Bay-Breasted Warbler	X	--	--	--
Blackpoll Warbler	X	--	--	--
Pine Warbler	X	--	--	--
Palm Warbler	X	--	--	--
Ovenbird	--	X	--	--
Northern Waterthrush	--	X	--	--
Mourning Warbler	--	X	--	--
Common Yellowthroat	--	X	--	--
Wilson's Warbler	X	--	--	--
American Redstart.	--	X	--	--
Ploceidae				
House Sparrow (Introduced)	--	X	--	--
Icteridae				
Bobolink	--	X	--	--
Eastern Meadowlark	--	X	--	--
Western Meadowlark.	--	X	--	--
Yellow-Headed Blackbird	--	--	X	--
Red-Winged Blackbird.	--	X	--	--
Northern Oriole	--	X	--	--
Rusty Blackbird	X	--	--	--
Brewer's Blackbird.	X	--	--	--
Common Grackle	--	X	--	--
Brown-Headed Cowbird.	--	X	--	--
Thraupidae				
Scarlet Tanager.	--	X	--	--
Fringillidae				
Cardinal	--	X	--	--
Rose-Breasted Grosbeak.	--	X	--	--
Indigo Bunting	--	X	--	--
Dickcissel	--	X	--	--
Evening Grosbeak	X	--	--	--
Purple Finch	X	--	--	--

Table 23 (continued)

Birds				
Scientific (family) and Common Name	Migrant	Breeder	Forager	Rare
Fringillidae (continued)				
Pine Grosbeak	X	--	--	--
Common Redpoll	X	--	--	--
Pine Siskin	X	--	--	--
American Goldfinch	--	X	--	--
Red Crossbill	X	--	--	--
White-Winged Crossbill	X	--	--	--
Rufous-Sided Towhee	--	X	--	--
Savannah Sparrow	--	X	--	--
Grasshopper Sparrow	--	X	--	--
Sharp-Tailed Sparrow	--	--	--	X
Vesper Sparrow	--	X	--	--
Dark-Eyed Junco	X	--	--	--
Tree Sparrow	X	--	--	--
Chipping Sparrow	X	--	--	--
Field Sparrow	--	X	--	--
White-Crowned Sparrow	X	--	--	--
White-Throated Sparrow	X	--	--	--
Fox Sparrow	X	--	--	--
Lincoln's Sparrow	X	--	--	--
Swamp Sparrow	--	X	--	--
Song Sparrow	--	X	--	--
Lapland Longspur	X	--	--	--
Snow Bunting	X	--	--	--

Source: SEWRPC.

Not all birds are viewed as an asset from an ecological, economic, or social point of view. With the advance of urbanization and, therefore, the loss of natural habitat, conditions have become less compatible for the more desirable bird species. English sparrows, starlings, grackles, and pigeons have replaced the more desirable birds in certain areas of the watershed because of their great tolerance for urban conditions. The redwing blackbird particularly is beginning to feel the urban impact as wetland areas, particularly cat-tail marshes, are drained or filled.

Mammals: A variety of mammals, ranging in size from large animals like the Northern white-tailed deer to small animals like the pygmy shrew, is found in the Pike River watershed. Table 24 lists 40 mammals whose range is known to extend into the watershed.

The larger mammals still fairly common in the less densely populated areas of the watershed include white-tailed deer, cottontail rabbit, gray squirrel, fox squirrel, muskrat, mink, weasel, raccoon, red fox, skunk, and opossum. The first four are often considered game mammals, while the balance are classified as fur-bearing mammals.

White-tailed deer are generally restricted to the larger wooded areas of the watershed near the Kenosha/Racine County line. The open meadows and croplands adjacent to the woodlots, as well as the shrub swamps, are also utilized by deer. While human population and associated activities create a stress condition for deer population, it is estimated that there may be 50 or more deer at times within the watershed. Because of the urban and urbanizing nature of the Pike River watershed, there is little potential for an increase in the size of the deer herd. Human and deer populations living in proximity are incompatible. When deer wander or are forced into residential, commercial, or industrial areas, they typically exhibit extreme panic, running wildly and presenting a threat to people, property, and themselves. Foraging deer sometimes cause damage to gardens, or ornamental trees, croplands, and orchards. Deer and automobile collisions often occur on the fringes of urban areas and are another example of the stress conditions that exist when deer inhabit urban fringe areas.

The cottontail rabbit is abundant throughout the watershed even in urbanized areas. Rabbit hunting is possible in some areas, while many people enjoy

Table 24

MAMMALS IN THE PIKE RIVER WATERSHED

Scientific (family) and Common Name	
Didelphidae	Castoridae
Virginia opossum	Michigan beaver
Soricidae	Cricetidae
Cinereous shrew	Prairie deer mouse
Smoky shrew	Northern white-footed mouse
American Pigmy shrew	Meadow vole
Short-tailed shrew	Prairie vole
Vespertilionidae	Common muskrat
Little brown bat	Muridae
Eastern long-eared bat	Norway rat (introduced)
Silver-haired bat	House mouse (introduced)
Big brown bat	Zapodidae
Red bat	Meadow jumping mouse
Hoary bat	Canidae
Georgian bat	Northeastern coyote
Leporidae	Eastern red fox
Mearn's cottontail	Gray fox
Sciuridae	Procyonidae
Southern woodchuck	Upper Mississippi Valley raccoon
Striped ground squirrel (gopher)	Mustelidae
Franklin's ground squirrel	Allegheny least weasel
Ohio chipmunk	New York long-tailed weasel
Minnesota grey squirrel	Upper Mississippi Valley mink
Western fox squirrel	Jackson's badger
Red squirrel	Northern plains skunk
Southern flying squirrel	Cervidae
	Northern white-tailed deer

Source: SEWRPC.

observing activities of this mammal. There is also an abundance of grey squirrels and fox squirrels in the watershed. The grey squirrel is found primarily in woodlots and wooded residential sections, while the fox squirrel is found in some of the more open woods and countryside. Both require trees of some maturity because natural cavities in such trees are needed both for the rearing of young and for winter protection.

Although there are no data available on the actual number of furbearing mammals in the watershed, muskrat and mink populations are believed to be relatively low due to the limited extent of the remaining wetlands. Next to the cottontail rabbit the muskrat is probably the most abundant and widely distributed furbearing mammal in and near the watershed and may bring an economic return to some trappers. Muskrats may be attracted to any significant water area in the watershed including wetlands, small ponds, creeks, and drainage ditches, all of which may provide suitable habitat. The familiar muskrat house contributes a certain amount of interest to the landscape and is often used by other wildlife. Waterfowl may make use of the houses for nesting, and mink and raccoon occasionally use muskrat houses as denning areas. Preservation and improvement of muskrat habitat would, therefore, benefit waterfowl, mink, and the raccoon. In areas near the Pike River watershed trapping still provides an income supplement to part-time trappers in that a 40-acre marsh can provide a yield of over 100 muskrats a year.

The raccoon is associated with the woodland areas of the watershed. Much of the raccoon's food, however, is water-based so it makes considerable transient use of wetland areas. Scavenging raccoons can become pests in wooded environments that contain urban fringe development.

The red fox is more characteristic of mixed habitat and farmland areas. Most people are tolerant of the fox due to its aesthetic appeal while others less well-informed consider it a threat to other wildlife.

Skunks and opossums are common watershed furbearers. Both of these mammals inhabit woodland areas bordering farmlands and urban fringe development and venture into wetlands in search of food. Skunks and opossums tend to become inactive in cold weather although neither is a true hibernator.

Small mammals fairly common in the watershed include the short-tailed shrew, striped ground squirrel or gopher, meadow vole, white-footed mouse, and little brown bat. These small mammals, with the exception of bats, are commonly associated with meadows, fence rows, and utility and transportation rights-of-way. They vary in their importance from insect predators and food sources for larger mammals and raptors—hawks and owls—to pests in croplands, gardens, and lawns.

Bats, despite their appearance and nocturnal habits, generally have a positive impact on the urban environment in that they are major insect predators, often consuming one-third their weight in insects a night. With the destruction of woodland and wetland habitats through urban development, the more adaptable species of these flying mammals may relocate within the areas of urban development.

Overview: As a result of urban and agricultural activity and the associated decrease in woodlands, wetlands, prairies, and other natural areas, wildlife habitat in the Pike River watershed has been seriously depleted. The habitat that remains generally consists of land parcels that have not to date been considered suitable for cultivation or urban development. Much of the remaining habitat has been modified or has been deteriorated and some of these remaining habitat areas are being increasingly stressed by approaching or encircling urban development.

As a consequence of the decrease in wildlife habitat, the wildlife population within the watershed has decreased. The fish, amphibian, reptile, bird, and mammal species once abundant to the watershed have diminished in type and quantity wherever intensive urbanization and agricultural land uses have occurred. Certain wildlife species, such as some songbirds, have the capacity to exist in small islands of undeveloped land within the urban and agricultural land complex or to adapt to this type of landscape, but this characteristic is not generally shared by most wildlife.

The most important consideration in maintaining, and even increasing, the existing remnants of wildlife within the watershed lies in achieving the required amount, type and pattern of habitat and, therefore, in providing a land use pattern within the watershed that preserves the remaining good wildlife habitat. It is also necessary to constantly remember that all wildlife species are dependent on each other in one way or another. This means that the loss of habitat for one species has an adverse effect on certain other species, even though the required habitat for these other species may remain.

Potential Values: Although little remains of the natural wildlife habitat that once existed within the watershed and, consequently, little remains of the wildlife that once inhabited those areas, that which does remain has the potential to significantly contribute to the quality of life in the watershed. If selected wildlife habitat areas are protected and properly managed, or if new wildlife habitat areas are created, sufficient wildlife can be maintained within the watershed to provide substantial aesthetic, ecological, educational and research, and recreation value.

Observation Value: Wildlife habitat areas, with their usual variety and richness of vegetal types, have an inherent aesthetic value in the watershed. These aesthetic values are heightened if the wildlife habitats are in relatively close proximity to urban development and can, therefore, provide a welcome and restful visual contrast to the urban scene. The aesthetic impact of wildlife habitat is enhanced by the observation of the various forms of wildlife—fish, amphibians, reptiles, birds, and mammals—that may inhabit those areas. Some forms of wildlife, such as birds, are readily seen and heard by even the most casual observers, whereas the viewing of other forms may require more careful examination and study.

Through thoughtful planning and management, some of the aesthetic benefits of wildlife and their habitat can be made an integral part of the watershed as illustrated by the Petrifying Springs and Sanders county parks, as well as the Alford and Pennoyer city parks. Opportunities for similar aesthetic experiences could be provided in the portions of the watershed adjacent to the Kenosha-Racine County line, along the lower reaches of Pike Creek, and the stream reaches along the Pike River between Petrifying Springs County Park and CTH Y. These portions of the watershed contain a variety of low-, medium-, and high-value wildlife habitat areas, most of which are in private ownership, but could be protected through an appropriate combination of zoning and public acquisition to form an interconnected network of linear wildlife habitat areas.

Ecological Function: As already noted, all wildlife species within the ecosystem of the watershed and its environments are interdependent. This means that the loss of one species—through destruction of its particular ecological niche—has an adverse effect on certain other wildlife species even though the ecological niche of those species may remain intact. From a narrow human perspective, a quality environment might be one in which certain "desirable" wildlife species such as songbirds exist but which is devoid of "troublesome" members of the animal community such as insect pests. However, it is generally not possible to have the benefit of the most "desirable" elements of the wildlife community without also accepting the less desirable elements.

The ecological importance of the woodlands and wetlands of the watershed and the wildlife residing in such areas was noted earlier in this chapter and will not be discussed further here. These woodland and wetland areas, however, constitute the biologically most productive areas of the watershed, and are important to the maintenance of diversity in watershed biota because of their ecological control function. Open space linkages must, however, be preserved between the best wildlife habitat areas, and the environmental corridor concept is particularly important in this respect. If adequately protected and properly managed, the remaining wildlife habitat in the watershed has the potential to provide the minimum elements needed to maintain a relatively heathy ecologic system.

Education and Research Function: Wildlife in the context of their natural habitat are valued by educators, naturalists, and researchers as objects of observation and study. The potential education and research function of wildlife and their habitats is very similar to the education and research value of woodland and wetland areas which were discussed earlier in this chapter. The remaining wildlife and wildlife habitat of the Pike River watershed have the potential to meet the educational needs of watershed residents if selected sites throughout the basin are protected by public or private acquisition for that purpose.

Recreation Related Values: The presence of wildlife contributes to the enjoyment of certain outdoor recreational activities. There is opportunity for the development of a limited recreational fishery in some of the watershed stream system provided that the adopted water use objectives and supporting standards are achieved. Bird watching and photography may be readily enjoyed by residents of the urban and urbanizing Pike River watershed provided that sufficient habitat is preserved. Opportunities for hunting are limited in the watershed because of the small size of the remaining habitat areas and, equally important, because of their close proximity to urban areas. Hunting for rabbit and other small game is presently possible in the western portion of the basin, but even these hunting opportunities may be expected to diminish with the advance of urban development in the watershed.

Park, Outdoor Recreation, and Related Open Space Sites

Existing Sites: An inventory of the existing parks, outdoor recreation areas, and related open space sites was conducted within the Region and the watershed during 1973, under the regional park, outdoor recreation, and related open space planning program of the Commission. This inventory indicated a total of 35 existing park, outdoor recreation, and related open space sites within the watershed, totaling 1,918 acres (3.0 square miles), or about 6 percent of the total area of the watershed.[12] The distribution of these sites by ownership is shown in Table 25. The spatial distribution of existing parks, outdoor recreation areas, and related open spaces is shown on Map 21, while Figure 13 illustrates the relative size of such areas to the watershed as a whole and also facilitates a comparison of public and private holdings.

Of the total 35 sites, and 1,918 acres of existing park, outdoor recreation, and related open space in the watershed, public ownership accounts for 23 sites covering 1,418 acres, or 74 percent of the total acreage. Nonpublic ownership accounts for the remaining 12 sites encompassing 500 acres, or 26 percent of the total acreage. Of the 1,418 acres of park, outdoor recreation, and related open space sites in public ownership, 747 acres, or about 53 percent, are owned by the State of Wisconsin, in the area belonging to the University of Wisconsin-Parkside. County-owned land amounts to 433 acres, or about 31 percent of these public lands, with 353 acres of the county total comprising Petrifying Springs Park.

[12] *The 3.00 square miles of "existing park, outdoor recreation, and related open space sites" in the watershed as inventoried in 1973 under the Commission's regional park, outdoor recreation, and related open space planning program is 1.81 square miles, or 152 percent, greater than the 1.19 square miles of "park and recreation" land inventoried in 1975 under the Commission's continuing land use-transportation study. This difference is primarily attributed to an ownership-based definition of park, recreation, and open space used in the former inventory, contrasted with a land use-oriented definition of park and recreation in the latter inventory. For example, a parking lot owned by a county and contained within a county park was considered part of a park, recreation, and open space site in the 1973 park and recreation study inventory, but was not so included in the 1975 land use inventory because the primary use was parking as opposed to recreation.*

Table 25

EXISTING PARK, OUTDOOR RECREATION, AND RELATED OPEN SPACE SITES IN THE PIKE RIVER WATERSHED: 1973

Ownership	Number of		Percent of Public		Percent of Nonpublic		Percent of Total	
	Sites	Acres	Sites	Acres	Sites	Acres	Sites	Acres
Public								
State	1	747	4.3	52.7	--	--	2.9	38.9
County	2	433	8.7	30.5	--	--	5.7	22.6
City-Village.	6	93	26.1	6.6	--	--	17.1	4.9
Town	3	14	13.1	1.0	--	--	8.6	0.7
School District.	11	131	47.8	9.2	--	--	31.4	6.8
Subtotal	23	1,418	100.0	100.0	--	--	65.7	73.9
Nonpublic								
Organizational	1	159	--	--	8.3	31.8	2.9	8.3
Commercial	7	137	--	--	58.4	27.4	20.0	7.2
Private (restricted). . .	4	204	--	--	33.3	40.8	11.4	10.6
Subtotal	12	500	--	--	100.0	100.0	34.3	26.1
Total	35	1,918	--	--	--	--	100.0	100.0

Source: SEWRPC.

The nonpublic recreation sites, consisting of private, organizational, and commercially operated recreational lands, account for about 34 percent of the number of sites in the watershed and 26 percent of the acreage. About 23 percent of the nonpublic acreage, or 363 acres, is owned by organizations such as parochial schools and private clubs. The remaining 137 acres are operated on a profitmaking commercial basis.

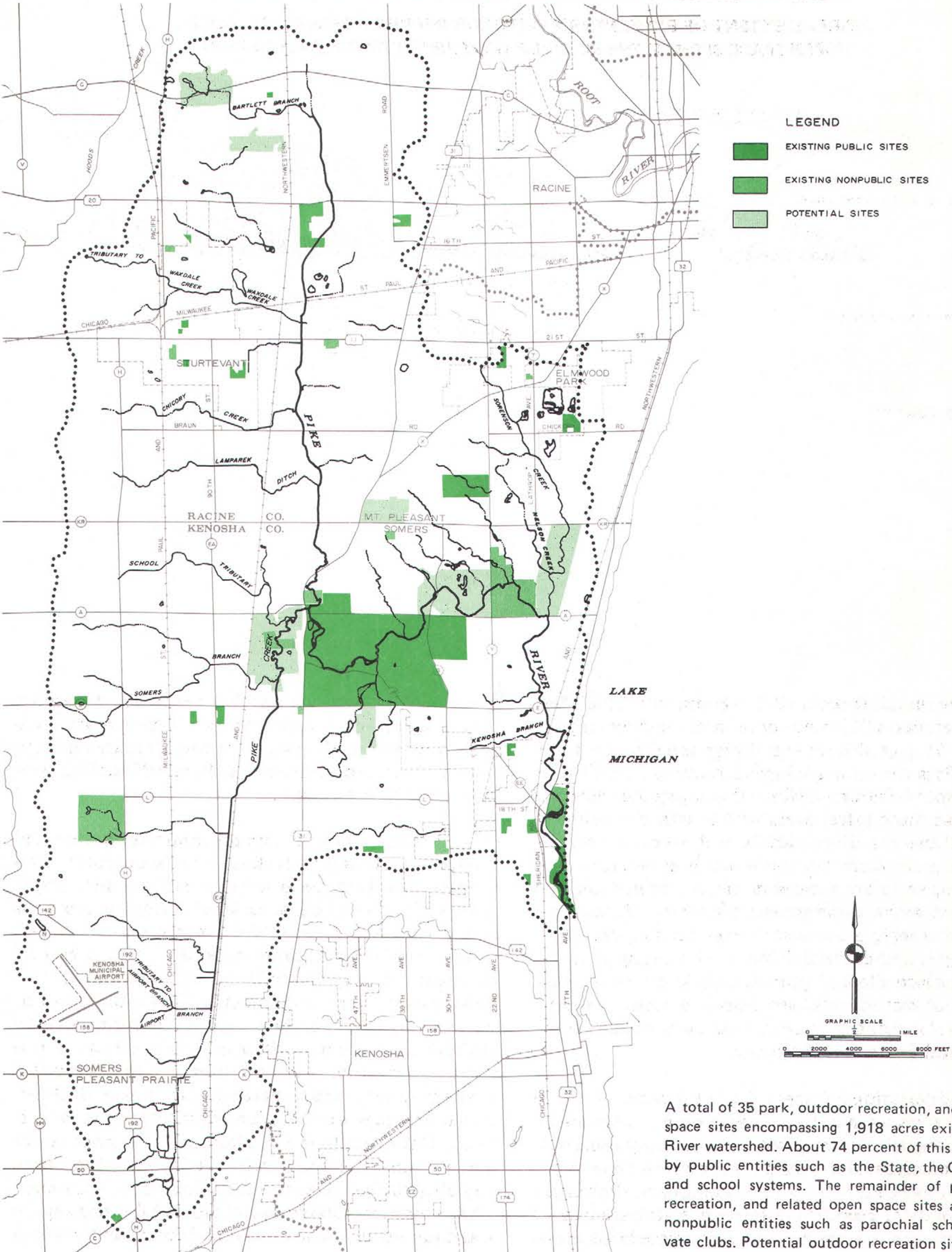
Potential Sites: According to an inventory of potential outdoor recreation and related open space sites which was also conducted within the Region during 1974 under the Commission's regional park, outdoor recreation, and related open space planning program, eight potential recreation and related open space sites exist in the Pike River watershed, as shown on Map 21. Four of these sites, covering 243 acres, are located in the Town of Mt. Pleasant in Racine County. The remaining four sites, covering 610 acres, are located in the Town of Somers in Kenosha County.

Environmental Corridors

One of the most important tasks completed under the regional planning effort has been the identification and delineation of those areas of the Region in which concentrations of recreational, aesthetic, ecological, and cultural resources occur and which, therefore, should be preserved and protected. Such areas normally include one or more of the following eight elements of the natural resource base which are essential to the maintenance of both the ecological balance and natural beauty of the Region: 1) lakes, rivers, and streams and their associated shorelands and floodlands;

Map 21

EXISTING AND POTENTIAL PARK, OUTDOOR RECREATION, AND RELATED OPEN SPACE SITES IN THE PIKE RIVER WATERSHED: 1973

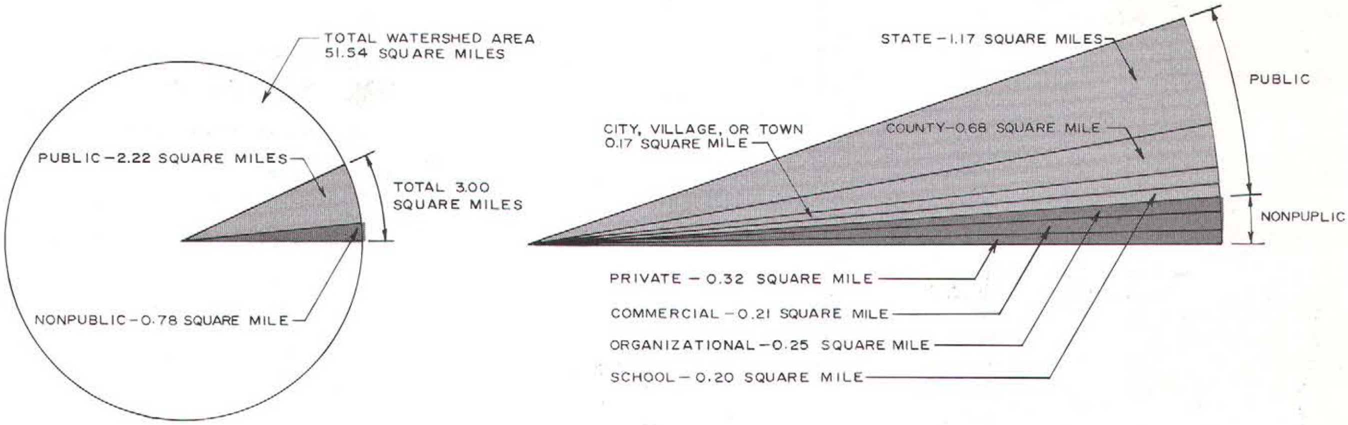


A total of 35 park, outdoor recreation, and related open space sites encompassing 1,918 acres exist in the Pike River watershed. About 74 percent of this land is owned by public entities such as the State, the County, cities, and school systems. The remainder of park, outdoor recreation, and related open space sites are owned by nonpublic entities such as parochial schools and private clubs. Potential outdoor recreation sites encompass about 853 acres.

Source: SEWRPC.

Figure 13

AREAL EXTENT OF EXISTING PARK, OUTDOOR RECREATION, AND RELATED OPEN SPACE SITES IN THE PIKE RIVER WATERSHED BY OWNERSHIP: 1973



Source: SEWRPC.

2) wetlands; 3) woodlands; 4) prairies; 5) wildlife habitat areas; 6) wet, poorly drained or organic soils; 7) rugged terrain and high relief topography; and 8) significant geological formations and physiographic features. While the foregoing elements comprise the integral parts of the natural resource base, there are five additional elements which, although not part of the natural resource base per se, are closely related to or centered on that base and are a determining factor in identifying and delineating areas with recreational, aesthetic, ecological, and cultural value: 1) existing park and open space sites; 2) potential park and open space sites; 3) historic, archaeological, and other cultural sites; 4) significant scenic areas and vistas; and 5) natural and scientific areas.

The delineation of these 13 natural resource and natural resource-related elements on a map results in an essentially linear pattern of relatively narrow, elongated areas which have been termed "environmental corridors" by the Commission. Primary environmental corridors include a wide variety of such important resource and resource-related elements and are at least 400 acres in size, two miles in length, and 200 feet in width. Secondary environmental corridors connect with primary environmental corridors, and are at least 100 acres in size and one mile in length.

In any discussion of environmental corridors and important natural features, it is important to point out that because of the many interacting relationships existing between living organisms and their environment, the destruction or deterioration of an important element of the total environment may lead to a chain reaction of deterioration and destruction. The drainage of wetlands, for example, may have far-reaching effects since such drainage may destroy fish spawning grounds, wildlife habitat, groundwater recharge areas, and natural filtration and floodwater storage areas of interconnecting stream systems. The resulting deterioration of surface water quality may, in turn, lead to a deterioration of the quality of the groundwater which serves as a source of domestic, municipal, and industrial water supply and upon which low flows of rivers and streams may depend. Similarly, the destruction of woodland cover may result in soil erosion, stream siltation, more rapid runoff, and increased flooding, as well as the loss of wildlife habitat. Although the effects of any one of these environmental changes may not in and of itself be overwhelming, the combined effects must eventually lead to serious deterioration of the underlying and supporting natural resource base and of the overall quality of the environment for life. The need to maintain the integrity of the remaining environmental corridors and important resource features within the Pike River watershed thus becomes apparent.

Primary Environmental Corridors: The primary environmental corridors in the Pike River watershed are located primarily along the main stem of the Pike River from the area within and adjacent to Petrifying Springs County Park located in the Town of Somers in Kenosha County to the mouth of the Pike River located in the City of Kenosha. These primary environmental corridors contain most of the remaining high-value woodlands, wetlands, and wildlife habitat areas in the watershed; are, in effect, a composite of the best individual elements of the natural resource base; and have truly immeasurable environmental and recreational value. The protection of the primary environmental corridors from intrusion by incompatible rural and urban uses, and thereby from degradation and destruction, should be one of the principal objectives of the watershed planning program. The primary environmental corridors should be considered inviolate; their preservation in an essentially open, natural state—including park and open space uses, limited agricultural uses, and country estate type residential uses—will serve to maintain a high level of environmental quality in the watershed, protect its natural beauty, and provide valuable recreation opportunities. As indicated on Map 22, about 1,189 acres, or 3 percent of the total watershed area, are encompassed within the primary environmental corridors.

Secondary Environmental Corridors: The secondary environmental corridors in the Pike River watershed are located along the main stem of the Pike River through the Town of Mt. Pleasant and upstream from the primary environmental corridors within and adjacent to Petrifying Springs County Park, along Pike Creek located in the Towns of Somers and Pleasant Prairie, also upstream from the primary environmental corridors within and adjacent to Petrifying Springs County Park, and along several intermittent streams tributary to the main stem of the Pike River located in the Towns of Mt. Pleasant and Somers. These secondary environmental corridors contain a variety of resource elements, often remnant resources from former primary environmental corridors which have been developed for intensive agricultural or urban purposes. Secondary environmental corridors facilitate surface water drainage, maintain "pockets" of natural resource features, and provide corridors for the movement of wildlife, as well as for the movement and dispersal of seeds for a variety of plant species. Such corridors are also important to the maintenance of environmental quality and should be preserved in an essentially open, natural state. As indicated on Map 22, about 596 acres, or 2 percent of the watershed, are encompassed within secondary environmental corridors.

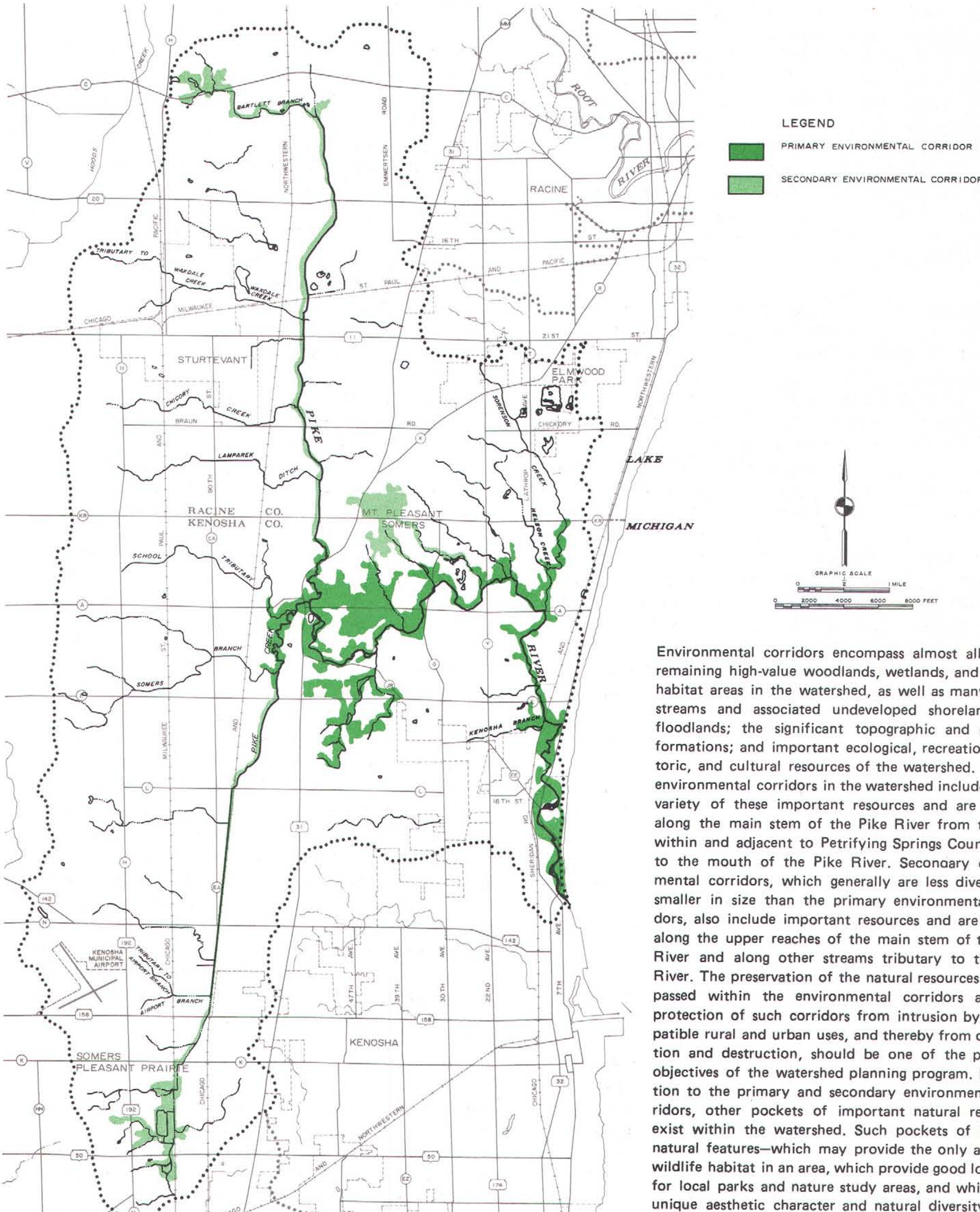
Isolated Natural Features: In addition to the primary and secondary environmental corridors, other smaller pockets of concentrations of natural resource base elements exist within the watershed area. These pockets are isolated from the environmental corridors by urban development or agricultural uses, and although separated from the environmental corridors network, such "isolated" natural features may have important natural values. Isolated natural features may provide the only available wildlife habitat in an area, provide good locations for local parks and nature study areas, and lend unique aesthetic character or natural diversity to an area. Important isolated natural features within the Pike River watershed include the Sanders County Park hardwoods—which have been designated as a state scientific area—and a variety of important isolated wetland and woodland areas located throughout the watershed. These isolated natural features should also be protected and preserved in their natural state whenever possible. Such isolated areas within the watershed are shown on Map 19, as those areas of woodlands and wetlands which do not correspond to primary or secondary environmental corridors. About 654 acres, or 2 percent of the watershed area, are encompassed within isolated natural areas that are five acres or greater in size.

SUMMARY

The Pike River watershed is a complex of natural and man-made features that interact to provide a changing environment for human life. Future changes in the watershed ecosystem and the favorable or unfavorable impact of those changes on the quality of life within the watershed will be largely

Map 22

ENVIRONMENTAL CORRIDORS IN THE PIKE RIVER WATERSHED: 1975



Source: SEWRPC.

Environmental corridors encompass almost all of the remaining high-value woodlands, wetlands, and wildlife habitat areas in the watershed, as well as many of the streams and associated undeveloped shorelands and floodlands; the significant topographic and geologic formations; and important ecological, recreational, historic, and cultural resources of the watershed. Primary environmental corridors in the watershed include a wide variety of these important resources and are located along the main stem of the Pike River from the area within and adjacent to Petrifying Springs County Park to the mouth of the Pike River. Seconoary environmental corridors, which generally are less diverse and smaller in size than the primary environmental corridors, also include important resources and are located along the upper reaches of the main stem of the Pike River and along other streams tributary to the Pike River. The preservation of the natural resources encompassed within the environmental corridors and the protection of such corridors from intrusion by incompatible rural and urban uses, and thereby from degradation and destruction, should be one of the principal objectives of the watershed planning program. In addition to the primary and secondary environmental corridors, other pockets of important natural resources exist within the watershed. Such pockets of isolated natural features—which may provide the only available wildlife habitat in an area, which provide good locations for local parks and nature study areas, and which lend unique aesthetic character and natural diversity to an area—should also be preserved and protected whenever possible.

determined by human actions. The Pike River watershed planning program seeks to rationally direct those actions so as to favorably affect the overall quality of life in the watershed. This chapter describes the natural resource base and man-made features of the watershed, thereby establishing a factual base upon which the watershed planning process may be built.

The man-made features of the watershed include its political boundaries, its land use pattern, its public utility network, and its transportation system. These features along with the resident population and the economic activities within the watershed may be thought of as the socioeconomic base of the watershed.

The 51.54-square-mile Pike River watershed comprises 2 percent of the Southeastern Wisconsin Planning Region and is the fifth smallest of the 11 distinct watersheds located wholly or partly within the Region. The watershed lies in two counties, three townships, two villages, and two cities.

The 1975 resident population of the watershed was estimated at about 29,000 persons, or about 2 percent of the total population of the Region. From 1950 to 1960, the Pike River watershed growth rate was slightly higher than that of Kenosha and Racine Counties and of the Region. However, from 1960 to 1970, the growth rate was significantly higher than that of Kenosha and Racine Counties and of the Region. Population densities within the watershed range from less than 350 persons per gross square mile in the still rural areas of the watershed to a maximum of 3,700 persons per gross square mile in the urbanized areas. Median age in the watershed is slightly less than that of the Region, whereas household size and household income are somewhat higher than that for the Region.

Total employment in the watershed in eight major industrial groups is estimated at 9,200. Of that total, 2,600 jobs, or 28 percent, are provided in the manufacturing sector. Of that sector total, 1,900 jobs, or 72 percent, are provided in the chemical, petroleum, rubber, and plastic products category.

Urbanization occurred first within the watershed in the vicinity of the Village of Sturtevant and by 1963 had occurred not only in the Sturtevant area but in scattered small areas throughout the watershed, constituting approximately 19 percent of the total area of the watershed. By 1975, approximately 28 percent of the total area of the watershed was in urban use. As of 1975, 37 square miles, or 72 percent of the watershed area, were in rural, as opposed to urban land use. The dominant land use in the watershed is still agriculture, which encompasses 32 square miles, or 63 percent of the total watershed area.

The watersheds' public utility base is composed of its sanitary sewerage, water supply, electric power, and gas service systems. Adequate supplies of both electric power and natural gas are available to all areas of the watershed. A total of eight sanitary sewerage systems or portions thereof serve about 19 percent of the total area of the watershed and approximately 85 percent of the total resident population of the watershed. Two sewage treatment plants serving a population of 5,100 persons, or 18 percent of the population of the watershed, and 21 percent of the sewered population of the watershed, discharge treated effluent to the surface waters of the watershed. The rest of the sewered area of the watershed drains to two large treatment plants located on Lake Michigan and a small treatment facility located outside the watershed in the Town of Pleasant Prairie. Four public water supply systems serve the urban areas of the Pike River watershed. The Kenosha Water Utility and Racine Water Department operate complete and independent water supply services, and provide wholesale service to the Town of Somers Sanitary District No. 1 and the Sturtevant Water and Sewer Utility, respectively. These four public water utilities all utilize Lake Michigan as a source of supply.

The watershed is well served by an extensive all-weather arterial street and highway system. Two types of bus service are available in the watershed: urban mass transit and intercity bus service, urban mass transit service being provided by the Cities of Kenosha and Racine. Railroad service in the watershed is limited to freight hauling, except for scheduled Amtrak passenger service over a line of the Milwaukee, St. Paul & Pacific Railroad Company (The Milwaukee Road) between Milwaukee and Chicago, with a stop in Sturtevant, and a commuter service from Kenosha to Chicago operated by the Chicago & North Western Transportation Company. Kenosha Municipal Airport, the only airport in the basin, provides general aviation service.

The natural resource base of the watershed is a composite of climate, physiography, geology, soils, water resources, and fish and wildlife resources. Inasmuch as the underlying and sustaining natural resource base is highly vulnerable to misuse and destruction, management of the remnants of that resource base must be a primary consideration in the Pike River watershed planning effort.

Because of its midcontinental location, far removed from the moderating effect of the oceans, the Pike River watershed has a climate characterized by a progression of markedly different seasons. An essentially continuous pattern of distinct weather changes occurring at about three day intervals is superimposed on the seasonal pattern. Air temperatures in the watershed range from a daily average of about 22°F in January to 72°F in July. Watershed temperature extremes have ranged from a low of about - 24°F to a high of approximately 103°F. The eastern portion of the watershed exhibits lakeshore temperature characteristics such as summer average daily maximum temperatures 1°F to 4°F lower than those experienced in the western portion of the basin which exhibits inland temperature characteristics.

Average annual precipitation within the watershed is 32.4 inches expressed as water equivalent, and average monthly amounts range from a low of 1.27 inches in February to a high of 3.89 inches in June. The average annual amount of snow and sleet expressed as snow and sleet is 46.3 inches which, when converted to its water equivalent, constitutes 14 percent of the total annual precipitation. About 90 percent of the annual snowfall occurs in the four months of December, January, February, and March. Annual total precipitation in the vicinity of the watershed has varied from a low of 17 inches to a high of 50 inches. Snowfall has, relative to the annual average, historically exhibited a wider variation than total precipitation, with the annual snowfall ranging from a low of five inches to a high of approximately 109 inches. As a result of its proximity to Lake Michigan, the eastern part of the watershed experiences an average of about 4.7 inches more seasonal snow and sleet accumulations than does the western part of the watershed.

With respect to snow cover, there is a 0.25 probability of having five or more inches of snow on the ground during January and the first half of February. A minimum of six or more inches of frozen ground normally exists in the watershed during January, February, and the first half of March. Annual potential evaporation in the watershed is about 29 inches and is approximately equal, both annually and seasonally, to precipitation. Prevailing winds follow a clockwise pattern in terms of prevailing direction over the seasons of the year, being northwesterly in the late fall and winter, northeasterly in the spring, and southwesterly in the summer and early fall.

Daylight in the watershed ranges from a minimum of 9.0 hours on about December 22nd to a maximum of 15.4 hours on about June 21st. The smallest amount of daytime sky cover occurs from July through October, when the mean monthly daytime sky cover is approximately 0.5, whereas a sky cover of about 0.7 may be expected from November through March.

Watershed topography and physiographic features have been largely determined by the underlying bedrock and overlying glacial deposits. The last of the four major stages of glaciation occurred about 11,000 years ago and was the most influential in sculpturing the watershed land surface. Watershed topography is asymmetrical, with the eastern border of the watershed being lower—about 80 to 170 feet—than the western edge of the basin. Surface elevations within the watershed range from a high of approximately 780 feet above National Geodetic Vertical Datum at the border of the watershed west of the Village of Sturtevant to a low of approximately 590 feet above National Geodetic Datum at the mouth of the Pike River, a maximum relief of 190 feet.

Surface drainage within the watershed is very diverse with respect to channel cross-sectional shape, channel slope, degree of stream sinuosity, and floodland shape and width. The heterogeneous character of the surface drainage system is due partly to the natural effect of glacial drift and partly to channel modifications and other results of urbanization in the basin.

The geology of the Pike River watershed is a complex system of various layers and ages of rock formations. These formations slope gently down toward the east, and consist of, in ascending order, predominantly Precambrian crystalline rocks—granite and quartzite; Cambrian through Silurian sedimentary rocks—sandstone, siltstone, dolomite, and shale; and unconsolidated surficial deposits—clay, silt, sand, gravel, and boulders.

Streams and associated floodlands comprise the most important elements of the natural resource base of the watershed, primarily because of the associated aesthetic, recreational, and economic values. There are 40.7 lineal miles of perennial streams within the watershed, and inasmuch as there are no major lakes of 50 acres or more in size in the watershed, these streams along with ponds and wetlands constitute the watershed's surface water resources.

Extensive groundwater resources underlie the Pike River watershed and are an integral part of the much larger groundwater system that lies beneath the Southeastern Wisconsin Planning Region. The aquifers lying beneath the watershed, which attain a combined thickness in excess of 1,500 feet, may be subdivided so as to identify three distinct groundwater sources. In order from the land surface downward they are the sand and gravel deposits in glacial drift, the shallow dolomite strata in the underlying bedrock, and the deeper bedrock strata composed of sandstone, dolomite, siltstone, and shale. The combined groundwater reservoirs are the source of water supply for the rural areas of the watershed while the gradual discharge from the groundwater reservoir supplies the baseflow to the Pike River and its tributaries.

Since the early settlement of the Pike River watershed there has been a sharp decrease in the variety and quantity of wildlife due to the decrease in woodlands, wetlands, and other natural areas. Woodlands and wetlands are both presently being lost at a rate of five acres per year due to activities such as agriculture and highway construction. Most of the remaining wildlife habitat areas are located in the headwater portions of the Pike Creek and along the Racine/Kenosha County line. The remaining fish and wildlife resources are particularly significant to the Pike River watershed because of the recreational, educational, and aesthetic value they impart.

There are 35 existing park, outdoor recreation, and related open space sites within the watershed, totaling 1,918 acres, or about 6 percent of the watershed area. Of this total, 23 sites encompassing 1,418 acres, or 74 percent of the total acreage, are in public ownership. A watershedwide inventory indicated the existence of only eight potential recreation and related open space sites, encompassing a total area of 853 acres.

The delineation of selected natural resource and natural resource-related elements in the watershed produces an essentially lineal pattern of narrow, elongated areas which have been termed environmental corridors by the Southeastern Wisconsin Regional Planning Commission. As of 1975, primary and secondary environmental corridors encompassing the best remaining elements of the natural resource base—including the surface waters, associated shorelands and floodlands, and the best remaining woodlands, wetlands, wildlife habitat areas, and existing and potential park sites—as well as isolated natural features occupied 2,439 acres, or 7 percent of the watershed area. The preservation of the remaining environmental corridors and isolated natural features in essentially natural, open uses is essential to maintaining a high level of environmental quality in the Pike River watershed.

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Chapter IV

ANTICIPATED GROWTH AND CHANGE IN THE WATERSHED

INTRODUCTION

In any planning effort, forecasts are required for all future events and conditions which are considered to lie outside the scope of the plans to be prepared, but which affect either the design of the plans or their implementation. Normally, the future demand for land and water resources in a planning area is determined primarily by the size and spatial distribution of future population and employment levels. Although the spatial distribution of future population and employment levels can be influenced by public land use regulation, control of changes in population and economic activity levels per se lies largely outside the scope of governmental activity—at least at the regional and local levels. In the preparation of a comprehensive watershed plan, therefore, future population and economic activity levels must be forecast. These forecasts can then be converted to future demand for land and water resources within the watershed, and a land and water use plan can be prepared to meet this demand. This land and water use plan can, in turn, provide a basis for the preparation of supporting water resource management facility plans.

It should be noted that the population and employment forecasts presented in this chapter have not been independently prepared for the current study, but rather are common to the forecasts used in the preparation of the Commission's regional land use and transportation plans, as well as to other functional elements of the comprehensive regional plan for southeastern Wisconsin—including the areawide water quality management plan. The use of this common body of data on anticipated change helps assure full coordination of all aspects of the Commission's long-range areawide planning activities. The forecasts and the techniques used to prepare those forecasts are fully described in Chapter III of SEWRPC Planning Report No. 25, A Regional Land Use Plan and a Regional Transportation Plan for Southeastern Wisconsin: 2000, Volume Two, Alternative and Recommended Plans, published in May 1978. The population data presented in this chapter were also based upon SEWRPC Technical Report No. 22, Recent Population Growth and Change in Southeastern Wisconsin, 1970-1977, which presents the findings of a reevaluation of the population forecasts contained in SEWRPC Planning Report No. 25.

While the design year 2000 population and employment levels and the corresponding 1985 stages for the Region and for Kenosha and Racine Counties as set forth in this chapter represent forecast levels, the design year 2000 and intermediate stage 1985 population and employment levels for the Pike River watershed represent levels expected to exist in the watershed if the forecast population and employment increases are spatially distributed in accordance with the adopted regional land use plan. Similarly, the year 2000 and year 1985 land use summaries presented represent planned changes in land use rather than forecasts of land use change. The procedures and methodology whereby forecast changes in population and employment are allocated to geographic units smaller than counties—thereby developing a measure of the changes in land use necessary to accommodate these population and employment changes—are reported in Chapter VII of Planning Report No. 25 cited above. The methodology is based upon both regional and local land use development objectives and standards and is consistent with federal policies which seek to centralize urban development and to protect environmentally significant areas and prime agricultural lands.

POPULATION GROWTH

The regional population forecast for the design year 2000 selected in 1974 by the Commission staff and Commission advisory committees anticipated that the resident population of the Region would reach a level of approximately 2.22 million persons by the year 2000 (see Table 26 and Figure 14). This would represent an increase of about 460,000 persons, or about 26 percent, over the 1970 level of about 1.76 million persons. This anticipated population increase—equivalent to about 15,300 persons per year from 1970 to 2000—is less than the actual rate of increase of 18,200 persons per year experienced in the Region from 1960 to 1970, and substantially less than the

Table 26

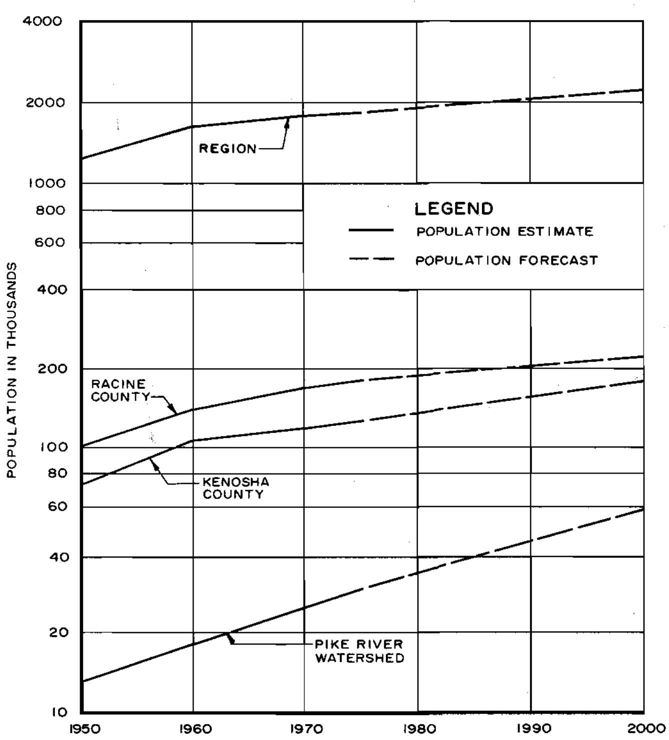
ANTICIPATED POPULATION CHANGE FOR THE REGION, KENOSHA COUNTY, RACINE COUNTY, AND THE PIKE RIVER WATERSHED: SELECTED YEARS 1970-2000

Year	Southeastern Wisconsin Region	Kenosha County	Racine County	Pike River Watershed	Watershed Population as Percentage of Regional Population
1970	1,756,083	117,917	170,838	24,224	1
1975	1,789,871	126,651	178,916	28,722	2
1985	1,954,100	149,800	195,500	39,100	2
2000	2,219,300	174,800	217,700	56,300	3
1970-2000 Percent Change	26.4	48.2	27.4	132.4	- -

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

Figure 14

POPULATION TRENDS AND FORECASTS FOR THE REGION, KENOSHA COUNTY, RACINE COUNTY, AND THE PIKE RIVER WATERSHED: 1950-2000



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

rate of 33,300 persons per year experienced from 1950 to 1960. The 1975 resident population of the Region is estimated to be 1,789,900 persons—about 33,800 persons, or about 2 percent, greater than in 1970. This was equivalent to an average annual increase of about 6,800 persons per year.

The county population forecasts to the design year 2000 developed for Kenosha and Racine Counties envisioned continued population increase in both of these counties. Kenosha County was forecast to increase from a resident population of 117,900 persons in 1970 to 174,800 persons in 2000—an increase of 56,900 persons, or about 48 percent. Racine County was forecast to increase from a resident population of 170,800 persons in 1970 to 217,700 persons in 2000—an increase of 46,900 persons, or about 27 percent. The 1975 resident populations of the two counties are estimated to be approximately 126,700 persons and 178,900 persons, respectively. This represented increases of about 8,800 persons—or about 7 percent—in Kenosha County and 8,100 persons—or about 5 percent—in Racine County.

The population of the Pike River watershed almost doubled between 1950 and 1970, increasing from a level of about 13,300 persons in 1950 to about 24,200 persons in 1970, an increase of about 82 percent. Based upon the anticipated regional population increase, and upon an allocation of that population to the Pike River watershed—an allocation based upon regional and local land use development objectives and standards—this rapid population growth may be expected to continue to the year 2000, with a forecast increase of 32,100 persons over the 1970 level to a level in the design year 2000 of about 56,300 persons. This would represent an increase of 132 percent. The 1975 resident population of the watershed is estimated at 28,700 persons—an increase of 4,500 persons, or 19 percent, over the 1970 resident population.

The 132 percent increase in population anticipated for the Pike River watershed between 1970 and 2000 substantially exceeds that anticipated for Kenosha and Racine Counties and for the Southeastern Wisconsin Region as a whole. A higher rate of growth for the Pike River watershed reflects an anticipated substantial increase in population in the areas of the Region peripheral to the Cities of Kenosha and Racine. As a result of higher growth rates, the Pike River watershed may be expected to increase in its proportion of the regional population from about 1 percent in 1970, to about 3 percent in 2000.

EMPLOYMENT GROWTH

Economic activity, considered primarily in terms of employment opportunities, is not linked functionally to watershed patterns within southeastern Wisconsin. Rather, the forces from which economic activity orginates and is sustained operate over the entire urbanizing Southeastern Wisconsin Region. Employment in the Pike River watershed is expected to increase substantially between 1970 and 2000, exceeding the growth rate forecast for the Region as a whole. Since the watershed was still predominantly rural in character in 1970, its higher anticipated rate of growth in employment reflects a continued decentralization of economic activity from the established urban areas of the Region to suburban and rural fringe area locations. As shown in Table 27, employment opportunities within the watershed may be expected to increase by about 204 percent, or by about 16,900 jobs, between 1970 and 2000, from about 8,300 jobs in 1970 to 25,200 jobs in 2000. This contrasts with the 37 percent increase in employment that is forecast for the Region over this same time period. By 1975, the employment in the watershed was estimated to be 9,200 jobs—an increase of 900 jobs, or 11 percent, above the 1970 level.[1]

Table 27

ANTICIPATED EMPLOYMENT FOR THE REGION AND THE PIKE RIVER WATERSHED SELECTED YEARS 1970-2000

Year	Southeastern Wisconsin Region	Pike River Watershed	Watershed Employment as Percentage of Regional Employment
1970	741,600	8,300	1
1975	779,000	9,200	1
1985	878,800	19,500	2
2000	1,015,900	25,200	2
1970-2000 Percent Change	37.0	203.6	- -

Source: Wisconsin Department of Industry, Labor and Human Relations, and SEWRPC.

LAND USE DEMAND

The anticipated population increase of 32,100 persons and the anticipated increase in employment of 16,900 jobs between 1970 and the design year 2000 in the Pike River watershed may be expected to require the continued conversion of land from rural to urban uses within the watershed. Between 1963 and 1970 approximately 2.2 square miles of land were converted from rural to urban uses, increasing the proportion of the total area of the watershed in urban land uses from 19 percent—

[1] *The regional employment forecasts and the methodology by which they were produced are discussed in SEWRPC Technical Report No. 10, The Economy of Southeastern Wisconsin, 1972, and in Chapter III of SEWRPC Planning Report No. 25, A Regional Land Use Plan and a Regional Transportation Plan for Southeastern Wisconsin: 2000, Volume Two, Alternative and Recommended Plans, 1978. The methodology by which anticipated future employment levels are determined for subregional areas such as watersheds is discussed in Chapter VII of Planning Report No. 25, Volume Two.*

equivalent to about 9.6 square miles—in 1963 to 23 percent—equivalent to about 11.8 square miles—in 1970. The adopted regional land use plan calls for the conversion of an additional 5.9 square miles of land from rural to urban land uses between 1970 and 2000—an increase of about 50 percent in urban land use over the plan period. By the plan design year 2000 approximately 17.7 square miles—about 34 percent of the approximately 52 square mile watershed—would be in urban land uses. By 1975 it is estimated that approximately 14.2 square miles—about 28 percent of the watershed area—was in urban land uses, indicating that about 2.4 square miles of the total planned change of 5.9 square miles had already occurred between 1970 and 1975.

SUMMARY

The resident population of the Pike River watershed is expected to increase from a 1970 level of about 24,200 persons to a design year 2000 level of about 56,300 persons—an increase of 32,100 persons, or about 132 percent. Between 1970 and 2000 employment within the watershed may be expected to increase by about 16,900 jobs, or about 204 percent, from approximately 8,300 jobs in 1970 to 25,200 jobs in the year 2000.

The substantial increase in population and employment anticipated for the Pike River watershed by the design year 2000 is a function of the anticipated urban development that will occur in the watershed in the immediate proximity of the existing Kenosha and Racine urbanized areas, both of which are anticipated to grow over the period of the forecasts. This anticipated growth in both population and employment will require the conversion of 5.9 square miles of land from rural to urban uses within the watershed between 1970 and the design year 2000. This will represent an increase of approximately 50 percent over the 11.8 square miles of urban land uses that existed in the watershed in 1970.

Chapter V

HYDROLOGY AND HYDRAULICS

INTRODUCTION

Hydrology may be defined as the study of the physical behavior of the water resource from its occurrence as precipitation to its entry into streams and lakes or its return to the atmosphere via evapotranspiration. In accordance with this definition, an inventory and analysis of the hydrology of a watershed may include consideration of precipitation, evapotranspiration, and other elements of the hydrologic budget; examination of such factors as soil types and land use that affect rainfall-runoff relationships; review of stream gaging records to ascertain the volume and timing of that portion of the precipitation that ultimately reaches the surface water system of the watershed as runoff; and determination of the volume of water that moves to and from and is contained within the aquifers lying beneath the watershed.

Hydraulics may be defined as the study of those factors that affect the physical behavior of water as it flows within stream channels and associated natural floodlands; under and over bridges, culverts and dams; through lakes and other impoundments; and within the aquifer system of the watershed. In accordance with this definition, an inventory and analysis of the hydraulics of a watershed may include examination of the length, slope, flow resistance, and other characteristics of both natural and modified stream reaches within the watershed; determination of the hydraulic significance of the numerous and varied hydraulic structures—bridges, culverts, dams, channelized sections—located throughout the stream system; and determination of the flow characteristics of the aquifers underlying the watershed.

Comprehensive planning for the wise use and development of the land and water resources of the Pike River watershed requires knowledge and understanding of the relationships existing among the many natural and man-made features that together comprise the hydrologic-hydraulic system of the watershed. The objective of this chapter is to present a description of the hydrologic-hydraulic system of the Pike River watershed, with emphasis upon the behavioral characteristics of that system pertinent to comprehensive watershed planning. An understanding of this system is important to the watershed planning process inasmuch as the system and its behavior form the framework within which all the water resource and water resource-related problems of the watershed must be analyzed and resolved. Because of the close interdependence between the various elements of the hydrologic and hydraulic system of a watershed, any planned modification to, or development of, one of these elements must consider the potential effects on the other elements. Only by considering the hydrologic-hydraulic system as a whole can a sound, comprehensive watershed plan be prepared and the water-related problems of the basin ultimately abated.

Digital computer simulation was used in the Pike River watershed study to accomplish the necessary integrated analysis of the hydrologic-hydraulic system of the watershed. The primary purpose of inventorying and analyzing the hydrologic and hydraulic data and information as presented in this chapter was to provide the data required by the hydrologic-hydraulic simulation model.

HYDROLOGY OF THE WATERSHED

The Hydrologic Cycle

The quantity and quality of water at a particular location within the Pike River watershed may vary greatly from time to time. These variations may occur rapidly or slowly and may occur in the atmosphere, on the land, in the surface waters, or in the groundwater of the watershed. Moreover, these variations may involve water in all its states—solid, liquid, and vapor. This continuous, unsteady pattern of circulation of the water resource from the atmosphere to and under the land surface and, by various processes, back to the atmosphere is known as the hydrologic cycle.

Precipitation is the primary source of all water in the Pike River watershed. Part of the precipitation runs directly off the land surface into stream channels and is ultimately discharged from the watershed; part is temporarily retained in snow packs, ponds, and depressions in the soil or on vegetation, and is subsequently transpired or evaporated, while the remainder is retained in the soil or passed through the soil into a zone of saturation or groundwater reservoir. Some water is retained in the groundwater system; but in the absence of groundwater development, much eventually returns to the surface as seepage or spring discharge into ponds and surface channels. This discharge constitutes the entire natural flow of surface streams in the Pike River watershed during extended periods of dry weather.

With the exception of the groundwater in the deep sandstone aquifer underlying the watershed, all of the water on the land surface and underlying the Pike River basin generally remains an active part of the hydrologic system. In the deep aquifer, water is held in storage beneath the nearly watertight Maquoketa shale formation and is, therefore, taken into the hydrologic cycle in only a very limited way. Since the deep aquifer recharge area lies entirely west of the Pike River watershed, artificial movement through wells and minor amounts of leakage through the shale beds provide the only connection between this water and the surface water and shallow groundwater resources of the watershed.

The Water Budget: Quantification of the Hydrologic Cycle

A quantitative statement of the hydrologic cycle, termed the water budget, is commonly used to equate the total gain, loss, and change in storage of the water resource in a watershed over a given time period. Water is gained by a basin from precipitation and subsurface inflow, while water is lost as a result of evaporation, transpiration, and surface and subsurface outflow. A change in surface and groundwater storage results from an imbalance between inflow and outflow. The complete hydrologic budget applicable to the watershed for any time interval may be expressed by the equation:

$$P - GW - E - T - R = S$$

in which the individual terms are volumes expressed in inches of water over the entire area of the watershed and are defined as follows:

P = precipitation on the watershed
GW = net inflow or outflow of groundwater from the aquifer beneath the watershed
E = evaporation from the watershed[1]
T = transpiration from the watershed[1]
R = runoff from the watershed measured as streamflow
S = net change in total surface and groundwater storage

Quantitative data, however, are normally available for only a few of the elements of the hydrologic budget. Quantitative measurements, or estimates, compiled for the Pike River watershed include precipitation, streamflow, evaporation, and groundwater levels; but the records of each of the phenomena are incomplete or of a relatively short duration. It is necessary, therefore, to express the hydrologic budget on an average annual water-year basis in a simplified form which includes the significant components of the hydrologic cycle but excludes those components for which sufficient data are not available. A water-year time frame—October 1 of a given year through September 30 of the following year—is used because the beginning and end of that period normally correspond to low and stable streamflows and groundwater levels; moreover, since water in the deep sandstone aquifer is taken into the hydrologic cycle in only a very limited way, a hydrologic budget for the Pike River watershed can be developed considering only the surface and shallow groundwater supplies. In its simplest form, then, the long-term hydrologic budget for the Pike River watershed may be expressed by the equation:

$$ET = P - R$$

where evaporation and transpiration have been combined into one variable, ET, denoting evapotranspiration, and where net groundwater flow out of the watershed has been assumed to be zero, as has the net change in the total surface and groundwater stored within the watershed. Because of seasonal variations in the behavior of the phases of the hydrologic cycle, this simplified equation is not generally valid for time durations of less than a year.

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[1] *Evaporation is the process by which water is transformed from the liquid or solid state to the vapor state and returned to the atmosphere. Transpiration is the process by which water in the liquid state moves up through the plants, is transformed to the vapor state, and returned to the atmosphere. Evapotranspiration is the sum of the two processes.*

As stated in Chapter III of this report, the average annual precipitation over the watershed is 32.4 inches. Streamflow records collected since October 1, 1971 at the U. S. Geological Survey gaging station on the Pike River at the University of Wisconsin-Parkside campus (station number 04087257) indicate that the average annual discharge at that location is about 37.9 cubic feet per second, which is equivalent to 13.3 inches of water spread uniformly over the land surface of the watershed upstream from the gaging station. Substitution of these values for precipitation and runoff into the simplified hydrologic budget equation indicates an average annual evapotranspiration of 19.1 inches. On an average annual water-year basis, therefore, about 59 percent of the precipitation that falls on the Pike River watershed is returned to the atmosphere by the evapotranspiration process, while the remaining 41 percent leaves the watershed as streamflow.

Atmospheric Phase of the Hydrologic Cycle

The processes of precipitation and evapotranspiration constitute the atmospheric phase of the hydrologic cycle of the Pike River watershed. On a water-year basis, precipitation accounts for essentially all the water entering the watershed while evapotranspiration is the process by which most of the water leaves the watershed.

Precipitation: The average annual total precipitation for the Pike River watershed based on a Thiessen polygon network analysis of data from three observation stations located near the watershed is 32.4 inches, as described in Chapter III of this report, whereas the average annual snow and sleet fall is 46.3 inches measured as snow and sleet. The location of these three stations and the availability of temperature and other meteorological data are shown on Map 11 and in Table 7 in Chapter III. That chapter also discusses the significance of precipitation data in the watershed planning process, and includes information on precipitation-related climatic factors such as temperatures, snow cover, and frost depth. Chapter X discusses the results of various statistical analyses of the basic precipitation data, with the results being presented in graphical and tabular form in Appendix C of this report. That appendix includes point rainfall-intensity-duration-frequency relationships in both graphical and tabular form, point rainfall depth-duration-frequency curves, and depth-duration-area curves.

Evapotranspiration: Annual evaporation from water surfaces, such as ponds and streams, within the Pike River watershed is about 29 inches and, therefore, approximately equal to the average annual precipitation of 32.4 inches. The average annual evapotranspiration, as calculated in the hydrologic budget for the watershed, is about 19.1 inches. The 10-inch difference between the potential for evaporation from a free water surface and long-term evapotranspiration over the watershed occurs because evapotranspiration from soils and plants, depending upon such factors as land use, temperature, available water, and soil conditions, is normally less than evaporation from free water surfaces.

Surface Water Phase of the Hydrologic Cycle

Surface water in the Pike River watershed is composed almost entirely of streamflow since, as indicated in Chapter III, there are no major lakes—that is, lakes of 50 acres or more in surface area—located within the watershed. Small ponds, which have a combined surface area of 153 acres, comprise the remainder of the surface water.

Monitoring Stations: Streamflow is unique among the components of the hydrologic cycle in that it is the only component so confined as to pass a finite location and is, therefore, amenable to relatively precise measurement of its total quantity. As shown on Map 23, three types of stream stage and discharge monitoring stations have been constructed and are, or have been, operated in the watershed by the U. S. Geological Survey.

Streamflow generally is not measured directly at discharge monitoring stations but is usually derived from measurements of "stage," that is, of water surface elevation at monitoring stations along a stream. In order to convert a measured stage to its corresponding discharge, a stage-discharge relationship must be developed for each monitoring site. Such relationships are normally constructed by making field measurements of discharge for a wide range of river stages. For each such stage, discharge is determined by partitioning the total flow cross section into subareas, using a meter to measure the flow velocity in each subarea, multiplying the velocity times the area for each subarea to obtain subarea discharge, and summing the discharges for all subareas to obtain the total discharge. Stage is determined by various types of indicators with the readings made at intervals by an observer or recorded by automatic instruments. Stage indicators are classified according to the method by which the stage is measured and by the manner in which it is read. The principal types are staff gages, crest stage indicators, wire weight gages, and continuous recording gages.[2]

Gaging stations operated principally for low-flow studies typically are nonrecording stations, and usually do not have stage-discharge relationships developed similar to those at continuous record or crest-stage gaging stations. Discharge measurements are made for a range of base-flow conditions. These base flow measurements are then correlated with simultaneous discharge at a nearby continuous record gaging station. Long-term discharge records for the continuous record station are then used to estimate discharge at the low-flow gaging site for the ungaged base flow periods.

The U. S. Geological Survey (USGS) publishes streamflow data collected each year in a series of annual publications entitled "Water Resources Data for Wisconsin." Crest-stage and low flow gaging data are summarized in USGS reports.[3] Table 28 lists the sites in the Pike River watershed where streamflow data have been collected by the USGS, describes the type of data collected at each site, defines the period of record, and identifies publications containing the data for each site.

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[2]*For a description, including photographs, of the various types of stage indicators, see SEWRPC Planning Report No. 26, A Comprehensive Plan for the Menomonee River Watershed, Volume One, Inventory Findings and Forecasts, October 1976, pp. 104-109.*

[3]*Duane H. Conger, Estimating Magnitude and Frequency of Floods in Wisconsin, U. S. Geological Survey Open-File Report, Madison, Wisconsin, 1971 (reprinted in 1976).*

B. K. Holmstrom, Low-Flow Characteristics of Wisconsin Streams at Sewage Treatment Plants and Industrial Plants, U. S. Geological Survey Water Resources Investigations 79-31, March 1979.

Stephen J. Field, Low-Flow Characteristics of Small Streams in Proposed Public Law 566 Basins, U. S. Geological Survey Open-File Report 78-664, October 1978.

One continuous record gaging station is currently being operated in the Pike River watershed by the USGS in cooperation with the Commission and the Kenosha Water Utility. The gage is located on the Pike River at the University of Wisconsin-Parkside campus, and monitors runoff from 38.7 square miles, or about 75 percent of the watershed. The gage has been in operation since October 1, 1971.

One crest-stage gaging station is currently being operated on Pike Creek near Kenosha by the USGS in cooperation with the Wisconsin Department of Transportation. This station has been in operation since 1960 and monitors peak discharges from a drainage area of 7.25 square miles.

No low-flow gages were in operation in the watershed, as of June 1980, but low-flow data were collected previously at eight sites in the watershed by the USGS in cooperation with the Wisconsin Department of Natural Resources.

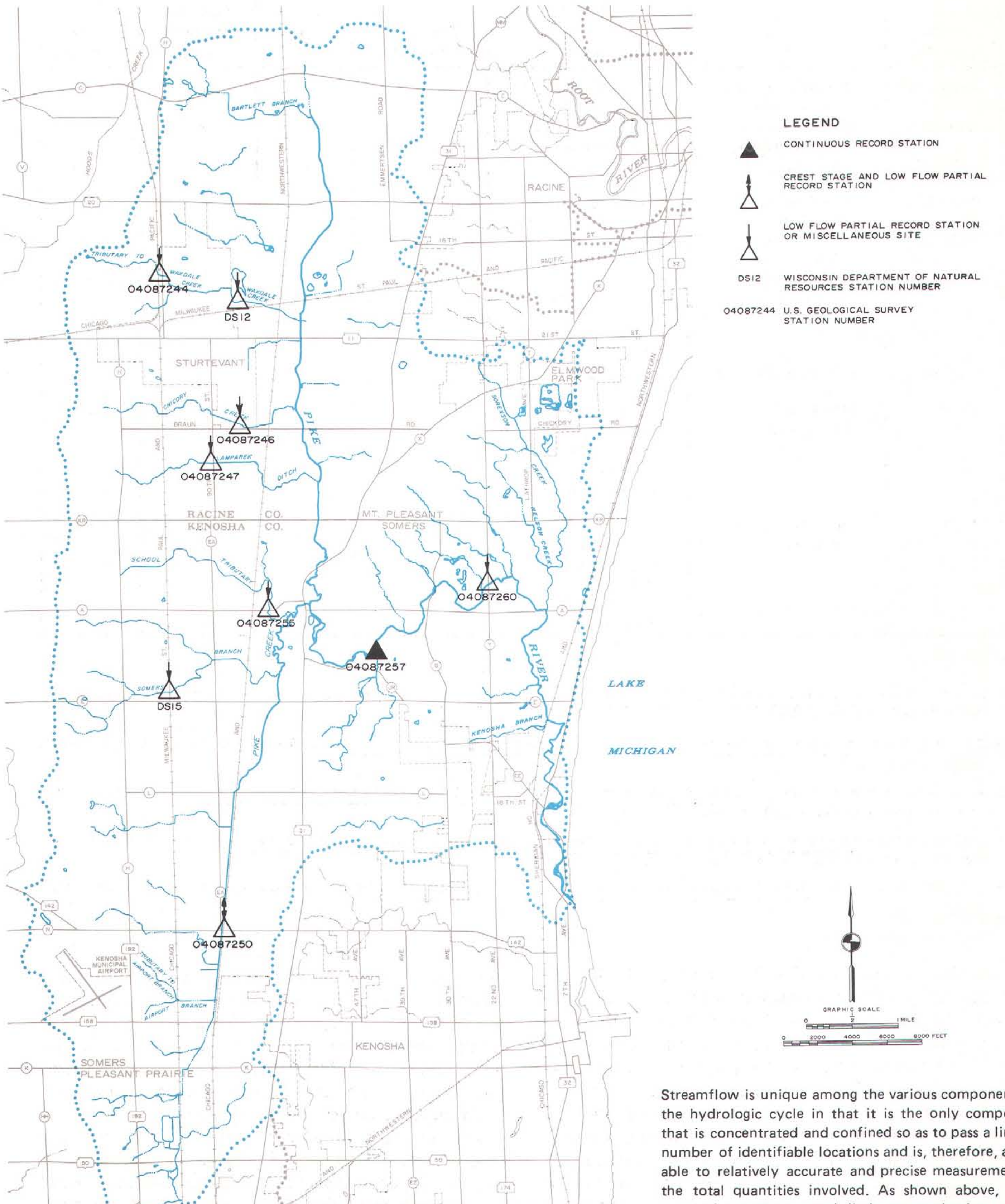
Seasonal Distribution of Peak Stages: Flood stages recorded at two U. S. Geological Survey gaging stations in the Pike River watershed—on the Pike River near Racine (station number 04087257) and on Pike Creek near Kenosha (0408725)—were used to evaluate the seasonal distribution of annual flood peaks. The seasonal distribution of the recorded peak discharges are shown in Figure 15.

The 20-year record for the station on the predominately rural Pike Creek near Kenosha—which has a drainage area of 7.25 square miles—indicates that the occurrence of highwater events is not limited to any one season, with annual peaks having occurred during the months of February through October. The low frequency of occurrence of annual peaks in the months of November, December and January is typical of not only small predominantly rural watersheds, but also of large predominantly rural watersheds in southeastern Wisconsin. The months of March, April, and June apparently were the most active flood runoff periods in the Pike Creek watershed between 1960 and 1979, with 65 percent of the recorded annual peaks having occurred in these months.

The eight years of record available for the station on the Pike River near Racine—which has a predominantly rural drainage area of 38.7 square miles—support this conclusion, with seven out of eight recorded annual peaks having occurred in the months of March, April, and June.

Map 23

STREAM STAGE AND DISCHARGE STATIONS IN THE PIKE RIVER WATERSHED



Source: U. S. Geological Survey, Wisconsin Department of Natural Resources, and SEWRPC.

Streamflow is unique among the various components of the hydrologic cycle in that it is the only component that is concentrated and confined so as to pass a limited number of identifiable locations and is, therefore, amenable to relatively accurate and precise measurement of the total quantities involved. As shown above, three types of stream stage and discharge monitoring stations have been installed and are, or have been, operated in the watershed.

STREAMFLOW GAGING IN THE PIKE RIVER WATERSHED

Station Number	Station Site	Period of Record	Continuous Recorder	Crest Stage Gage	Low-Flow or Other Site	Data Source
04087244	Pike River tributary at Sturtevant	September 12, 1972- September 18, 1975			X	2
04087247	Pike River tributary near Sturtevant	October 25, 1973 September 19, 1974			X	2
04087250	Pike Creek near Kenosha	June 29, 1959- continuing		X	X	1,2,5
04087255	Pike Creek tributary near Somers	October 25, 1973 September 19, 1974			X	2
04087257	Pike River near Racine	October 1, 1971- continuing	X			5
04087260	Pike River near Kenosha	April 26, 1962- August 16, 1967 October 26, 1973 September 20, 1974 October 22, 1977			X	2
40872465	Pike River tributary near Sturtevant	October 25,1973- September 19, 1974			X	2
DS12	Pike River tributary at Sturtevant	September 2, 1972 July 17, 1973 August 8, 1973 October 25, 1973 September 19, 1974 September 19, 1975			X	3,4
DS15	Pike River tributary at Somers	September 2, 1972 July 17, 1973 August 8, 1973 October 26, 1973 September 19, 1974 September 19, 1975			X	3,4

Data Sources

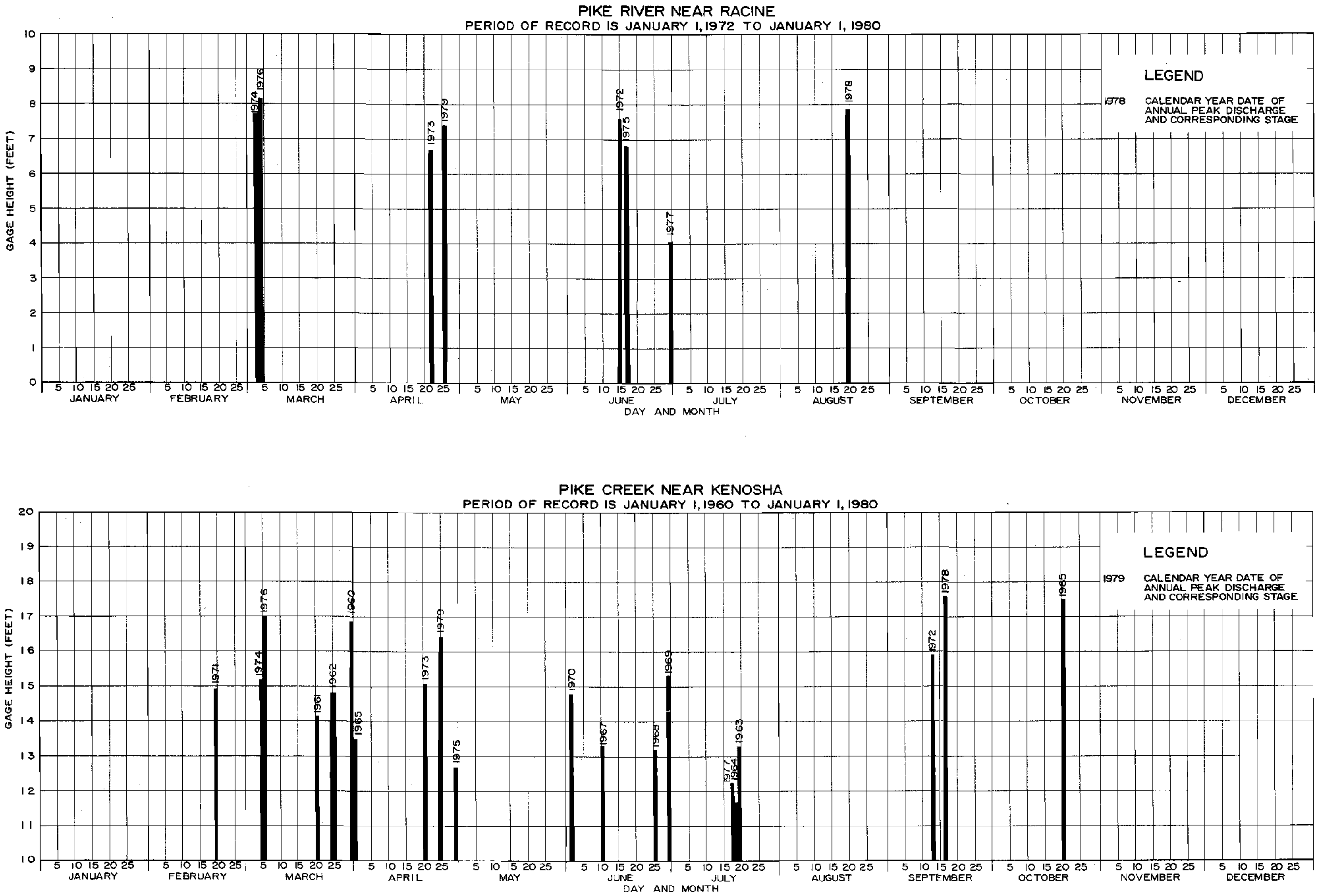
1. Duane H. Conger, Estimating Magnitude and Frequency of Floods in Wisconsin, U. S. Geological Survey Open-File Report, Madison, Wisconsin, 1971 (reprinted in 1976).
2. Stephen J. Field, Low-Flow Characteristics of Small Streams in Proposed Public Law 566 Basins, U. S. Geological Survey Open-File Report 78-664, October 1978.
3. W. A. Gebert and B. K. Holmstrom, Low-Flow Characteristics of Wisconsin Streams at Sewage Treatment Plants, U. S. Geological Survey Water Resources Investigations 45-74, December 1974.
4. B. K. Holmstrom, Low-Flow Characteristics of Wisconsin Streams at Sewage Treatment Plants and Industrial Plants, U. S. Geological Survey Water Resources Investigations 79-31, March 1979.
5. U. S. Geological Survey, Water Resources Data for Wisconsin, U. S. Geological Survey Water Data Report, published yearly since 1961.

Source: SEWRPC.

A review of the Pike Creek data record indicated a similarity with the seasonal distribution of peak stages for the predominantly rural Milwaukee River watershed. Sixty-four years of gaging record for the Milwaukee River at Milwaukee indicate that 67 percent of the annual peaks occurred in the months of March, April, and June, as compared to 65 percent for Pike Creek for the same months for the 20-year period of record. However, the longer term Milwaukee River data also indicate that a relatively high number of annual peaks occurred in February. Including the February data in the analysis, it was found that 80 percent of the annual peaks in the Milwaukee River watershed occurred in what appear to be two distinct periods, February through April and the month of June. The Pike Creek data for the period 1960-1979 contained only one annual peak in the month of February. However, the Milwaukee River data also show only one February annual peak during the same period. Therefore, based on the above analyses, it appears that for the predominantly rural Pike Creek watershed, and probably for the rural areas of the entire Pike River watershed, two flood-

Figure 15

SEASONAL DISTRIBUTION OF ANNUAL PEAK DISCHARGES FOR THE PIKE RIVER NEAR RACINE (04087257) AND FOR PIKE CREEK NEAR KENOSHA (04087250)



Source: U. S. Geological Survey and SEWRPC.

ing seasons may exist. The period February through April may be classified as a high runoff period because of the effects of snow accumulation and frozen ground in February and March, and the effects of snowmelt or rainfall on near-saturated soils in March and April when the drying effects of transpiration are still minimal and when air and surface temperatures still inhibit evaporation. Frequent severe thunderstorms occurring in the month of June but before the peak period of summer evapotranspiration may explain the relatively frequent occurrence of major floods during June as compared to July and August, two months of potentially more severe precipitation, but periods of heavy foliation and evapotranspiration losses of soil moisture.

In contrast to the predominantly rural areas of the Pike River watershed, streams draining predominantly urban areas, such as the upper reaches of Sorenson Creek, exhibit a more uniform distribution of major flooding events during the period February through November. Although the occurrence of flooding events is not equally distributed among these months of the year, the occurrence of events causing high water in highly urbanized watersheds is not concentrated within any given season. The explanation for this phenomenon is that in predominantly urban watersheds relatively large proportions of impervious surface area inhibit infiltration, thereby significantly increasing land surface runoff during even minor rainfall events or snowmelt periods. Because significant rainfall events can be expected for the most part to occur during all months of the year with the possible exception of the winter months of December and January, and because the runoff dampening effects of infiltration and leaf interception of rainfall during the summer months are diminished in urban areas, it follows that the annual distribution of flood events in highly urbanized watersheds is somewhat similar to the annual distribution of significant rainfall events, and is therefore more uniformly distributed than that in predominantly rural watersheds. As a consequence, if uncontrolled urbanization encroaches into undeveloped areas in the Pike River watershed, a change in the annual distribution of major flooding events can be expected to occur.

Rainfall-Runoff Response: From the perspective of watershed hydrology and hydraulics, urbanization is the conversion of floodland and nonfloodland areas of a basin from rural to urban uses. The urbanization process, in the absence of compensatory detention storage or other similar structural flood control measures, may increase downstream flood discharges and stages. Increased discharges result from the more extensive areas being covered by impervious surfaces and from the shortened runoff times which usually accompany the conversion of land from rural to urban uses.

The rainfall-runoff relationship is influenced by the degree of imperviousness of the surface in that the proportion of runoff resulting from a given amount of rainfall may be expected to increase as the proportion of impervious surface increases. Since urbanization is normally accompanied by an increase in area covered by impervious surfaces, it follows that urbanization will result in larger volumes of runoff for given rainfall events.

The response time of the watershed or subwatershed varies with the hydraulic resistance characteristics of its surfaces, which in turn are determined largely by land use. Smooth surfaces, such as paved areas and the paved channels, gutters, and sewers typical of urban drainage systems, reduce runoff times and reduce the base and increase the peak of runoff hydrographs. In summary, then, the increase in imperviousness and increased efficiency of drainage systems associated with the urbanization process increases runoff volumes and decreases runoff times. These two effects of urbanization are additive with the result that incremental urbanization can cause large increases in flood volumes, discharges, stages, and areas subject to inundation.

Because of the impact of urbanization, small, intensely urbanized basins tend to show a rapid rise in runoff hydrographs subsequent to the beginning of rainfall events relative to the rate of rise of runoff hydrographs in rural basins of similar size. The primary significance of the rapid response of flood flow hydrographs to rainfall events in highly urbanized watersheds is that very little time is available to warn riverine area residents of impending flood damage and disruption.

Because significant urbanization may be expected to occur in the Pike River watershed, the impacts of such urbanization upon flood flows and stages and response time have been evaluated in the watershed planning effort. This evaluation is described in the analysis of alternative plans, set forth in Chapter XII of this report.

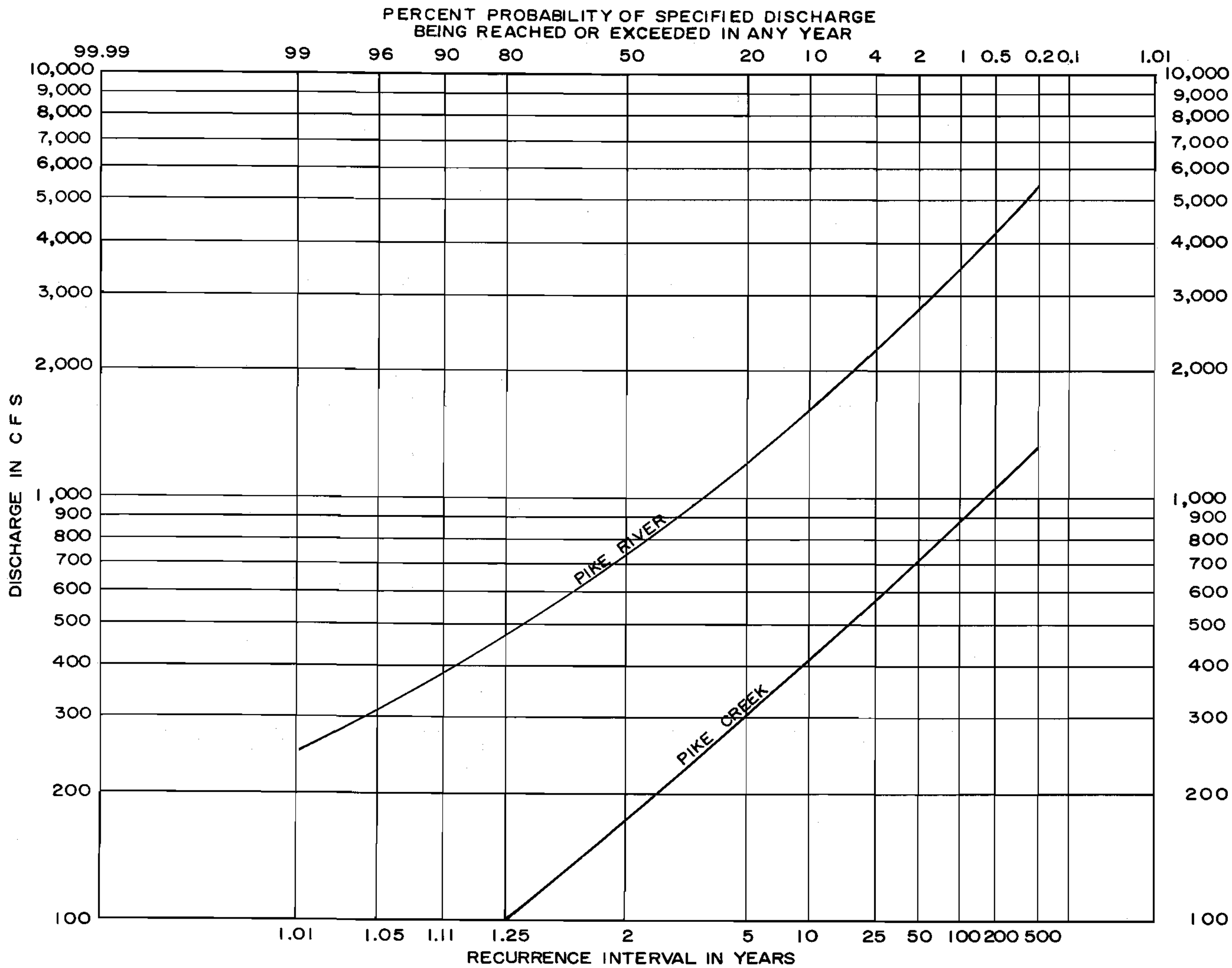
High-Flow Discharge-Frequency Relationships: The most important hydrologic characteristics of floods for watershed planning purposes are the frequency of occurrence, the peak rate of discharge, the volume of runoff, and the duration and timing of the event. Frequency—or "probability"— of occurrence is defined as the chance of occurrence, in any year, of a flood equal to or exceeding a specified magnitude. Probability may be expressed as a decimal, a fraction, or a percentage. "Recurrence interval" is defined as the average time interval between floods of a given magnitude and is equal to the reciprocal of the probability. For example, a flood that would be equalled or exceeded on the average of once in 100 years would have a recurrence interval of 100 years and a 0.01 probability, or 1 percent, chance of occurring or being exceeded in any year.

A long and continuous record of river discharge is the best basis for determining flood discharge-frequency relationships. Discharge records for the Pike River at the University of Wisconsin-Parkside campus encompass the period since October 1971, and for the crest-stage gaging station on Pike Creek at STH 142, the period since 1960. These records were considered to be of insufficient length to provide a direct basis for discharge-frequency analysis. However, the available streamflow record, in combination with historic flood stage data, was considered invaluable for the calibration of the hydrologic-hydraulic model of the watershed system as described in Chapter VIII of this report. Simulated annual instantaneous peak discharges of the Pike River at Parkside, for Pike Creek at STH 142, and for other locations throughout the watershed for the 40-year period from 1940 through 1979 were used to determine one- through 500-year recurrence interval discharges for existing land use and channel-floodplain conditions. Statistical analyses required to compute the discharges corresponding to the desired recurrence intervals were conducted using the log Pearson Type III method of analysis. That method was used because, as discussed in Chapter X, "Watershed Development Objectives, Principles, and Standards," it is recommended by the U. S. Water Resources Council and is specified for floodplain regulatory purposes by the Wisconsin Department of Natural Resources. A graphical representation of the resulting existing watershed condition discharge-frequency relationships for the Pike River at Parkside and Pike Creek at STH 142 is shown in Figure 16.

Whereas Figure 16 presents the discharge-frequency relationship for instantaneous peak discharges under existing conditions in the watershed, Figure 17 shows high-flow discharge-frequency relationships under existing conditions in the watershed at Parkside for periods of 1, 7, 30, and 120 days. These relationships also were developed using simulated stream flows and the log Pearson Type III method of statistical analysis. For a specified discharge, these curves facilitate estimating the probability that a specified high streamflow will be maintained

Figure 16

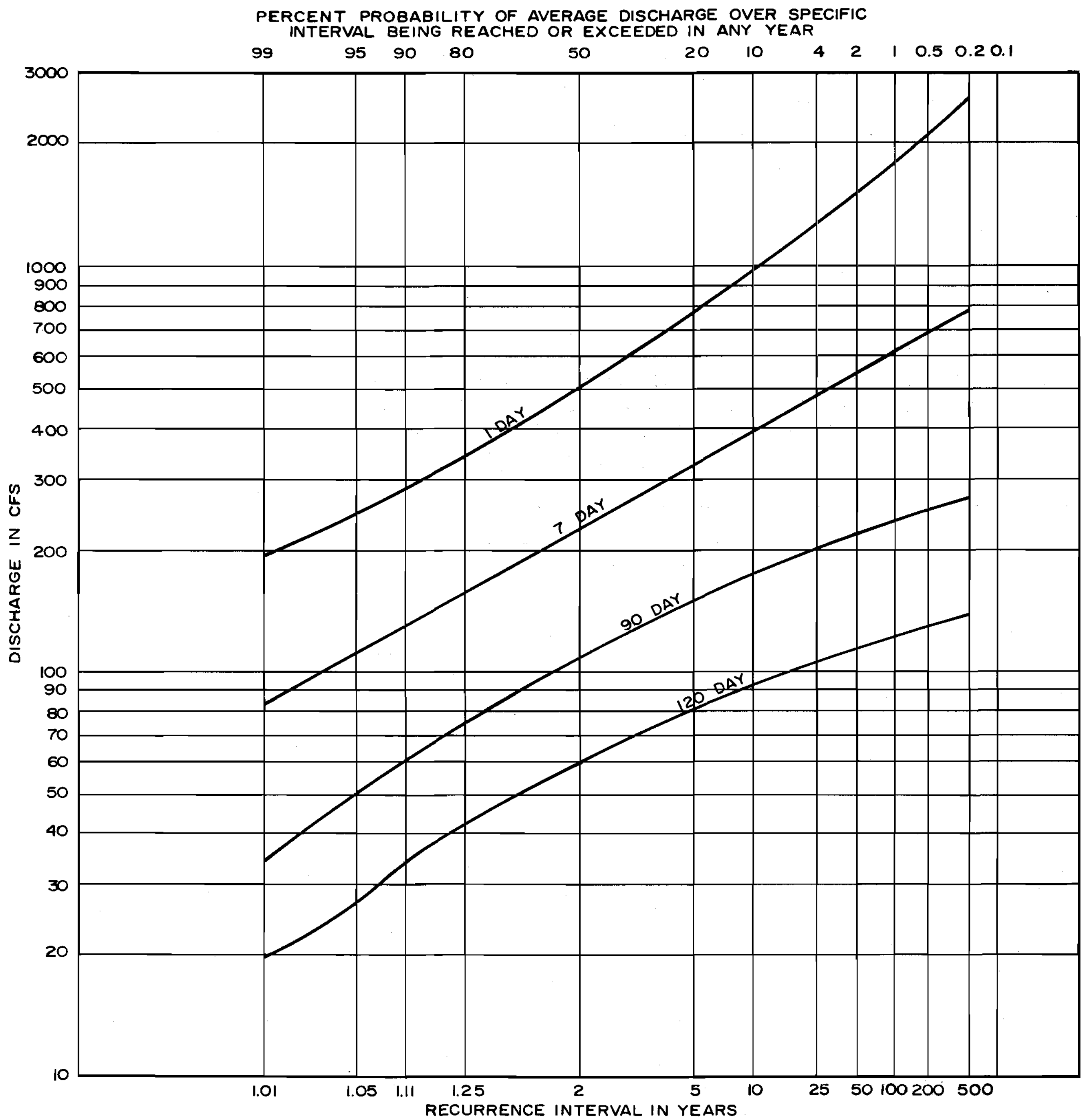
DISCHARGE-FREQUENCY RELATIONSHIPS FOR THE PIKE RIVER NEAR RACINE AT THE UNIVERSITY OF WISCONSIN-PARKSIDE (04087257) AND FOR PIKE CREEK NEAR KENOSHA AT STH 142 (04087250): EXISTING LAND USE-FLOODLAND DEVELOPMENT CONDITIONS



Source: SEWRPC.

Figure 17

HIGH-FLOW DISCHARGE-FREQUENCY RELATIONSHIPS FOR THE PIKE RIVER NEAR RACINE AT THE UNIVERSITY OF WISCONSIN-PARKSIDE GAGE (04087257) EXISTING LAND USE-FLOODLAND DEVELOPMENT CONDITIONS



Source: SEWRPC.

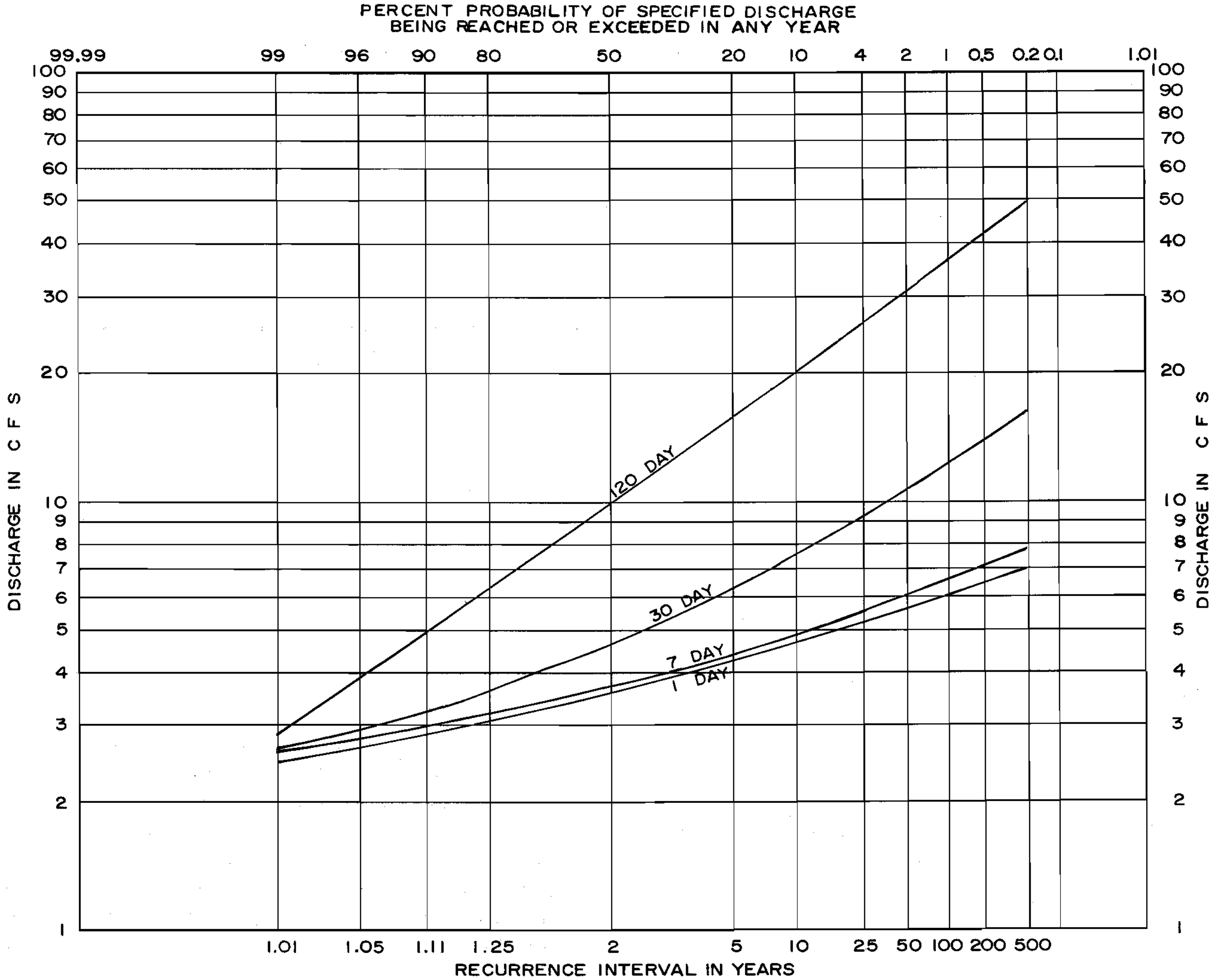
or exceeded for a given period of time during any water year. For example, the probability of maintaining an average flow of 100 cubic feet per second (cfs) or more for a seven-day period in any water year is about 97 percent, while the probability of maintaining that average flow for 30 days is a lower 58 percent, and for 120 days an even lower 6 percent.

Low-Flow Discharge-Frequency Relationships: Figure 18 shows low-flow discharge-frequency relationships for the Pike River near Parkside for periods of 1, 7, 30, and 120 days. Simulated discharges for the 40-year period from 1940 through 1979 were used, in conjunction with the log Pearson Type III method of statistical analysis, to develop these relationships.

Low-flow discharge-frequency relationships are useful in water quality management aspects of comprehensive watershed studies. For example, the low-flow condition established by the Wisconsin Department of Natural Resources for evaluating compliance with water use objectives and sup-

Figure 18

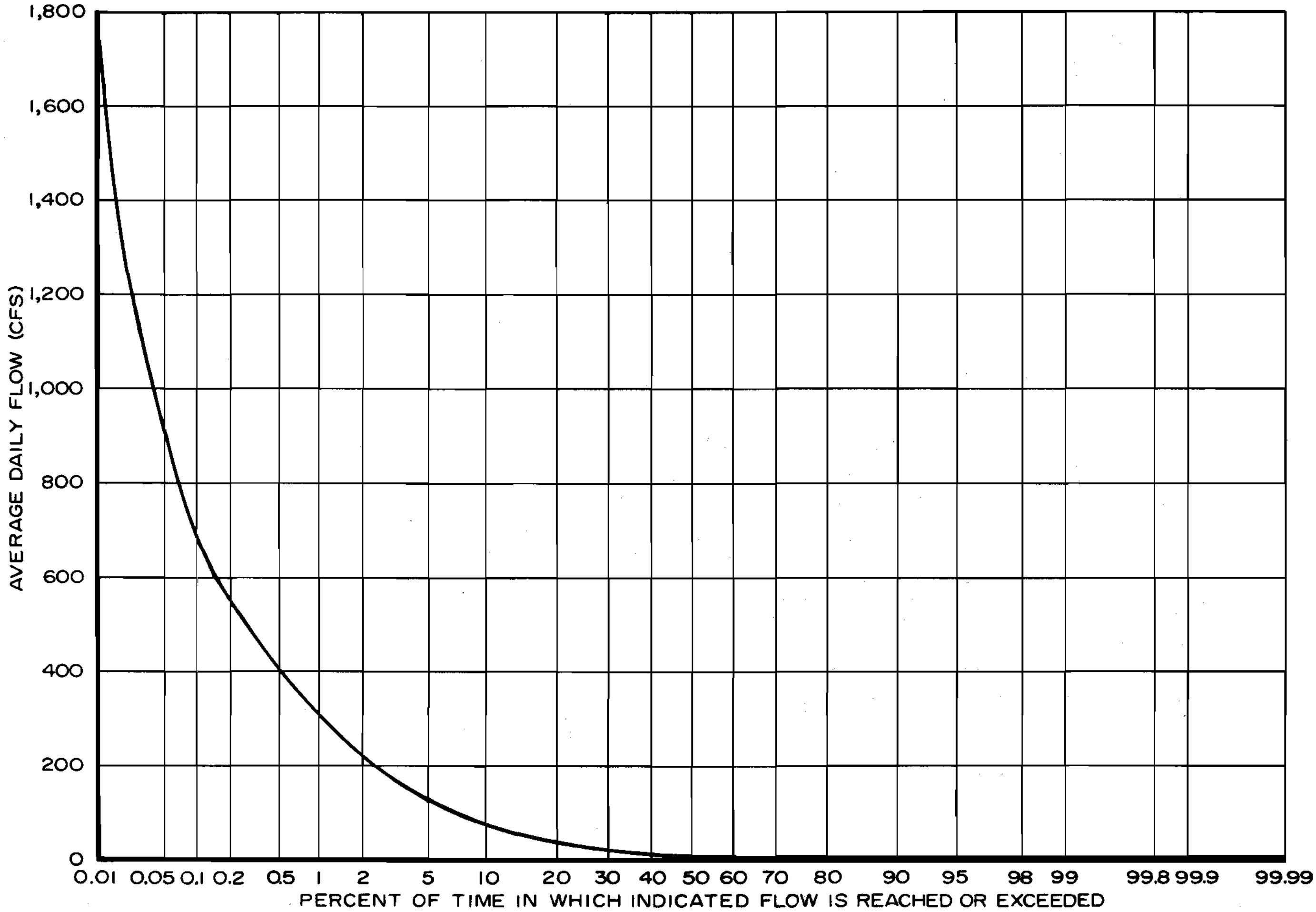
LOW-FLOW DISCHARGE-FREQUENCY RELATIONSHIPS FOR THE PIKE RIVER NEAR RACINE AT THE UNIVERSITY OF WISCONSIN-PARKSIDE GAGE (04087257) EXISTING LAND USE-FLOODLAND DEVELOPMENT CONDITIONS



Source: SEWRPC.

Figure 19

FLOW DURATION RELATIONSHIPS FOR THE PIKE RIVER NEAR RACINE AT THE UNIVERSITY OF WISCONSIN-PARKSIDE (04087257): EXISTING LAND USE-FLOODLAND DEVELOPMENT CONDITIONS



Source: SEWRPC.

porting standards is a streamflow equivalent to the minimum average seven-day flow expected to occur once on the average of every 10 years. The seven day-10 year low flow for the Pike River at Parkside, as obtained from Figure 18, is 5 cfs. However, as shown in Figure 18, the minimum flow possible is 2 to 3 cfs due to the constant nature of the existing upstream industrial discharges.

Flow Duration Analysis: A flow duration curve is defined as a cumulative frequency curve that indicates the percentage of time that specified discharges may be expected to be equalled or exceeded. Figure 19 is a flow duration curve for existing land use-floodland and channel development conditions based on simulated hourly streamflows for the Pike River at Parkside for the 40 water years from 1940 through 1979. The hourly simulated flows, on which the Pike River flow duration relationship is based, range from a low of 2 to 3 cfs from industrial discharges to a high of 2,900 cfs on March 30, 1960. Since the flow duration curve is based on all hourly flows in the simulated period, it is an effective means of summarizing streamflow characteristics.

Flow duration curves are most frequently used as an aid in forecasting the availability of specified rates of flow. For example, the flow duration curve for the Pike River at Parkside indicates that an hourly flow of 2 cfs has been, and may be expected to be, exceeded 95 percent of the time under existing land use-floodland development conditions, whereas much higher hourly discharges of 80 cfs and 550 cfs have been, and may be expected to be, exceeded only 10 percent and 0.2 percent of the time, respectively.

Groundwater Phase of the Hydrologic Cycle

That part of precipitation that infiltrates into the ground and escapes becoming evapotranspiration or part of the soil moisture percolates downward until it reaches the zone of saturation and becomes part of the groundwater reservoir. The inventory and analysis of the groundwater resources may be subdivided into two phases: groundwater hydrology and groundwater hydraulics. Groundwater hydrology, as described below, has to do with the vertical and horizontal extent of the significant aquifers[4] underlying the watershed, their relative positions, and the quantities of water contained within them. In contrast, groundwater hydraulics relates to such factors as the flow resistance of the aquifers and the flow patterns associated with those aquifers.

As stated in Chapter I of this report, the Pike River watershed planning program is directed primarily at the resolution of existing and possible future surface water quantity problems, that is, flooding problems and surface water pollution problems. However, an overview of groundwater hydrology is presented below inasmuch as it contributes to an understanding of surface water quantity and quality. Groundwater hydraulics are not discussed in this report with the exception of a brief treatment of the potentiometric surface of deep and shallow aquifers.

Principles of Occurrence: Groundwater in saturated rock occupies the pore spaces and other openings in the rock materials. Similarly, in loose, unconsolidated materials, groundwater occupies the spaces between individual grains of silt, clay, sand, or gravel. In rock, the openings that may be filled with water include those along bedding planes, fractures, faults, joints, and solution cavities. Solution cavities probably are important in the dolomite formations of the Pike River watershed. Intergranular pore openings in rocks may be fewer and smaller than those in unconsolidated materials because they are often constricted by cementing material, such as calcite and silica. In rocks such as dolomite, which contain little or no intergranular pore space, the groundwater occupies primarily the fractures and crevices that pass through such rocks.

Groundwater occurs under water table conditions whenever the surface of the zone of saturation is at atmospheric pressure. Groundwater occurs under confined or artesian conditions wherever a saturated formation is directly overlain by a relatively impermeable formation which confines the water in the permeable unit under pressure greater than atmospheric pressure. Flow of groundwater from an artesian aquifer is similar to gravity flow from a high elevation reservoir through a pipe distribution system. The static water level in wells tapping artesian aquifers always rises above the top of the artesian aquifer. Discharge from artesian aquifers is controlled by the confining stratum, and most of the recharge of the artesian aquifer occurs where the confining stratum is missing. Uncased wells provide conduits for the movement of groundwater between aquifers in a multiaquifer system, such as that present in the Pike River watershed, both upward under artesian head and downward under gravity flow conditions. Flowing wells result if the static water level at the well is higher than the land surface. Flow continues until the water level is lowered below the land surface.

Groundwater is released from storage in water table and artesian aquifers as the result of different physical processes. In a water table aquifer, groundwater is released to wells by gravity drainage of the aquifer pore spaces. In an artesian aquifer, water is released to the well as the result of compression of the aquifer and expansion of groundwater. An

[4]*An aquifer is a porous water-bearing geologic formation. As used here, it is a relative term designating geologic formations, or deposits, that contain significant amounts of groundwater which can be used as a principal source of water supply.*

aquifer consisting of tightly packed, well-sorted spherical particles of sand may contain up to 40 percent water by volume—about three gallons per cubic foot of aquifer. Given sufficient time, about one-half of this volume of water may be drained by gravity from a water table aquifer with the other half adhering to the aquifer against the force of gravity. The quantity of groundwater released from a cubic foot of similar materials under artesian conditions is extremely small by comparison because, under artesian conditions, the aquifer is not drained but the released water is instead attributable solely to the expansion of the water and the compression of the solid material comprising the aquifer. This expansion of the water and contraction of the aquifer material is in response to the reduced water pressure caused by pumping the aquifer. The practical consequence of this difference in the origin of water taken from an unconfined aquifer, compared to a confined or artesian aquifer, is that pumping from an artesian aquifer affects an immense area compared to the area affected by pumping at an equivalent rate from a water table aquifer of similar vertical and horizontal extent and materials.

Hydrologic Characteristics by Aquifer: There are three principal aquifers underlying the Pike River watershed: the sandstone aquifer, the deepest of the three; the dolomite aquifer; and the sand and gravel aquifer, the shallowest of the three. The latter two are hydraulically interconnected and, therefore, are sometimes considered to comprise a single aquifer. The dolomite aquifer also is commonly, although incorrectly, called the "limestone" aquifer. The deep sandstone aquifer is separated from the shallower dolomite aquifer by a layer of relatively impermeable shale. The more important of the three aquifers are the sandstone and the dolomite aquifers, which underlie the entire watershed and are generally available for use in any locality. The sand and gravel aquifer is of lesser importance because, although it reaches a thickness of 250 feet in some watershed areas, it does not yield large quantities of water, and it is particularly susceptible to pollution from overlying land uses. The stratigraphic units comprising each of the three aquifers are summarized in Table 13 of Chapter III. Hydrologic characteristics of each of the three principal aquifers are discussed below.

The Sandstone Aquifer: In the Pike River watershed, the sandstone aquifer includes all of the geologic units bounded above by the Maquoketa shale and bounded below by the Precambrian rocks. Although it is commonly referred to as the sandstone aquifer, some of the units contained within it—for example, the Galena dolomite—are not sandstones. The Maquoketa shale confines water in the sandstone aquifer under artesian pressure and the shale is normally cased off in wells to prevent destruction of the well by caving of the formation.

The surface of the sandstone aquifer is located approximately 500 to 600 feet beneath the ground surface of the Pike River watershed. The sandstone aquifer dips gently downward in an easterly direction at a slope of about 20 feet per mile (about 0.4 foot per 100 feet). The thickness of the sandstone aquifer beneath the watershed is known to exceed 1,200 feet. Assuming an average porosity of 15 percent, it is estimated that at least 5.9 million acre-feet of water are contained within that portion of the aquifer lying immediately beneath the Pike River watershed. This volume of water would be sufficient to cover the entire watershed to the depth of 180 feet.

Recharge to the sandstone aquifer enters the aquifer system in three ways. It occurs as infiltration of precipitation through glacial deposits in a recharge area located west of the watershed along the western edge of the seven-county Planning Region where the Maquoketa shale and younger formations are absent. Second, a small amount of recharge occurs as vertical leakage through the Maquoketa shale because of the hydraulic head difference existing between the top and the bottom of the shale. Third, and also because of that hydraulic head difference, deep wells uncased in both the dolomite and sandstone aquifers allow movement of water from a dolomite aquifer immediately above the Maquoketa shale to the sandstone aquifer beneath. The elevation of the potentiometric surface ranges from a high between 500 and 525 feet above National Geodetic Vertical Datum (Mean Sea Level Datum) in the southern three-quarters of the watershed to a low of about 490 feet in the extreme northern portion of the basin.

The direction of groundwater movement in the sandstone aquifer is defined by the potentiometric surface of the aquifer. Groundwater in about the northern two-thirds of the sandstone aquifer beneath the Pike River watershed flows in a generally northerly direction toward the Milwaukee area, and in the southern one-third toward the Chicago area.

The potentiometric surface of the sandstone aquifer sloped gently eastward throughout the watershed in 1880, when the sandstone aquifer was first tapped by wells. Wells in the aquifer in the Kenosha-Racine area generally flowed at the surface as a result of the artesian pressure. Subsequent development of the aquifer in southeastern Wisconsin and northeastern Illinois has resulted in a decline of the potentiometric surface within the Pike River watershed in excess of 250 feet and consequently wells no longer flow.

As noted earlier, a small amount of sandstone aquifer recharge occurs as downward flow through the Maquoketa shale from the overlying dolomite aquifer. This flow occurs because there is a hydraulic head difference between the dolomite and sandstone aquifers. The difference in elevation between the potentiometric surfaces of these two aquifers defines the approximate head difference acting across the Maquoketa shale at any locality. If the vertical permeability of the Maquoketa shale is assumed to be uniform, leakage will be greatest where the head differences are largest.

Map 24 indicates the potentiometric surface for the combined dolomite aquifer and glacial deposits. The elevation of the potentiometric surface of the combined dolomite aquifer and glacial deposits is greater than the elevation of the potentiometric surface of the sandstone aquifer throughout the watershed. The difference in hydraulic head for the two aquifers ranges from 70 to 200 feet. Because of the head difference between these aquifers, deep wells encased in both the dolomite and sandstone aquifers allow easy movement of water from the dolomite aquifer into the sandstone aquifer.

The Dolomite Aquifer: The dolomite aquifer underlies the entire Pike River watershed and consists of silurian dolomite. Maps 13 and 14 in Chapter III graphically represent, respectively, the surface topography of the dolomite aquifer and the thickness of the sand and gravel aquifer. The relatively impermeable Maquoketa shale is positioned immediately below the aquifer, whereas unconsolidated glacial till, drift, and alluvial deposits, varying in thickness from 100 to 250 feet, lie immediately above.

The topography of the surface of the dolomite aquifer, as shown on Map 13 in Chapter III, indicates a low-lying area extending roughly from west to east across the central part of the watershed as a result of erosion prior to deposition of the overlying glacial till. The aquifer has a thickness of approximately 200 feet and dips gently downward in an easterly direction at about 20 feet per mile (about 0.4 foot per 100 feet).

Recharge to the dolomite aquifer is primarily from infiltration of precipitation through overlying glacial deposits. The entire 200-foot thickness of the dolomite aquifer lies beneath the water table and is, therefore, saturated with groundwater. Assuming an average porosity of 5 percent, about 330,000 acre-feet of water exist beneath the Pike River watershed in the dolomite aquifer. This quantity of water would be sufficient to cover the entire watershed to a depth of 10 feet.

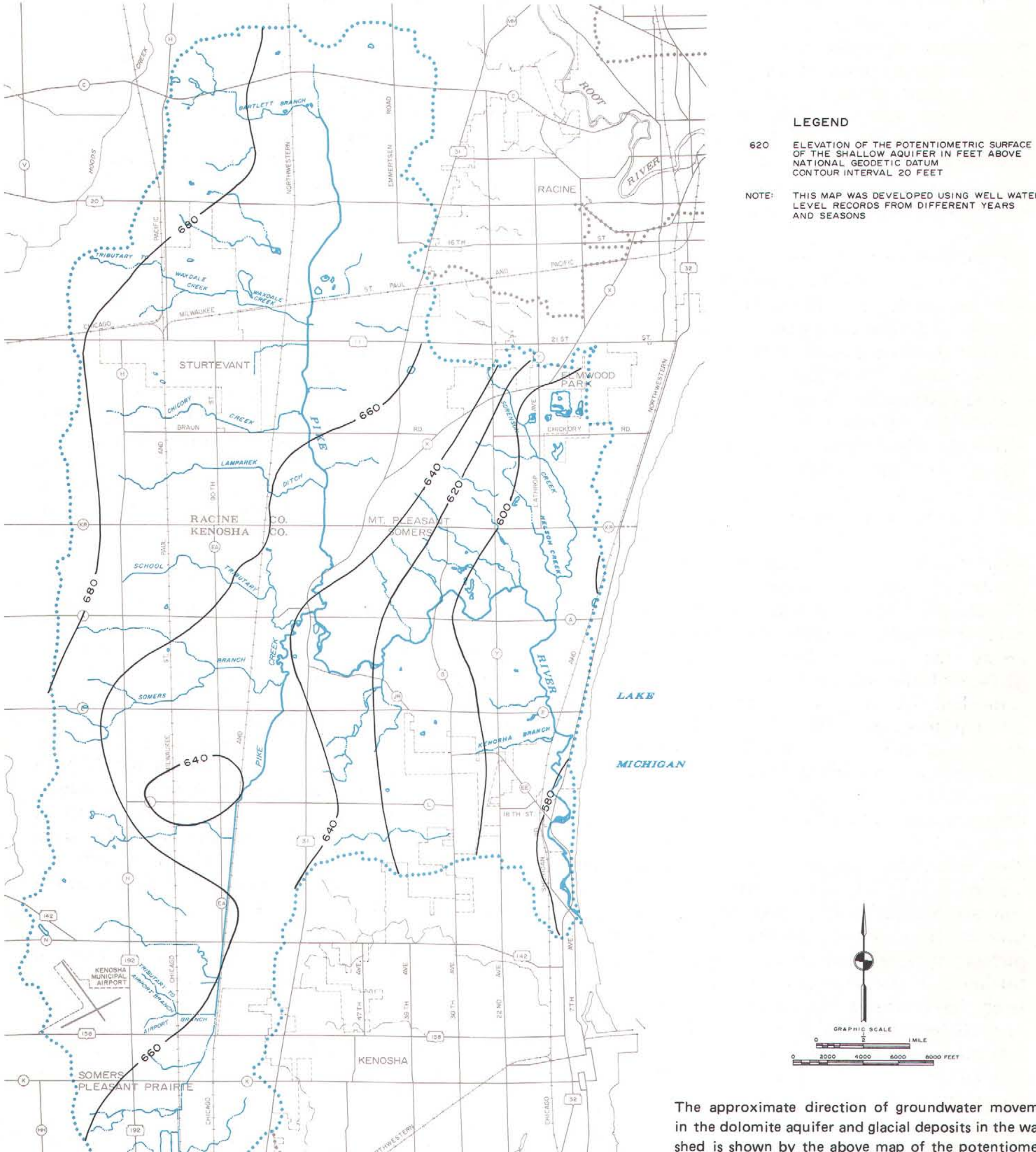
The potentiometric surface for the combined dolomite aquifer and glacial deposits, as shown on Map 24, approximately defines the direction of the groundwater movement in these units in the watershed. The elevation of the potentiometric surface ranges from a high of about 700 feet above National Geodetic Vertical Datum along the northwesterly edge of the watershed to a low of about 580 feet near the watershed outlet at the confluence with Lake Michigan. Movement is down the hydraulic gradient toward Lake Michigan.

The Sand and Gravel Aquifer: The sand and gravel aquifer consists of stratified, unconsolidated glacial and alluvial sand and gravel deposits. As shown on Map 14 in Chapter III, the thickness of the unconsolidated deposits forming the sand and gravel aquifer varies from 100 to 250 feet in the Pike River watershed. The thickness of the zone of saturation, however, varies from about 230 to 50 feet with an average value of about 110 feet. Assuming an average porosity of 0.30, about 1.1 million acre-feet of water exist within the saturated strata of the sand and gravel. This quantity of water would be sufficient to cover the watershed to a depth of about 35 feet.

Direct infiltration of precipitation is a major source of recharge to the sand and gravel aquifer. Recharge is greatest where the sand and gravel deposits and associated permeable soils occur at the surface, and it is smallest where fine-grain soils, clay, silt, or till form the surficial deposits. Water in the subsurface moves downward through the soils to the water table and then laterally toward streams and pumping areas. The potentiometric surface for the combined dolomite aquifer and glacial deposits, as shown on Map 24, defines approximately the direction of movement of the groundwater in these units and also the approximate elevation of static water levels in wells tapping these units.

Map 24

GENERALIZED POTENTIOMETRIC SURFACE OF THE DOLOMITE AQUIFER AND GLACIAL DEPOSITS IN THE PIKE RIVER WATERSHED



The approximate direction of groundwater movement in the dolomite aquifer and glacial deposits in the watershed is shown by the above map of the potentiometric surface—the elevation to which water would rise in an open well tapping the aquifer. Movement is down the hydraulic gradient towards discharge points generally located at the mouth of the watershed near the Lake Michigan shoreline. Groundwater discharge sustains the dry-weather flow of the streams in the watershed.

Source: U. S. Geological Survey and SEWRPC.

Natural discharge of groundwater from the glacial deposits occurs as seepage into the surface water system, by direct evaporation to the atmosphere where the water table is shallow, by plant transpiration during growing seasons, and by filtration to the dolomite aquifer. Groundwater seepage into the surface water system, primarily from glacial deposits, is estimated to be 31.1 inches annually under existing land use-floodland development conditions.[5] This is approximately 74 percent of the total dry-weather flow of streams in the watershed: the remaining 1.1 inches, or 26 percent, come from municipal and industrial point source discharges.

Map 25 shows the estimated depth to seasonal high water in the sand and gravel aquifer for the Pike River watershed. Seasonal high water is the average of annual highest groundwater levels most of which occur in the spring. Soils mapping and soils moisture information was used by the U. S. Geological Survey to determine the seasonal high water levels.[6] Seasonal high water in this aquifer may be expected to be less than 10 feet beneath the land surface for about 44 percent of the watershed area. The seasonal high water may be expected to be between 10 and 30 feet beneath the land surface for 55 percent of the watershed area and in excess of 30 feet beneath the land surface for the remaining 1 percent of the watershed.

HYDRAULICS OF THE WATERSHED

As defined earlier in this chapter, hydraulics—in the context of comprehensive watershed planning—involves the inventory and analysis of those factors that affect the physical behavior of water as it flows within stream channels and on attendant natural floodplains; under and over bridges, culverts and dams; through lakes and other impoundments; and within the watershed aquifer system. The preceding portion of this chapter has concentrated on the hydrology of the Pike River watershed under the broad categories of surface water and groundwater hydrology. This section of the chapter describes the results of the inventory and initial analysis of surface water hydraulics in the Pike River watershed. Inasmuch as there are no major lakes in the Pike River watershed, the surface water system of the watershed consists essentially of the streams and associated floodplains. An overview of the watershed surface water resources is presented in Chapter III, "Description of the Watershed."

Portion of the Stream System Selected for Development of Detailed Flood Hazard Data

The lineal extent of the perennial and intermittent streams in the watershed is extensive if each tributary to the Pike River is traced upstream to its origin. The cost of hydrologic-hydraulic simulation—which includes the cost of data collection, collation and coding; the cost of computer runs; and the cost of analyzing model results—increases in proportion to the lineal miles of streams that are modeled. Therefore, a decision was required on the portion of the watershed stream system for which detailed flood hazard information would be developed by hydrologic-hydraulic simulation studies prior to inventorying the hydraulic features of the stream system. Detailed flood hazard data are defined to include discharge-frequency relationships under existing and probable future land use conditions and corresponding flood stage profiles and areas subject to inundation by floods of selected recurrence intervals.

Selected Reaches: Stream reaches studied were selected by the Pike River Watershed Committee based on historic and anticipated flooding problems as determined by deliberations with local officials and citizens of the watershed, based on previous data availability, and based on availability of funding.

It should be noted that the stream reaches selected for study are independent of the perennial or intermittent nature of the streams as defined on U. S. Geological Survey quadrangle maps. The perennial or intermittent classification of a stream, particularly in an urban area, was considered to be of no consequence since it is not an index to the severity of either existing or potential flood problems in an urban area or an indication of the availability of data for analyzing those problems.

Parts of 12 streams within the Pike River watershed were selected for hydrologic-hydraulic simulation leading to the development of detailed flood hazard information including discharge-frequency relationships under existing and probable future development of floodland and nonfloodland areas;

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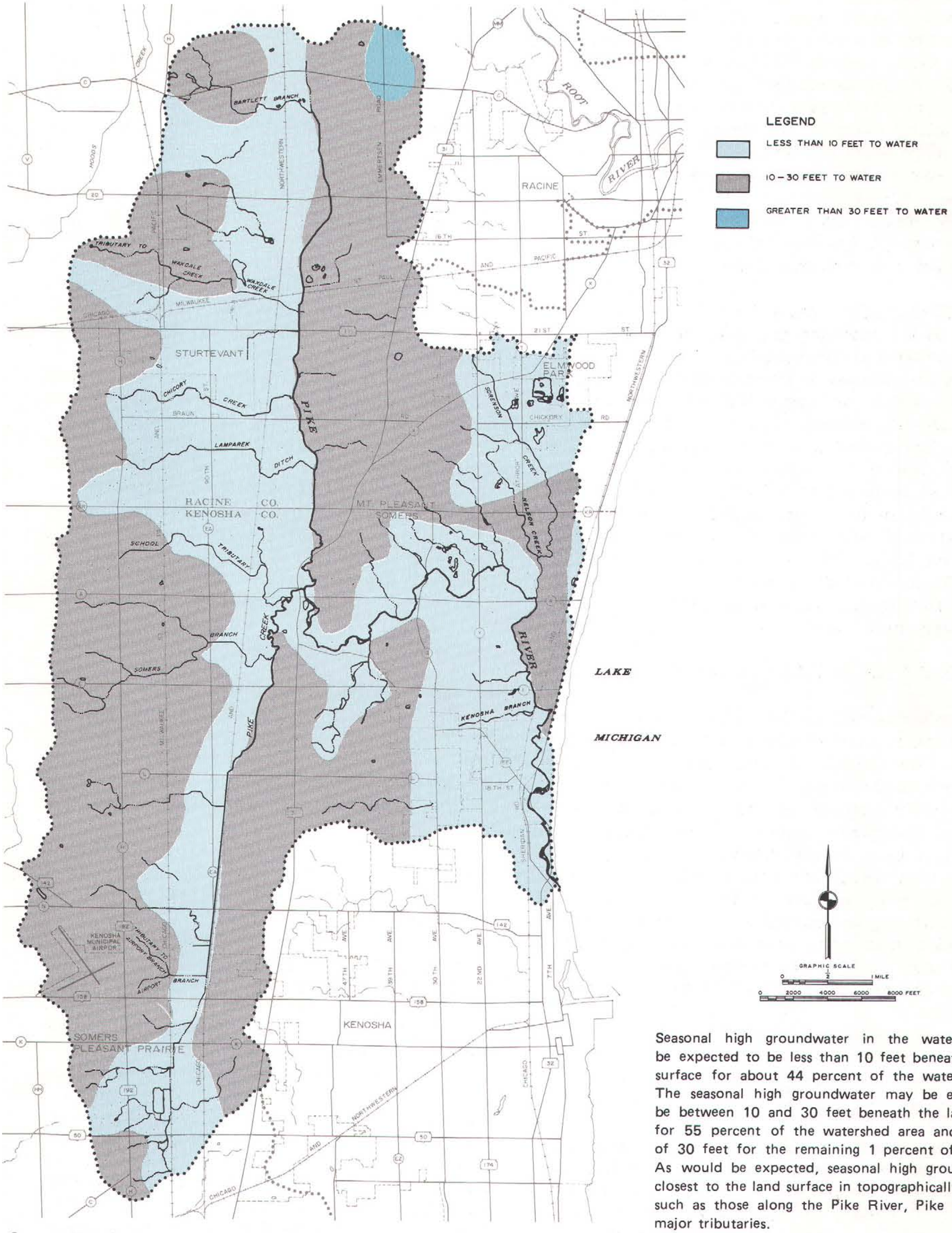
[5] *Determined using the hydrologic-hydraulic model described in Chapter VIII.*

[6] *Map 25 was developed from an unpublished map of the Planning Region entitled "Depth to Seasonal High Water" prepared by the U. S. Geological Survey in January 1977 for the SEWRPC areawide water quality management planning program.*

Map 25

SEASONAL HIGH GROUNDWATER IN THE PIKE RIVER WATERSHED



Source: U. S. Geological Survey and SEWRPC.

Seasonal high groundwater in the watershed may be expected to be less than 10 feet beneath the land surface for about 44 percent of the watershed area. The seasonal high groundwater may be expected to be between 10 and 30 feet beneath the land surface for 55 percent of the watershed area and in excess of 30 feet for the remaining 1 percent of the basin. As would be expected, seasonal high groundwater is closest to the land surface in topographically low areas such as those along the Pike River, Pike Creek, and major tributaries.

and corresponding flood stage profiles and areas of inundation. These streams are shown on Map 26 and consist of: 1) the main stem of the Pike River in the Towns of Mt. Pleasant and Somers, and in the City of Kenosha; 2) Pike Creek in the Towns of Pleasant Prairie and Somers; 3) Somers Branch, Airport Branch and Tributary to Airport Branch (tributary to Pike Creek), and Kenosha Branch (tributary to the Pike River), all in the Town of Somers; 4) Lamparek Ditch, Chicory Creek, Waxdale Creek, and Bartlett Branch (tributary to the Pike River) in the Town of Mt. Pleasant; 5) Tributary to Waxdale Creek in the Village of Sturtevant; and 6) Sorenson Creek and Nelson Creek in the Towns of Mt. Pleasant and Somers. Tables 29 and 30, and Map 29 present selected information on these stream reaches and the tributary drainage areas. As indicated in Table 29, detailed flood hazard information was developed for a total of 42.27 miles of streams in the Pike River watershed.

Subsequent to the identification of the above 42.27 miles of stream, the Commission conducted a detailed engineering inventory of the selected reaches. This inventory included collection, collation, and preliminary analysis of floodland characteristics as well as definitive data on bridges and culverts and physical information about dams and sills.

Floodland Characteristics: Included in the category of floodland characteristics are the magnitude and variation of channel slope, floodplain shape and roughness, and the extent and nature of channel improvements. For a given discharge, each of these floodland characteristics can be a primary determinant of river stage.

Channel Profiles: Figure 20 shows channel profiles for the 42.27 miles of stream selected for the development of detailed flood hazard information. The sources of data for these channel bottom profiles were channel bottom elevations at bridges, culverts, dams, and drop structures which were determined from U. S. Soil Conservation Service and SEWRPC structure drawings, field surveyed channel cross sections, and stream channel contour crossings shown on the large-scale topographic mapping of the watershed. All of these data were collected and collated as part of the watershed hydraulic structure inventory.

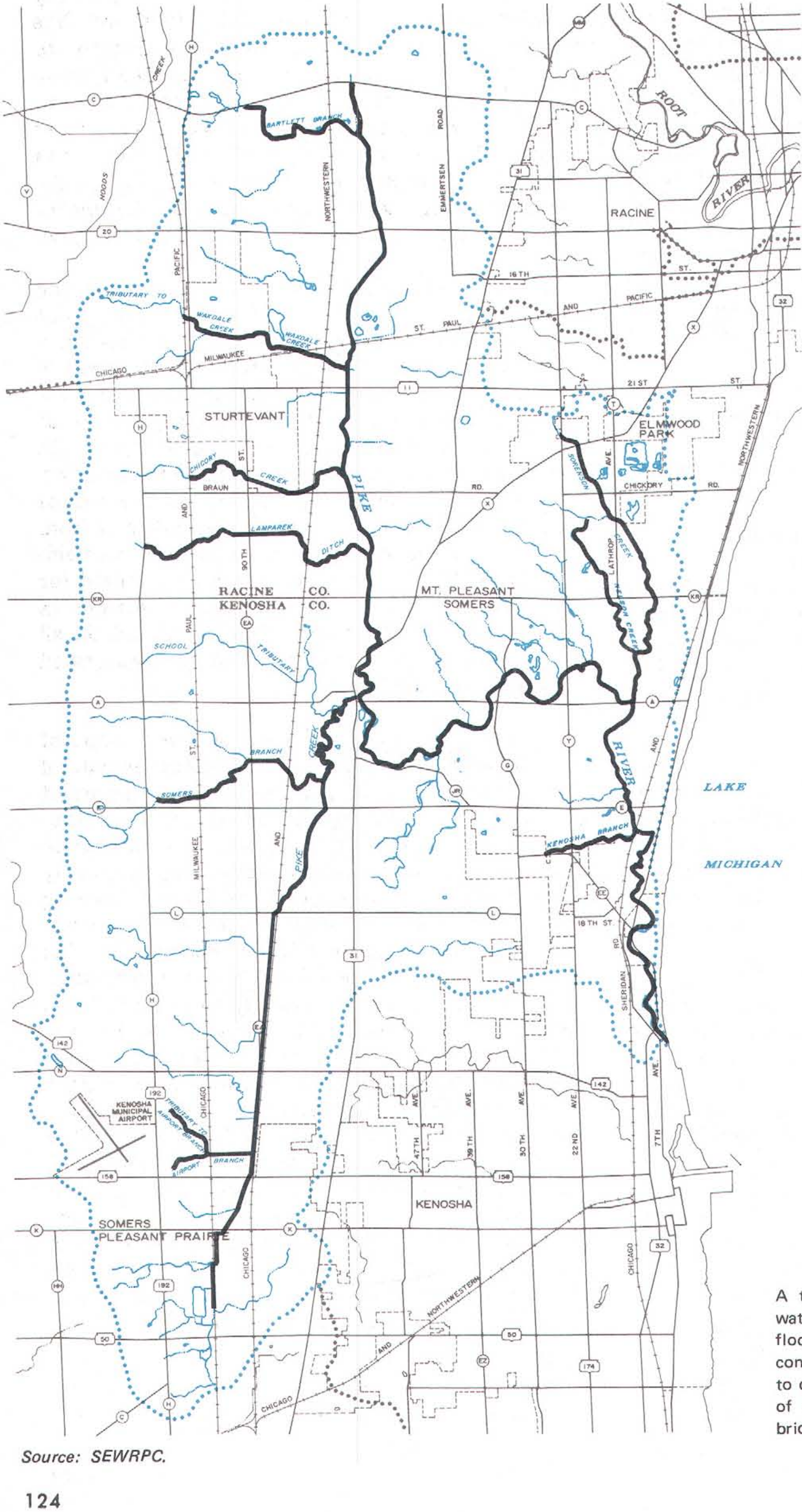
Channel slopes are irregular, with the steepest slopes being on the Upper Pike River and generally flatter slopes on the Lower Pike River and Pike Creek. All other hydraulic factors being equal or similar, steep channel slopes result in high streamflow velocities and shorter runoff times, whereas flat slopes produce lower velocities and longer runoff times. Channel slopes in the Pike River and Pike Creek range from 5.9 to 6.2 feet per mile, whereas much steeper slopes occur in the smaller tributaries, ranging from 8.4 to 29.8 feet per mile.

Although the channel profiles do illustrate the magnitude and variation of slopes throughout the watershed stream system, the primary purpose of developing the profiles was to provide a basis for estimating channel bottom elevations for channel-floodplain cross sections located at points between the bridges, culverts, dams, and sills at which channel bottom elevations were not determined by field surveys. Channel bottom elevations for these intermediate locations—as obtained from the channel bottom profiles and in some cases field-surveyed channel cross sections—were required for the development of floodland cross sections as discussed below. This procedure was used on all the streams studied under the Pike River watershed planning program.

Floodland Cross Sections: The size and shape of the floodlands, that is, the channel and its natural floodplain, particularly the latter, are important floodland characteristics inasmuch as they influence flood stages and the lateral extent of inundation for a given flood discharge. Approximately 700 floodland cross sections at an average spacing of 300 feet were developed for the 42.27 miles of stream studied in the Pike River watershed for the development of detailed flood hazard information. The aforementioned cross sections exclude those immediately upstream and downstream of bridges, culverts, and other hydraulic structures inasmuch as the latter are intended to represent the configuration of the riverine area near and around the structures. In contrast, cross sections located 50 or more feet upstream and downstream of structures are intended to reflect the full conveyance of the unobstructed floodland area. After conversion to numeric form, these cross sections were input to the hydraulic submodel of the hydrologic-hydraulic similation model as described in Chapter VIII, "Water Resources Simulation Model."

Map 26

STREAM REACHES IN THE PIKE RIVER WATERSHED SELECTED FOR PREPARATION OF FLOOD HAZARD INFORMATION



LEGEND

STREAM REACHES FOR WHICH FLOOD DISCHARGES AND PROFILES WERE DEVELOPED UNDER THE WATERSHED STUDY

GRAPHIC SCALE
0 1/2 1 MILE
0 2000 4000 6000 8000 FEET

A total of 42.27 miles of streams in the Pike River watershed were selected for development of detailed flood hazard information. A detailed inventory was conducted of the 42.27 miles of selected stream reach to determine the storage and conveyance characteristics of the floodlands and the hydraulic capacity of all bridges, culverts, dams, and drop structures.

Source: SEWRPC.

Table 29

SELECTED HYDRAULIC DATA FOR THE PIKE RIVER WATERSHED: 1980

Stream Reach For Which Flood Stage Profiles Were Developed	Length (miles)	Elevation Difference in Feet from Mouth to Upstream End	Stream Slope (feet/mile)	Bridges and Culverts[a]			Dams and Sills			All Structures			Major Channel Modifications	
				Hydraulically Significant	Hydraulically Insignificant	Total	Hydraulically Significant	Hydraulically Insignificant	Total	Hydraulically Significant	Hydraulically Insignificant	Total	Miles	Percent
Upper Pike River	6.63	40	6.2	9	5	14	--	--	--	9	5	14	5.43	81
Lower Pike River	9.61	58	6.0	15	18	33	2	--	2	17	18	35	--	--
Pike Creek	7.35	44	5.9	10	5	15	--	--	--	10	5	15	4.65	76
Sorenson Creek	3.70	64	17.4	9	2	11	--	--	--	9	2	11	2.14	--
Nelson Creek	1.80	36	25.1	6	4	10	--	--	--	6	4	10	--	--
Kenosha Branch.	1.21	36	29.8	3	2	5	--	--	--	3	2	5	--	--
Bartlett Branch	1.53	12	8.4	6	3	9	--	--	--	6	3	9	1.53	100
Waxdale Creek and Tributary to Waxdale Creek . .	1.95	46	23.6	6	1	7	--	--	--	6	1	7	0.47	24
Chicory Creek	1.89	50	26.6	4	1	5	--	--	--	4	1	5	1.13	60
Lamparek Ditch.	2.83	62	21.9	5	2	7	--	--	--	5	2	7	2.83	100
Somers Branch	2.38	44	18.5	4	5	9	--	--	--	4	5	9	--	--
Airport Branch	0.97	20	21.1	1	2	3	--	--	--	1	2	3	0.52	55
Tributary to Airport Branch. . .	0.42	3	10.7	--	--	--	--	--	--	--	--	--	--	--
Total	42.27	--	--	78	50	128	2	--	2	80	50	130	18.70	41

[a] *Includes tunnel inlets and outlets and outfall structures.*

Source: SEWRPC.

Table 30

SELECTED HYDROLOGIC DATA FOR THE PIKE RIVER WATERSHED: 1975

Subwatershed[a]		Area			Total Area Tributary to Downstream-Most Point		Subbasins				1975 Land Use: Rural					
											Agriculture and Related		Other Open Lands[b]		Total Rural	
Number	Name	Acres (1975)	Square Miles (1975)	Percent of Watershed	Acres	Square Miles	Number	Largest (square miles)	Smallest (square miles)	Mean Area (square miles)	Acres	Percent of Subwatershed	Acres	Percent of Subwatershed	Acres	Percent of Subwatershed
1	Pike Creek	11,874.19	18.52	36.1	11,874.19	18.52	16	2.13	0.06	1.20	9,277	78.1	443	3.7	9,720	81.8
2	Upper Pike River . .	11,399.83	17.78	34.6	11,399.83	17.78	15	2.18	0.42	1.16	7,177	63.0	1,077	9.4	8,254	72.4
3	Lower Pike River . .	9,636.12	15.04	29.3	32,910.14	51.34	15	1.84	0.20	0.94	4,204	43.6	1,616	16.8	5,820	60.4
Total		32,910.14	51.34	100.0	32,910.14	51.34	46	2.18	0.06	1.10	20,658	62.8	3,136	9.5	23,794	72.3

Subwatershed[a]		1975 Urban Land Use: Residential		Retail and Service		Industrial		Governmental and Institutional		Park and Recreational		Transportation, Communications, and Utility Facilities		Total Urban	
Number	Name	Acres	Percent of Subwatershed	Acres	Percent of Subwatershed	Acres	Percent of Subwatershed	Acres	Percent of Subwatershed	Acres	Percent of Subwatershed	Acres	Percent of Subwatershed	Acres	Percent of Subwatershed
1	Pike Creek	622	5.2	16	0.2	158	1.3	48	0.4	208	1.8	1,103	9.3	2,155	18.2
2	Upper Pike River . .	1,516	13.3	71	0.6	228	2.0	282	2.5	41	0.4	1,007	8.8	3,145	27.6
3	Lower Pike River . .	1,874	19.4	58	0.6	62	0.7	323	3.4	522	5.4	977	10.1	3,816	39.6
Total		4,012	12.2	145	0.4	448	1.4	653	2.0	771	2.3	3,087	9.4	9,116	27.7

[a] *With the exception of subbasin areas, data presented in this table were determined by means of approximating the subwatersheds by U. S. Public Land Survey quarter sections. The actual measured total watershed area is 51.54 square miles, whereas the watershed area as approximated by 205 quarter sections is 51.34 square miles.*

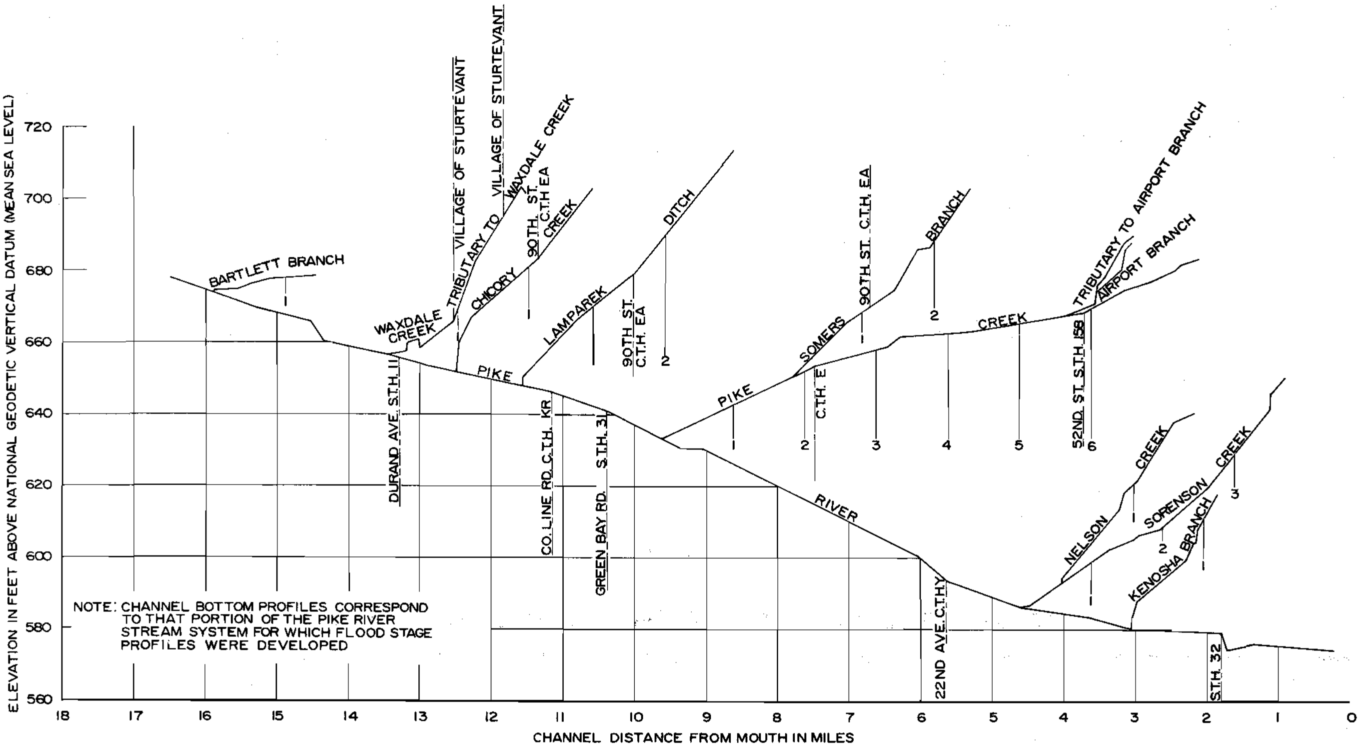
[b] *Includes water, wetlands, woodlands, quarries, and other open lands.*

Source: SEWRPC.

Floodland cross sections were developed from several sources including the available large-scale topographic maps, and field-surveyed cross sections obtained under the watershed study. Channel bottom elevations for some cross sections were obtained from the channel profiles prepared under the study. Map 27 indicates the primary source of floodland cross-section data by river reach throughout the 42.27 miles of stream for which detailed flood hazard information was developed. A flood-

Figure 20

CHANNEL BOTTOM PROFILES FOR THE PIKE RIVER AND SELECTED TRIBUTARIES



Source: SEWRPC.

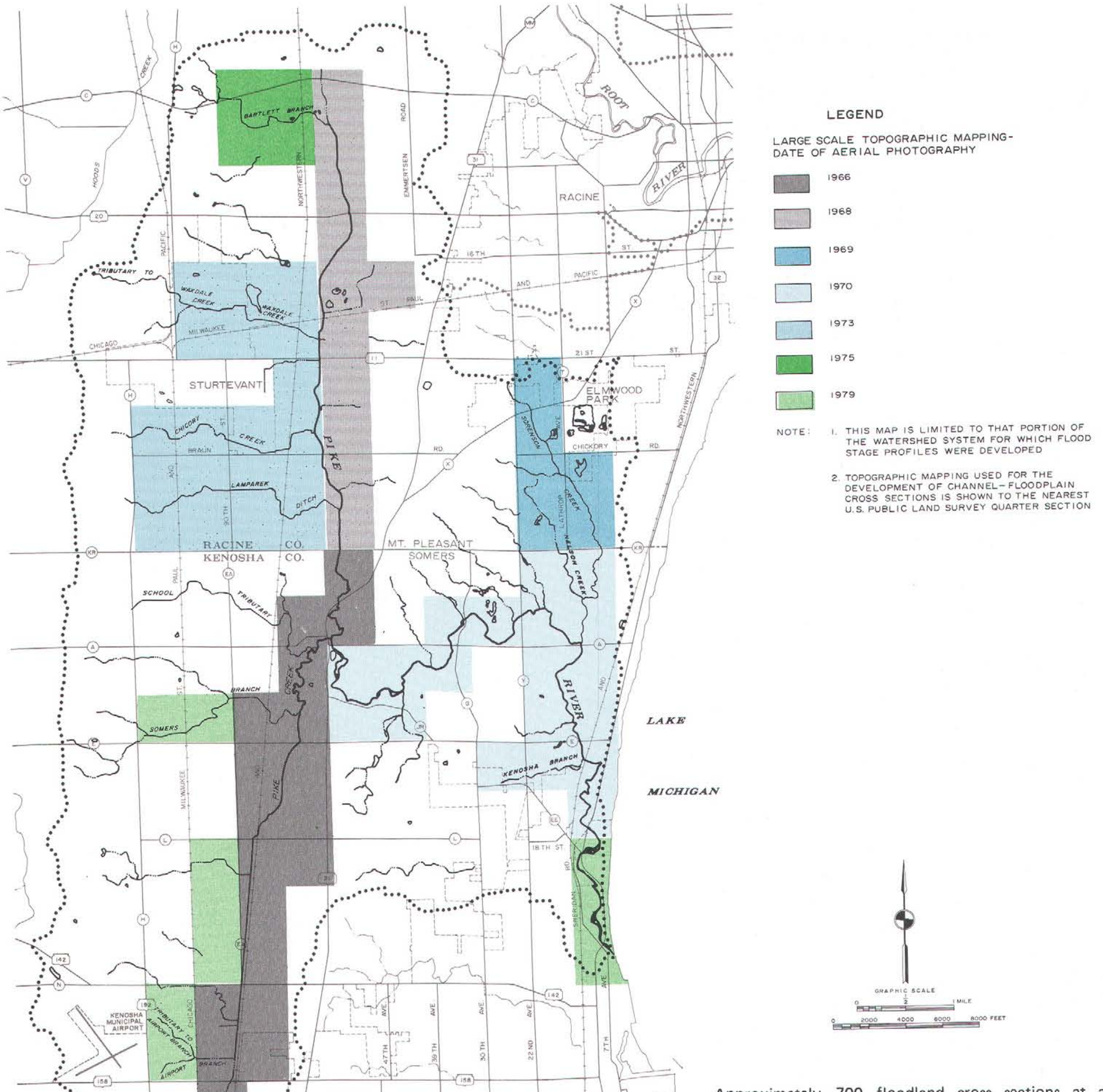
land cross section, typical of those that were drawn prior to coding the data for input to the hydraulic submodel, is shown in Figure 21.

Numerous factors were considered in the selection of the location, length, and orientation of the floodland cross sections. These factors included nonhydraulic plan preparation and implementation as well as strictly hydraulic considerations.

A principal hydraulic consideration was the selection of locations representative of the reach encompassed by the cross section. Other hydraulic factors influencing cross-section location included abrupt changes in cross-sectional area or shape of the channel, or abrupt changes in natural floodplain roughness, and discontinuities in channel slope. Cross sections were generally located at close, regular intervals so as to assure that computed flood stages would be of sufficient accuracy to be useful in all phases of floodland management including the delineation of floodland regulatory zones. Furthermore, closely spaced cross sections facilitate, subsequent to completion of the watershed plan, the hydraulic evaluation of proposed floodland developments or other riverine area changes.

One nonhydraulic factor entering into the location of floodland cross sections was placement at points where civil division boundaries intersect the streams, which was done to permit the evaluation of the hydraulic effect of proposed riverine area developments in one community on upstream or downstream communities. Another nonhydraulic consideration was placement of cross sections at the points where U. S. Public Land Survey section and quarter section lines intersect the streams in order to facilitate the preparation of large-scale

SOURCES OF CROSS SECTION DATA FOR CHANNEL AND FLOODPLAIN IN THE PIKE RIVER WATERSHED

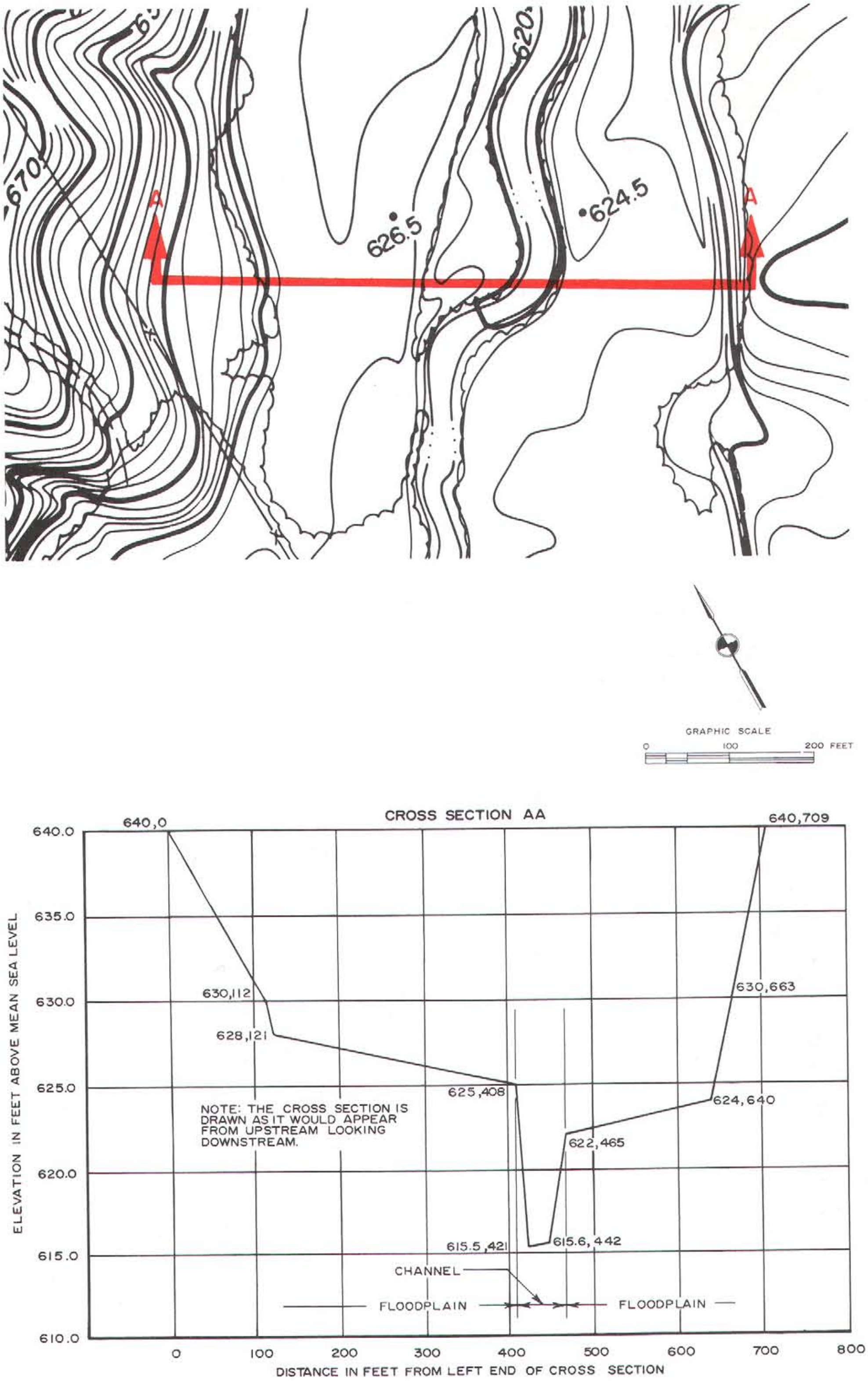


Approximately 700 floodland cross sections at an average spacing of 300 feet were developed for the 42.27 miles of stream modeled under the Pike River watershed study. The floodland cross sections were developed from the several sources shown above which include large-scale topographic maps of the riverine areas and field-surveyed cross sections of the riverine areas. Floodland cross sections are used to determine the hydraulic characteristics of the stream channel and floodplains, characteristics that determine flood stage and the lateral extent of inundation for a given flood discharge.

Source: SEWRPC.

Figure 21

TYPICAL CROSS SECTION OF CHANNEL AND FLOODPLAIN IN THE PIKE RIVER WATERSHED



Source: SEWRPC.

flood hazard maps showing the numerical value of the regulatory flood stages related to real property boundary lines.

With respect to orientation, the floodland cross sections were positioned to be approximately perpendicular to the main flow of the stream and its floodplain during flood flow conditions. The terminal points of the cross sections were established at sufficient distance laterally from the stream so as to be well outside of the anticipated 100-year recurrence interval floodland limits.

Roughness Coefficients: The Manning roughness coefficient is a relative measure of the ability of a channel and its floodplain to convey flow. The discharge that can be conveyed in a given reach of channel at a specified channel slope and water stage is inversely proportional to the Manning roughness coefficient. Thus, the carrying capacity of the channel and its floodplain diminishes as the value of the roughness coefficient increases. Roughness coefficients are a function of several factors, including the kind of material—such as earth, gravel, and rock—forming the channel and attendant natural floodplain; the kind and density of vegetation—for example, rooted aquatic plants in the channel, and grass, agricultural crops, brush, and trees on the adjacent natural floodplains; and the sinuosity or degree of meandering of the channel.

Floodland Manning roughness coefficients were assigned on the basis of field examination of the 42.27 miles of stream in the watershed for which detailed flood hazard information was to be developed. Values were estimated on the basis of the various factors summarized in Table 31, assuming summer or growing season conditions. These data which, in a particular reach, were developed separately for the channel and each attendant natural floodplain, were input to the hydrologic-hydraulic model used in the watershed planning program.

Channel Modifications: Channel modifications—or channelization as it is commonly termed—usually include one or more of the following changes to the natural stream channel: channel straightening; channel deepening and thereby lowering of the channel profile; channel widening; placement of a concrete invert and sidewalls; removal of dams, sills, or other obstructions to flow; and reconstruction of selected bridges and culverts. At times the natural channel may be relocated or completely enclosed in a conduit. These modifications to the natural channel generally yield a lower, hydraulically more efficient waterway, which results in significantly lower flood stages within the channelized reach. While channelization can be an effective means of reducing flood damages, it may entail high aesthetic and ecological costs. Furthermore, because of decreased floodplain storage and increased streamflow velocities resulting from channelization, channel modifications tend to increase downstream peak flood discharges and stages, and, therefore, may cause new flood problems or aggravate existing ones.

Channelization is also employed with artificial subsurface drainage for agricultural drainage purposes to lower high groundwater tables beneath fields near streams to improve soil moisture conditions for crops and for the operation of farm machinery. Such channelization may also be beneficial for flood control purposes because of the increase in channel size attendant to channel deepening. However, channelization for agricultural drainage purposes, as for urban drainage purposes, can cause increased flood flows and stages in downstream reaches.

A large portion of the stream system of the Pike River watershed has been intentionally modified for flood control and agricultural drainage purposes. Of the 42.27 miles of stream system in the watershed selected for development of detailed flood hazard data, approximately 18.70 miles, or 44 percent, are known to have undergone some type of major man-made channel modification. The channel modifications for the most part have been made over a long period of time, presumably by numerous public and private parties, and consequently adequate records are not available to identify all of the stream reaches so modified.

Artificial Subsurface Drainage: Artificial subsurface drainage is a factor primarily affecting the low-flow regimen of a watershed and is often closely associated with channel improvement. Large portions of the Pike River watershed have such poor surface drainage under natural conditions that it has been deemed necessary to install tile underdrains to permit efficient agricultural operations. Because of the individual manner and long period of time over which such drainage improvements have been installed, it is not possible to determine precisely the total tile-drained area. Map 3 shows the drainage districts within the Pike River watershed where tile underdrains may exist. Tile outfalls observed at numerous other locations in the watershed indicate that artificial subsurface drainage of agricultural lands is wide-

Table 31

MANNING ROUGHNESS COEFFICIENTS APPLIED TO THE CHANNEL AND FLOODPLAINS OF THE PIKE RIVER WATERSHED

Channel				Floodplain				
Condition		Roughness Coefficient Component[a]		Condition		Roughness Coefficient		
						Minimum	Normal	Maximum
Material Involved	Concrete		0.013					
	Earth		0.020	Pasture	Short grass	0.025	0.030	0.035
	Rock cut		0.025		High grass	0.030	0.035	0.050
	Fine gravel	n_1	0.024	Cultivated Areas	No Crop	0.020	0.030	0.040
	Coarse gravel		0.028		Mature row crops	0.025	0.035	0.045
Degree of Irregularity	Smooth		0.000		Mature field crops	0.030	0.040	0.050
	Minor		0.005	Brush	Scattered brush, heavy weeds	0.035	0.050	0.070
	Moderate	n_2	0.010		Light brush and trees, in winter	0.035	0.050	0.060
	Severe		0.020		Light brush and trees, in summer	0.040	0.060	0.080
Relative Effect of Obstructions	Negligible		0.000		Medium to dense brush, in winter	0.045	0.070	0.110
	Minor		0.010-0.015		Medium to dense brush, in summer	0.070	0.100	0.160
	Appreciable	n_3	0.020-0.030	Trees	Dense willows, summer, straight	0.110	0.150	0.200
	Severe		0.040-0.060		Cleared land with tree stumps, no sprouts	0.030	0.040	0.050
Vegetation	Low		0.005-0.010					
	Medium		0.010-0.025		Same as above, but with heavy growth of sprouts	0.050	0.060	0.080
	High	n_4	0.025-0.050		Heavy stand of timber a few down trees, little undergrowth, flood stage below branches	0.080	0.100	0.120
	Very high		0.050-0.100					
Degree of Meandering	Minor		1.000		Same as above, but with flood stage reaching branches	0.100	0.120	0.160
	Appreciable	k	1.150					
	Severe		1.300					

[a] *The composite Manning roughness coefficient for a channel reach =* $k\ (n_1 + n_2 + n_3 + n_4)$.

Source: Chow, V. T., Open Channel Hydraulics, Chapter 5, McGraw-Hill Book Co., 1959.

spread in the basin. Tile-drained areas are often, through not always, associated with channel improvement. This is because straightening and deepening of natural channels is often required to provide adequate outlets for the agricultural drain tiles.

The effect of artificial drainage on the flow regimen of a watershed is particularly difficult to analyze, because the effect of the drainage is not to reduce the surface water storage, but rather to increase the capacity for temporary soil water storage during the growing season. The net result may generally be expected to increase the total volume of streamflow due to a reduction of evapotranspiration losses. In the spring, when ice and snow conditions cause blocking of the drainage courses, there is probably little overall effect on natural flow conditions. During the frost-free months, however, when tile underdrains are fully operable, it is probable that areas that have been tiled to eliminate poor surface drainage, or to lower a high groundwater table, will exhibit a decrease in peak surface runoff due to the increased storage made available in the dewatered soil profile, but will result in the ultimate release of a greater volume of flow. However, for the more infrequent, high-intensity, short-duration rainfall events during which soil infiltration capacity is the limiting factor, it is doubtful that tiling in the Pike River watershed has a significant influence on peak rates of runoff.

Map 28 shows the lineal extent and the nature of known major man-made channel modifications within the Pike River watershed on the stream system selected for development of detailed flood hazard data. The following two types of channelization were observed in the Pike River watershed:

1. Minor channelization: Localized clearing and widening with scattered straightening. Little or no concrete or masonry on either the channel bottom or side slopes. Channel modifications not readily apparent to the casual observer. Examples of minor channelization include drainage improvements along Somers Branch in the Town of Somers and urban area modifications along the tributary to Waxdale Creek in the Village of Sturtevant.

2. Major channelization: Continuous and extensive deepening, widening, and straightening, possibly with major relocations. Extensive application of concrete or masonry to channel bottom or side walls. Channel modifications are readily apparent to the casual observer. Major channelization is exemplified by Lamparek Ditch in the Town of Mt. Pleasant and in the urbanized reaches of Sorenson Creek in Elmwood Park.

The 42.27 miles of the watershed stream system selected for hydrologic-hydraulic simulation contain, as shown in Table 29, about 18.70 miles of known major channel modifications, or about 44 percent of the stream system selected for development of detailed flood hazard data. It is difficult to identify with certainty all of those stream reaches in the minor channelization category as various degrees of channel modifications are located throughout the Pike River watershed, which suggests that widespread mitigation of flood damage to riverine area agricultural and urban development along with agricultural subsurface drainage have been the primary motivations for channel modifications in the Pike River watershed.

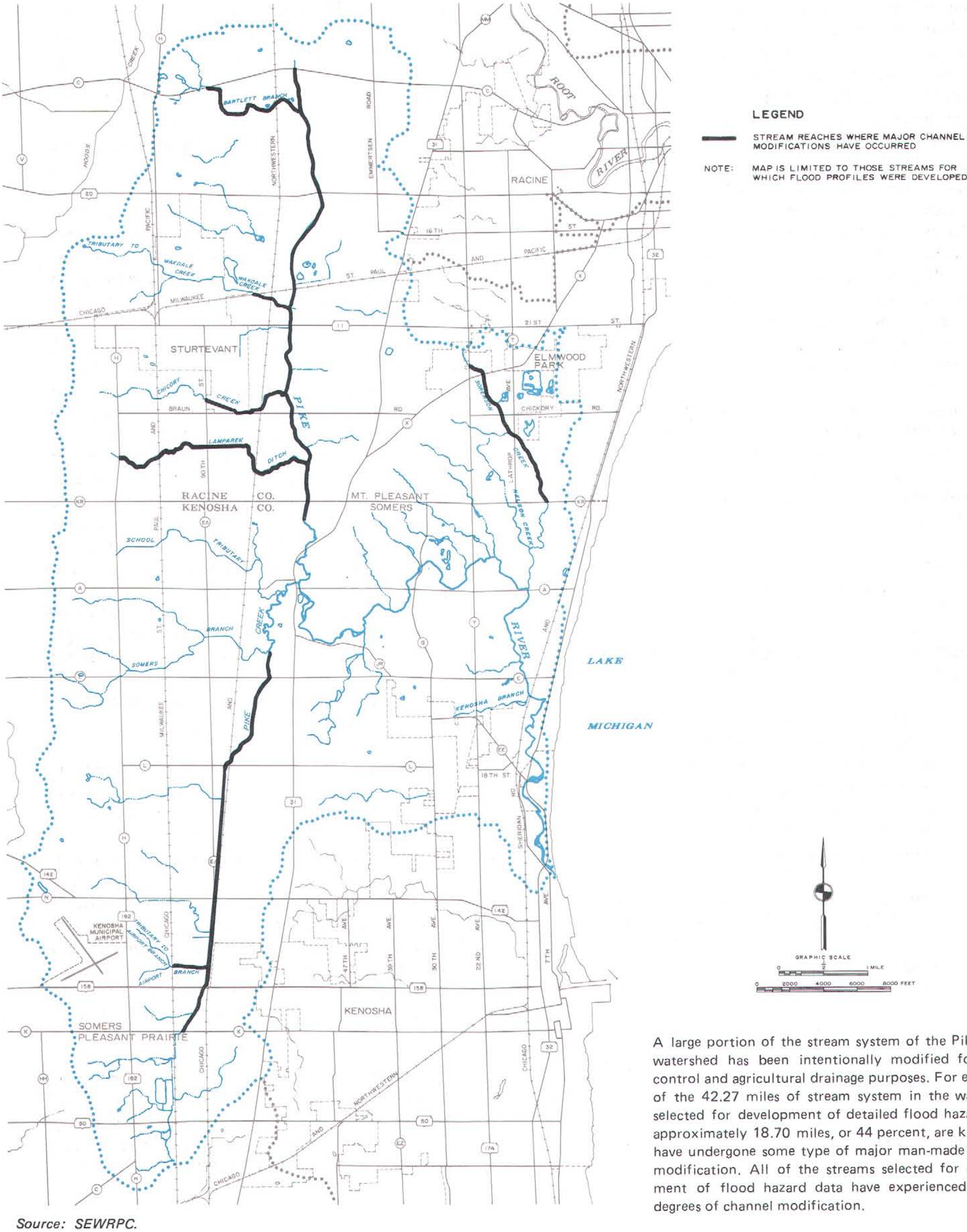
As for downstream riverine areas, the hydraulic effect of channelization is very similar to that of floodplain fill and development. Channelization, like floodplain fill and development, reduces the floodwater storage capability of the modified reach, thereby generally giving rise to downstream flood hydrographs that have, relative to prechannelization conditions, shorter bases and higher peaks. It is possible, however, depending on the relative position of the channelized reach or reaches in the watershed stream system, for channelization to result in reduced downstream discharges. For example, channelization in the lower reaches of a watershed may provide for the rapid removal of runoff from the lower portion of the watershed prior to the arrival of middle and upper watershed drainage, thereby reducing lower watershed discharges and stages.

The effects of channel improvement projects are the reverse of the effect of other structural flood control measures, such as reservoirs, which are designed to impede flow, decrease velocity, and cause backwater effects. Channel improvements accelerate flow, increase velocity, and reduce upstream backwater effects. Floodwater storage structures tend to prolong the base time of surface runoff and decrease peak discharges in the downstream direction, while channel improvements have the effect of decreasing base time and increasing stage and peak flow rates downstream from the improvement.

It is apparent, therefore, that haphazard and uncoordinated channel modification may cause adverse effects elsewhere in a watershed, resulting in little or no net overall improvement of the floodwater problems of a watershed. This pos-

Map 28

CHANNEL MODIFICATIONS IN THE PIKE RIVER WATERSHED



Source: SEWRPC.

A large portion of the stream system of the Pike River watershed has been intentionally modified for flood control and agricultural drainage purposes. For example, of the 42.27 miles of stream system in the watershed selected for development of detailed flood hazard data approximately 18.70 miles, or 44 percent, are known to have undergone some type of major man-made channel modification. All of the streams selected for development of flood hazard data have experienced various degrees of channel modification.

sibility points to the need for proper water management practices based upon a comprehensive watershed plan. In recognition of the need to evaluate the potential downstream effect of channelization proposals within the Pike River watershed, one of the standards supporting the adopted water control facility development objectives, as set forth in Chapter X, "Watershed Development Objectives, Principles, and Standards," requires the explicit determination of the downstream impact of proposed channel modifications. Because historic data are lacking, it is not possible to make a meaningful quantitative evaluation of the overall effect which the existing channel improvement projects have had on the history of the flow regimen of the stream system of the watershed.

Bridges and Culverts: Depending on the size of the waterway opening and the characteristics of the approaches, bridges and culverts can be important elements in the hydraulics of a watershed, particularly with respect to localized effects. The constriction caused by an inadequately designed bridge or culvert under flood discharge conditions can result in a large backwater effect and thereby create upstream flood stages that are significantly higher and an upstream floodland that is significantly larger than would exist in the absence of the bridge or culvert.

As of the end of 1979, the 42.27 lineal miles of Pike River watershed stream system selected for hydrologic-hydraulic modeling were crossed, as shown on Map 29, by 113 bridges and culverts having an average spacing of 0.4 mile. While the hydraulic submodel of the hydrologic-hydraulic simulation model, as described in Chapter VIII, has the capability of accommodating any number or type of bridges or culverts, the cost of the field surveys necessary to acquire the input data for the submodel required that a determination be made, based on a field reconnaissance, of the hydraulic significance of each bridge or culvert in order to significantly reduce the number of structures for which complete physical descriptions would have to be obtained.

A bridge or culvert was defined as being hydraulically significant if field inspection suggested that the structure might increase flood stages for the 10- through 100-year recurrence interval flood discharges. In examining each bridge or culvert to evaluate its potential hydraulic significance, the structure was considered to consist of the roadway or railroad approaches as well as the structural components, such as abutments, piers, and deck, in the immediate vicinity of the waterway opening. One category of hydraulically insignificant bridges and culverts consists of those having a relatively small superstructure compared to the combined width of the channel and its natural floodplain. Such structures typically have approaches that do not rise significantly above the floodplain while the portion of the structure in the immediate vicinity of the channel simply spans the channel. Pedestrian crossings and private roadway bridges and culverts comprise most of the bridges and culverts in this category of hydraulically insignificant structures. An example of this type of hydraulically insignificant structure is, as shown in Figure 22, a park pedestrian bridge over the Pike River in Petrifying Springs Park in the Town of Somers.

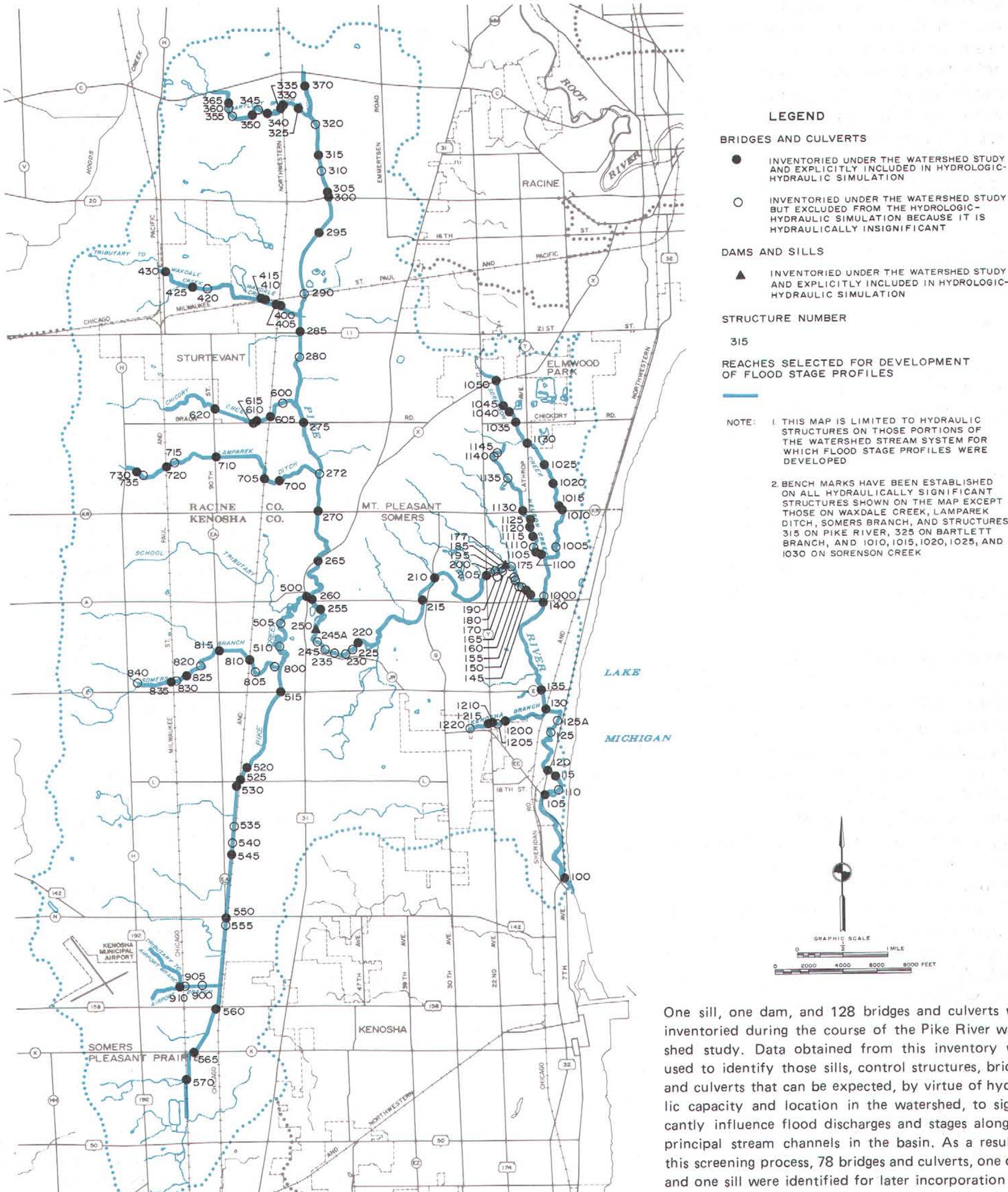
The second category of hydraulically insignificant bridges and culverts consists of those that are elevated on piers well above the channel and the floodplain. While being major or significant structures in the transportation sense in that they carry railroads and public streets and highways and particularly arterial streets and highways across the floodland, they are hydraulically insignificant in that they utilize little or no fill for the approaches and, therefore, offer little impedance to flow during even major flood events. An example of this type of hydraulically insignificant structure, as shown in Figure 22 is the Chicago, Milwaukee, St. Paul & Pacific Railroad bridge over the Pike River in the Town of Mt. Pleasant.

Hydraulically significant bridges and culverts generally are characterized by relatively small waterway openings in combination with approaches that are constructed well above the elevation of the floodplain. Such structures function as dams and have the potential for obstructing streamflow during major flood events. As shown in Figure 23, examples of hydraulically significant structures include the CTH E—12th Street—and CTH Y—22nd Avenue—crossings of the Pike River in the Town of Somers.

Based on field reconnaissance, 78, or 61 percent, of the 128 bridges or culverts on that portion of the Pike River watershed stream system selected for development of detailed flood hazard data were determined to be hydraulically significant. The location of these hydraulically significant bridges and culverts is shown on Map 29 and the

Map 29

HYDRAULIC STRUCTURE INDEX FOR THE PIKE RIVER WATERSHED: 1979



Source: SEWRPC.

One sill, one dam, and 128 bridges and culverts were inventoried during the course of the Pike River watershed study. Data obtained from this inventory were used to identify those sills, control structures, bridges, and culverts that can be expected, by virtue of hydraulic capacity and location in the watershed, to significantly influence flood discharges and stages along the principal stream channels in the basin. As a result of this screening process, 78 bridges and culverts, one dam, and one sill were identified for later incorporation into the water resources simulation model, as described in Chapter VIII.

Figure 22

EXAMPLES OF HYDRAULICALLY INSIGNIFICANT RIVER CROSSINGS IN THE PIKE RIVER WATERSHED

FOOTBRIDGE OVER THE PIKE RIVER

CHICAGO, MILWAUKEE, ST. PAUL & PACIFIC RAILROAD CROSSING OF THE PIKE RIVER

Source: SEWRPC.

Figure 23

EXAMPLES OF HYDRAULICALLY SIGNIFICANT RIVER CROSSINGS IN THE PIKE RIVER WATERSHED

COUNTY TRUNK HIGHWAY E–12TH STREET–CROSSING OF THE PIKE RIVER

COUNTY TRUNK HIGHWAY Y–22ND AVENUE–CROSSING OF THE PIKE RIVER

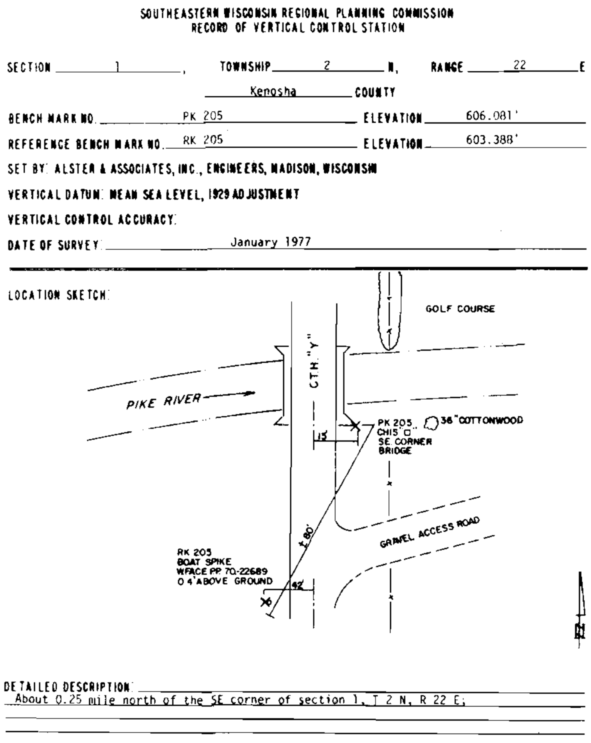
Source: SEWRPC.

number of structures on each of the selected stream reaches is set forth in Table 29. The average spacing of these hydraulically significant structures is 0.4 mile.

To meet the input data needs of the hydraulic submodel, it was necessary to obtain detailed data on these 78 structures. Data needs included measurement of the waterway opening, determination of channel bottom elevations, and construction of a profile—from one side of the floodplain to the other—along the crown of the roadway or the top of rail of the railroad. The necessary information for each of the 78 hydraulically significant bridges and culverts was obtained by field survey. A network of vertical survey control stations—bench marks—referenced to National Geodetic Vertical Datum (Mean Sea Level Datum) was established on all hydraulically significant bridges and culverts prior to the acquisition of detailed data on the structures. Closed spirit level circuits were run to establish permanent bench marks on each structure to third order accuracy. At least one reference bench mark was established for each permanent bench mark and a record of vertical survey control, like that shown in Figure 24, was prepared for each hydraulically significant bridge or culvert. As part of the field survey work needed to establish the vertical survey control network, the channel bottom elevation was determined at the upstream

Figure 24

TYPICAL RECORD OF A VERTICAL CONTROL STATION ALONG THE PIKE RIVER WATERSHED STREAM SYSTEM: 1977



SOUTHEASTERN WISCONSIN REGIONAL PLANNING COMMISSION
RECORD OF VERTICAL CONTROL STATION

SECTION 1, TOWNSHIP 2 N, RANGE 22 E

Kenosha COUNTY

BENCH MARK NO. PK 205 ELEVATION 606.081'

REFERENCE BENCH MARK NO. RK 205 ELEVATION 603.388'

SET BY: ALSTER & ASSOCIATES, INC., ENGINEERS, MADISON, WISCONSIN

VERTICAL DATUM: MEAN SEA LEVEL, 1929 ADJUSTMENT

VERTICAL CONTROL ACCURACY:

DATE OF SURVEY: January 1977

LOCATION SKETCH:

DETAILED DESCRIPTION: About 0.25 mile north of the SE corner of section 1, T 2 N, R 22 E;

Source: SEWRPC.

face of each of the 78 hydraulically significant bridges and culverts, which, in addition to providing information about the waterway opening, facilitated the drawing of channel bottom profiles.

Prior to coding the bridge and culvert data for input to the hydraulic model, the structure information was used to draw a cross section showing the physical configuration of the waterway opening and the approach roads. Figure 25 shows a structure drawing typical of those prepared for each of the hydraulically significant bridges and culverts in the Pike River watershed.

Dams and Sills: In addition to the 128 bridges and culverts located on that portion of the Pike River watershed stream system selected for development of detailed flood hazard information, there is one dam and a low dam-like structure, herein called a sill, for a total of 130 hydraulic control structures. The dam is on the Pike River in Petrifying Springs Park and is used to control the pool level in a pond upstream.

The sill, located on the Pike River 3,500 feet upstream from the confluence with Sorenson Creek, and the dam were determined by field examination to be hydraulically significant using criteria similar to those applied to bridges and culverts. The locations of the dam and the sill are shown on Map 29. Of the 130 hydraulic structures located on the stream system, a total of 80 or about 62 percent, were determined to be hydraulically significant.

The vertical survey control network discussed above was extended to the hydraulically significant dam and sill, and channel bottom elevations were determined at each structure. Detailed information on the physical characteristics of the dam and sill was obtained from the U. S. Soil Conservation Service. Additional necessary information was obtained by field survey. Cross section drawings were prepared for the dam and the sill prior to coding the data for use in the hydrologic-hydraulic modeling.

SUBWATERSHEDS AND SUBBASINS IN THE PIKE RIVER WATERSHED

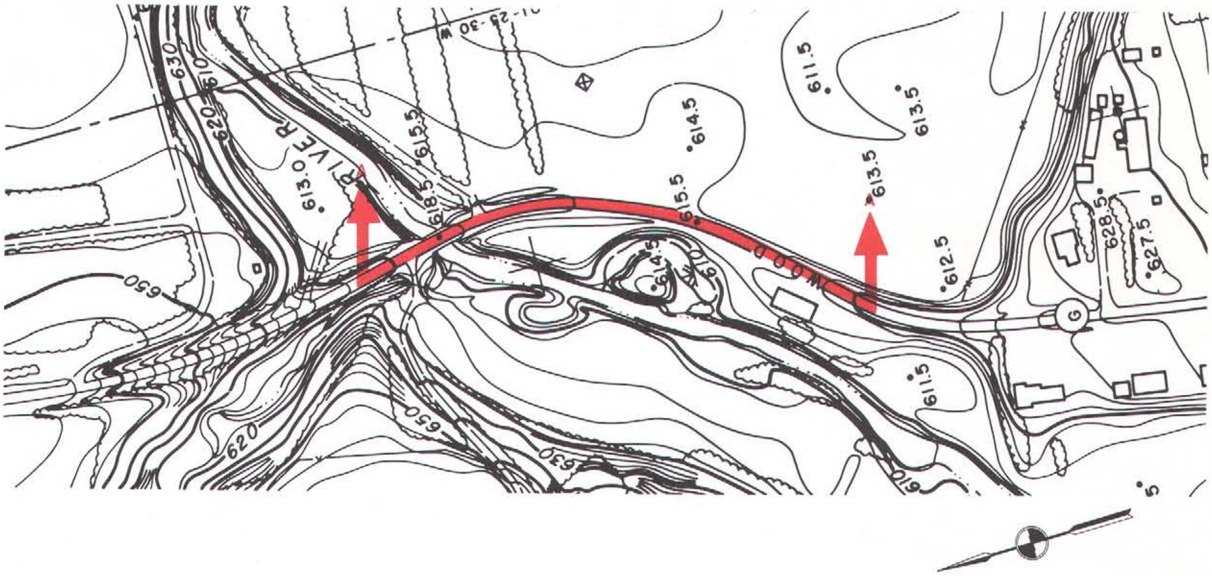
Whereas previous sections of this chapter have described watershed hydrologic-hydraulic charactersitics on the basis of the entire watershed, this last section of the chapter presents hydrologic and hydraulic data for each subwatershed. More specifically, data and information on subbasins, land use, channel slopes, hydraulic structures and channel modifications are presented and discussed below. Summaries of hydraulic and hydrologic data by subwatershed are set forth in Tables 29 and 30, respectively, and subwatershed and subbasin areas are set forth in Table 32.

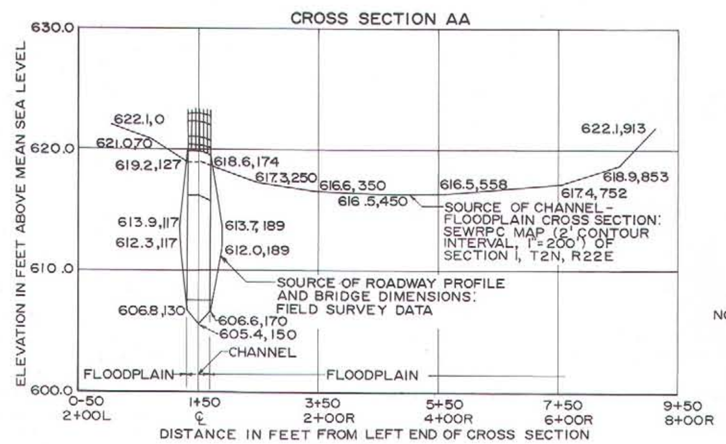
Subwatersheds

The Pike River watershed may be considered to be a composite of three subwatersheds, as shown on Map 30, each of which is defined as the area directly tributary to all or portions of the 12 stream reaches selected for application of hydrologic-hydraulic simulation culminating in the development of detailed flood hazard data. These subwatersheds are: 1) the Lower Pike River subwatershed which encompasses 15.00 square miles, or 29.1 percent of the total watershed area; 2) the Upper Pike River subwatershed which encompasses

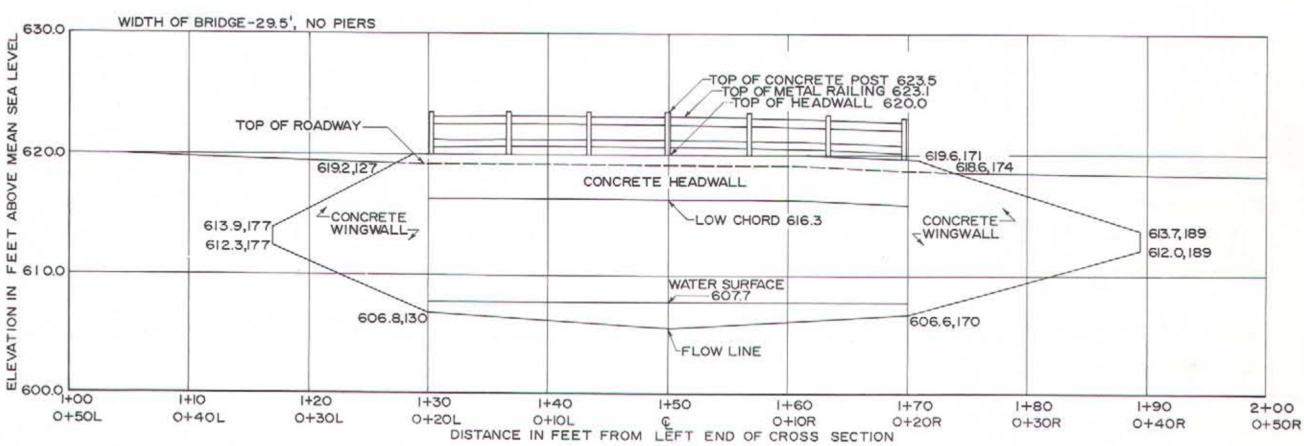
Figure 25

TYPICAL DRAWING OF A HYDRAULIC STRUCTURE IN THE PIKE RIVER WATERSHED





NOTE: THE CROSS SECTIONS ARE DRAWN AS THEY WOULD APPEAR FROM UPSTREAM LOOKING DOWNSTREAM



Source: SEWRPC.

Table 32

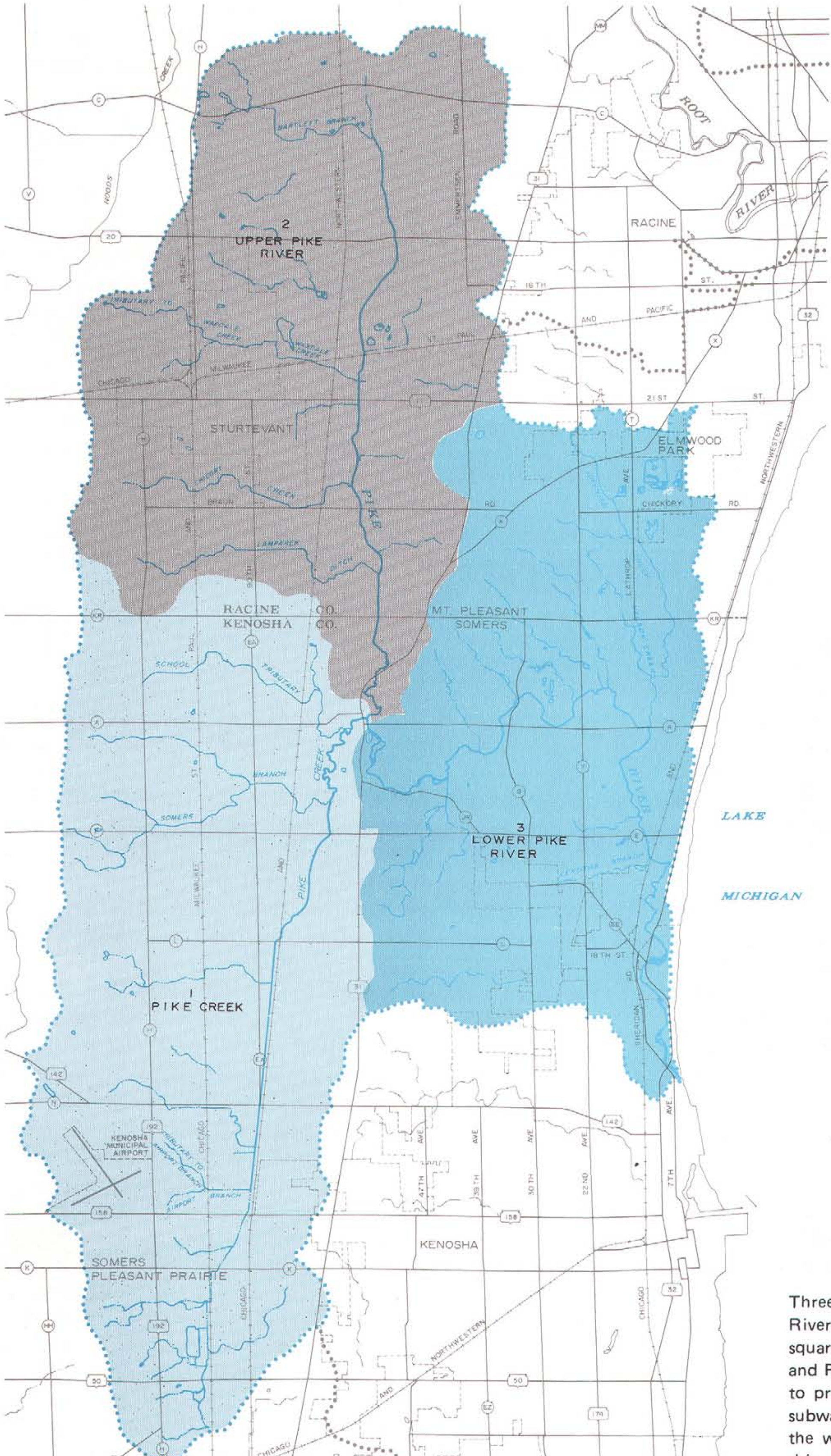
AREAS OF SUBWATERSHEDS AND SUBBASINS IN THE PIKE RIVER WATERSHED

Subwatersheds				Subbasins		
Number	Name	Area (square miles)	Total Area Tributary to Subwatershed Discharge Point (square miles)	Identification	Area (square miles)	Total Area Tributary to Subwatershed Discharge Point (square miles)
1	Pike Creek	19.205	19.205	PC-1	1.111	1.111
				PC-2	1.568	2.679
				PC-3	0.830	3.509
				PC-4	1.585	1.585
				PC-5	2.128	7.222
				PC-6	1.812	9.034
				PC-7	1.957	1.957
				PC-8	1.516	12.507
				PC-9	0.693	13.200
				PC-10	1.186	1.186
				PC-11	1.488	2.674
				PC-12	0.253	16.127
				PC-13	1.327	1.327
				PC-14	0.400	1.727
				PC-15	1.292	3.019
				PC-16	0.059	19.205
2	Upper Pike River	17.338	17.338	UPR-1	1.668	1.668
				UPR-2	1.246	1.246
				UPR-3	1.458	4.372
				UPR-4	1.755	1.755
				UPR-5	2.182	8.309
				UPR-6	1.055	1.055
				UPR-7	0.531	1.586
				UPR-8	0.619	2.205
				UPR-9	1.980	12.494
				UPR-10	0.833	0.833
				UPR-11	0.421	1.254
				UPR-12	1.006	14.754
				UPR-13	0.953	0.953
				UPR-14	0.659	1.612
				UPR-15	0.972	17.338
3	Lower Pike River	14.997	51.540	LPR-1	0.574	37.117
				LPR-2	1.149	1.149
				LPR-3	0.966	39.232
				LPR-4	0.680	39.912
				LPR-5	1.024	40.936
				LPR-6	0.855	0.855
				LPR-7	0.204	41.995
				LPR-8	1.610	1.610
				LPR-9	1.437	3.047
				LPR-10	0.713	3.760
				LPR-11	1.184	46.939
				LPR-12	0.889	47.828
				LPR-13	1.135	48.963
				LPR-14	1.844	50.807
				LPR-15	0.733	51.540

Source: SEWRPC.

Map 30

SUBWATERSHEDS OF THE PIKE RIVER WATERSHED



Source: SEWRPC.

Three subwatersheds were delineated within the Pike River watershed with areas of 17.34, 15.00, and 19.20 square miles for the Upper Pike River, Lower Pike River, and Pike Creek subwatersheds, respectively. In addition to providing rational units for hydrologic analysis, the subwatersheds serve as geographic units that enable the watershed resident to readily identify the relationship of his or her local drainage area to the large Pike River watershed.

17.34 square miles, or 33.6 percent of the total watershed area; and 3) the Pike Creek subwatershed which encompasses 19.20 square miles, or 37.3 percent of the total watershed area.

In the Upper Pike River subwatershed, major channel modifications are known to have occurred in over 83 percent of the stream reaches selected for development of flood hazard information and in the Pike Creek subwatershed over 57 percent are known to have been modified. In the Lower Pike River, the extent of channel modifications is unknown but appears to be minimal at least with respect to the flood control impacts.

Subbasins

Hydrologic-hydraulic simulation modeling, the function of which is described in Chapter VIII, "Water Resource Simulation Model," requires that the subwatersheds be further subdivided into hydrologic subbasins. Hydrologic subbasins are the basic "building blocks" for simulating the hydrologic-hydraulic response of the watershed land surface. As shown on Map 31, a total of 46 subbasins was delineated in the watershed, ranging in size from 0.06 to 2.18 square miles, and having an average area of 1.12 square miles. These subbasins were delineated using topographic mapping, supplemented with street grade data and information on the location, configuration, and elevation of storm sewer systems as available and necessary.

A number of factors were considered in the delineation of the subbasins. Some of these were strictly hydrologic-hydraulic factors while others were more directly related to plan preparation and implementation. Subbasins were delineated to encompass areas tributary to intermittent streams, drainageways, and storm sewers. Even through those streams and drainageways may not have been selected for development of detailed flood hazard data under the watershed planning program, such delineations may be useful in subsequent extensions and refinements of the Pike River watershed plan. The boundaries of subbasins were selected to reflect land use, vegetative cover, and land slope. The existence of prominent natural features, such as potential sites for surface water impoundments and prominent man-made features, such as dams, or long or high railroad and roadway embankments, also entered into selection of the discharge point to be delineated for some subbasins. Subbasins were delineated to terminate at streamflow and water quality monitoring stations, near village and city boundaries, and at the upstream end of stream reaches for which flood hazard data were to be developed. Some subbasins were established to correspond to areas of special concern for watershed management, such as those areas subject to urbanization or to other significant land use changes.

SUMMARY

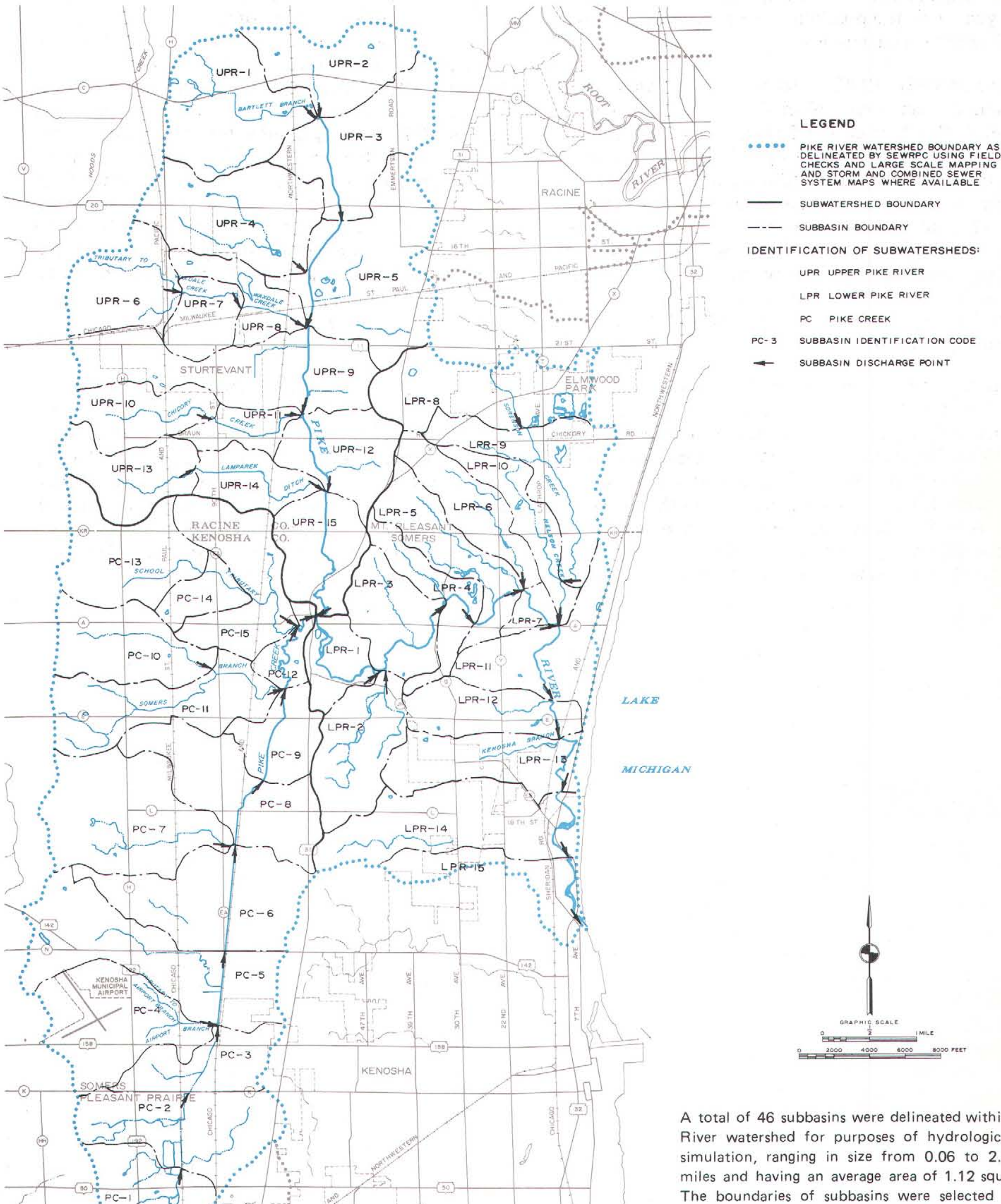
This chapter describes those elements of the hydrologic-hydraulic system of the Pike River watershed which constitute the framework within which all the water resource-related problems of the watershed must be analyzed and resolved. Included in the description of the hydrology of the watershed are data on precipitation, evapotranspiration, and other aspects of the hydrologic budget; data on the volume and timing of runoff as revealed by stream gaging records; and data on the location and quantity of water contained within the aquifers lying beneath the watershed. Included in the discussion of the hydraulics of the watershed are data on the length, slope, and flow resistance of the stream system; and an evaluation of the hydraulic significance of hydraulic structures.

Knowledge of the complex hydrologic cycle as it affects the watershed is necessary to assess the availability of surface and groundwater for various uses and to improve the potential managment of water during times of flooding or drought. The quantitative relationships between inflow and outflow—termed the hydrologic budget—were determined for the watershed. Precipitation is the primary source of water to the watershed and averages 32.4 inches annually. Surface water runoff and evapotranspiration losses constitute the primary outflow from the basin. The average annual runoff approximates 13.3 inches and the annual evapotranspiration loss total is about 19.1 inches.

Streamflow and flood stage records available for the Pike River stream system reveal that for predominantly rural areas two periods during the year are the most likely to produce major flooding. Historically, the period February through April and the month of June have produced about 80 percent of the annual flood peaks in the rural areas of the Pike River watershed. In contrast, highly urbanized watersheds which contain relatively large amounts of impervious surface area, extensive storm water drainage systems, and channelization works exhibit a more uniform annual distribution of flooding events somewhat similar to the annual distribution of major rainfall events which can be

Map 31

SUBBASINS OF THE PIKE RIVER WATERSHED



Source: SEWRPC.

A total of 46 subbasins were delineated within the Pike River watershed for purposes of hydrologic-hydraulic simulation, ranging in size from 0.06 to 2.18 square miles and having an average area of 1.12 square miles. The boundaries of subbasins were selected to reflect homogeneous hydrologic soil groups, land use, vegetal cover, and land slope, and thus permit more ready characterization of hydrologic-hydraulic behavior of the land surface.

expected, for the most part, during all months of the year with the possible exception of the months of December and January.

Approximately 42.27 lineal miles of the watershed stream system were selected for development of detailed flood hazard information, including discharge-frequency relationships, flood stage profiles, and mapped areas of inundation for selected flood recurrence intervals. Detailed data were obtained for 81 hydraulically significant bridges, culverts, dams, and sills on that portion of the stream system, and for 700 floodland cross sections, all of this data being required as input to the hydrologic-hydraulic simulation model developed for the watershed.

There are three main groundwater aquifers beneath the watershed: the deep sandstone, the shallow dolomite, and the unconsolidated sand and gravel aquifers. The confined or artesian sandstone aquifer is the deepest of the three systems and, except for minor leakage and a connection to the recharge area, is hydraulically separated from the remainder of the hydrologic-hydraulic system by the overlying semipermeable Maquoketa shale formation. The dolomite aquifer and the unconsolidated sand and gravel aquifers are, in contrast to the sandstone aquifer, recharged locally. It is estimated that the volume of water contained within the three aquifers directly beneath the watershed would be sufficient to cover the entire watershed to a depth at least 200 feet. Groundwater in the deep sandstone aquifer beneath the northern two-thirds of the watershed moves in a generally northerly direction toward Milwaukee, whereas in the southern third of the watershed the flow is generally to the south toward Chicago area wells. Flow in the dolomite and sand and gravel aquifers tends to be more varied but exhibits an overall movement toward Lake Michigan.

The Pike River watershed may be considered as a composite of three subwatersheds, namely the Upper Pike River, Pike Creek, and Lower Pike River subwatersheds having areas of 17.34, 19.20, and 15.00 square miles, respectively. Hydrologic-hydraulic information, including land use, channel slopes, hydraulic structure, and channel modification data, was inventoried and analyzed for each of these subwatersheds.

Chapter VI

HISTORIC FLOOD CHARACTERISTICS AND PROBLEMS

INTRODUCTION

Flooding of the stream system of the Pike River watershed has been, and, in the absence of corrective action, may be expected to continue to be a common and natural occurrence. In portions of the watershed, the streams leave their channels and occupy portions of the adjacent natural floodplains almost annually as a result of late winter-early spring snowmelt or snowmelt-rainfall events or in response to spring, summer, and fall thunderstorms. Damage from this flooding has been largely a consequence of the failure to recognize and understand the relationships which should exist between the use of land—in both floodland and nonfloodland areas of the basin—and the hydrologic-hydraulic behavior of the stream system. Unnecessary occupancy of the natural floodlands by flood-vulnerable land uses, together with development-induced changes in the flow characteristics of the streams, has produced serious flood problems in the watershed. Some of these problems, but not all, have been at least partially resolved through the construction of channel improvements. In some cases channel improvements have aggravated flooding problems downstream.

Comprehensive watershed planning is the first step in achieving or restoring a balance between the use of land and the hydrologic-hydraulic regimen of the watershed. To ensure that future flood damage will be held to a minimum, plans for the proper utilization of the riverine areas of the watershed must be developed so that control of land uses in flood hazard areas, public acquisition of floodlands, and river engineering can be used to properly direct new development into a pattern compatible with the demands of the river system on its natural floodlands and to achieve an adjustment or balance between land use development and floodwater flow and storage needs.

Flood damage potential and flood risk have grown from a nuisance level during initial development of the watershed to substantial proportions as urban land use has increased. Some of the present flood risk can be ascribed to the unnecessary location of flood-damage-prone urban development in the natural floodlands—unnecessary since adequate alternative locations are available within the watershed and Region for such development—aggravated by increased flood flows attributable to upstream urbanization. Because the Pike River watershed is not yet highly urbanized, opportunity still exists for limiting flood damage risk through sound land use development in relation to the riverine areas of the watershed.

This chapter presents a summary of historic information on the character and nature of flooding within this primarily rural but urbanizing basin. Included in this chapter are discussions of direct, indirect, and intangible flood losses and risks; the categorization of flood losses and risks by private and public ownership; and the methodology used to quantify flood risks in monetary terms.

This chapter, which discusses historic flood characteristics and damage, and most of Chapter XII, "Alternative Floodland Management Measures," are directed primarily at the inventory, analysis, and resolution of flood problems along the 42.27 miles of stream channels in the Pike River watershed selected for development of detailed flood hazard data and attendant flood control plans, as shown on Map 26. The Pike River watershed plan is intended to provide recommendations for the resolution of existing flood problems along the selected stream channel reaches and the prevention of future flood problems in the associated riverine areas. The watershed planning process is not intended to address the resolution of storm water problems not directly attributable to flooding of the watershed stream system.

Basic Concepts and Related Definitions

Flooding is herein defined as inundation of the floodplains of the watershed, that is, of the relatively wide, low-lying, flat to gently sloping areas contiguous to and usually lying on both sides of the stream channels, as a direct result of stream water moving out of and away from the major stream channels. Flooding is a natural and certain process in hydrologic-hydraulic systems—one that is unpredictable only in the sense that the exact time of occurrence of a flood of a given magnitude cannot be predetermined, although the average recurrence interval of such a flood is amenable to engineering analyses. How much of a natural floodland will be occupied depends on the severity of the flood and, more particularly, on the peak elevation of the floodwaters. Thus, an infinite number of outer limits of natural floodlands may be delineated, each related to a specified recurrence interval as determined by engineering analyses. Based upon such analyses, floodlands may be delineated on large-scale topographic maps as continuous linear areas lying along the streams and water courses. Flooding is not necessarily synonymous with the presence of flood problems. Flood problems—and the demand for flood control works and measures—are created only when flood-damage-prone land uses are allowed to intrude upon the natural floodlands of the watershed in such a fashion and to such an extent that the certain, although random, inundation of the floodlands results in disruption, monetary damages, and risks to human health and life.

Storm water inundation is defined herein as the localized ponding of storm water runoff which occurs when such runoff moving toward streams and other low-lying areas via small intermittent channels, storm sewers, and other drainageways, or as overland or sheet flow, either exceeds the conveyance capacity of those channels, sewers, or drainageways and flows onto adjacent low-lying areas, or, in the case of overland flow, encounters flow resistance or obstruction and temporarily accumulates on the land surface.

Storm water inundation and riverine area flooding, as defined herein, differ in several significant ways. While storm water inundation involves water moving downslope toward major rivers, flooding is caused by water moving in the opposite way, that is, out and away from major stream channels. Flooding is generally associated with river reaches having tributary drainage areas of tens or hundreds of square miles, whereas tributary drainage areas pertinent to storm water inundation are small—generally less than one square mile. Flooding generally occurs along the major perennial streams, whereas storm water inundation is associated with intermittent channels or man-made drainageways or drainage swales. In contrast to areas experiencing flooding, areas experiencing storm water inundation tend to be discontinuous, consisting of a series of relatively small and scattered pockets not necessarily located in the lowest areas or near major streams or even near small intermittent channels or other well-defined drainageways. The definition of urban areas subject to storm water inundation requires detailed analysis of local topography and local street and associated building grades and of local storm water drainage and sanitary sewerage systems, whereas the definition of flood-prone areas requires a broader, watershedwide analysis of the riverine areas of the major streams.

Storm water problems are not necessarily synonymous with storm water inundation. Storm water problems, and the demand for works and measures to control storm water runoff as it moves toward the natural and man-made drainageways, are created only when urban development occurs without proper regard for storm water runoff conveyance and storage needs. Such local problems in urban design are to be differentiated from the areawide problems referred to as flooding—associated with the movement of waters away from a channel, and up onto adjacent lands. Thus, the analysis of local storm water drainage problems is not addressed in the comprehensive watershed planning studies conducted by the Commission generally, and is therefore beyond the scope of the Pike River watershed study specifically, as agreed by the Pike River Watershed Committee during preparation of the Pike River Watershed Planning Program Prospectus.

USES OF HISTORIC FLOOD INFORMATION

The collection, collation, and analysis of historic flood information are important elements of any comprehensive watershed study. Historic flood data have six primary applications in watershed planning and plan implementation, each of which is discussed below. Five of these applications occur during the planning process and one is directly related to plan implementation.

Identification and Delineation of Flood-Prone Areas

While the location and extent of some flood-prone areas within the Pike River watershed were known at the outset of the watershed study, the location and extent of all such areas within the watershed were not known for existing land use and channel conditions, nor was the existing information adequate to facilitate the development of alternative solutions to the flood problems. One important use of historic flood information in the watershed study, therefore, was the identification and delineation of all riverine areas in the watershed that not only are subject to flooding, but in which the flooding either causes or has the potential for causing significant monetary flood damages.

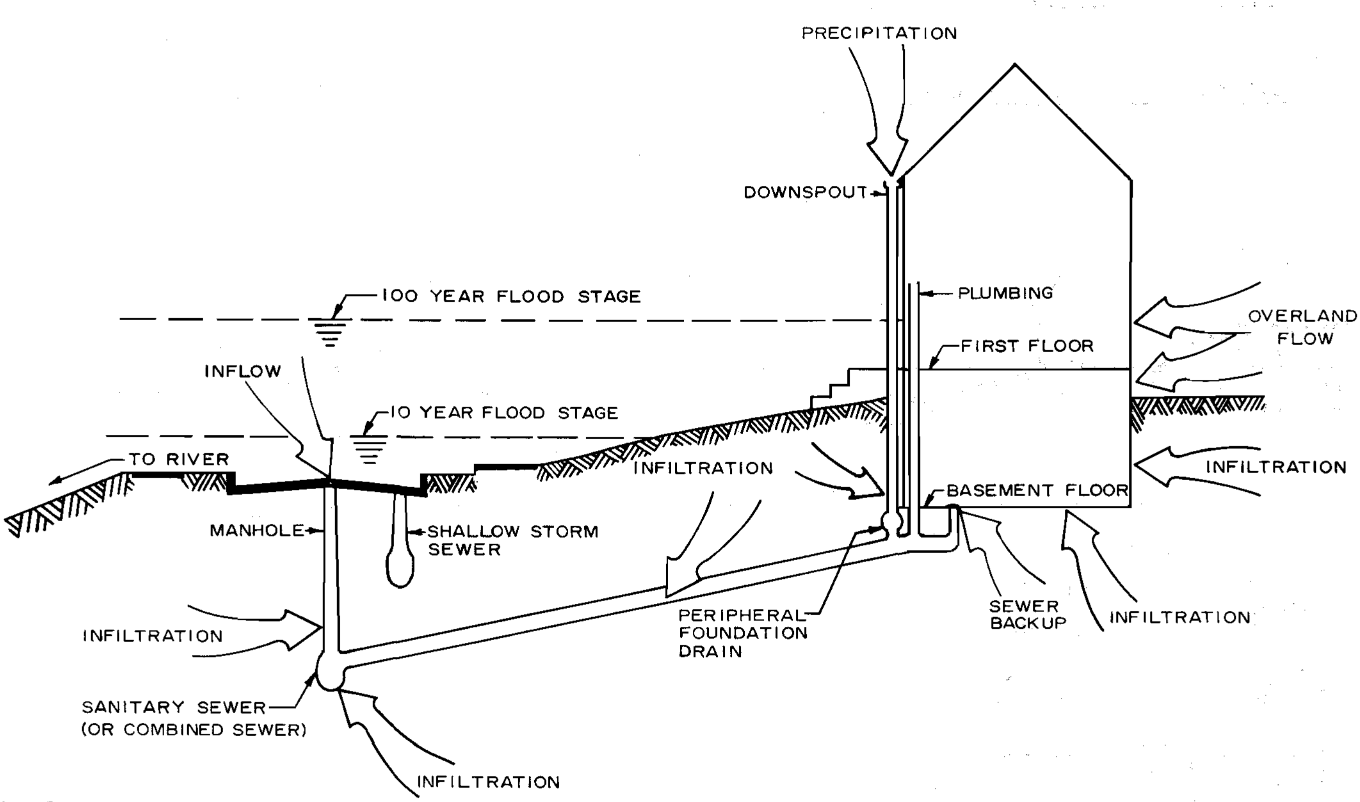
Determination of the Cause of Flood Damage

Flood damages in rural areas are caused primarily by the inundation of crops, and, to a lesser extent, by the inundation of roadways, agricultural buildings, and agricultural drainage systems. Historic floods have caused a wide range of agricultural damage in the watershed, including damage to and destruction of crops. Crop damage and destruction are dependent upon the date of flood occurrence, the duration and depth of flooding, the floodwater velocity, and the type of crop. Early spring floods can delay planting, not only during the flooding periods but also afterwards, when field conditions may be too wet for the operation of farm machinery, resulting in an effectively shorter growing season and attendant reductions in agricultural production and farm income.

Flood damages in urban areas are caused primarily by the inundation of buildings and, to a lesser extent, by the inundation of roadways and utilities. Residential, commercial, and industrial buildings are particularly vulnerable to flood damage partly because of the many ways in which floodwaters can enter such structures. As illustrated in Figure 26, an unprotected floodland structure is a virtual "sieve" for the entry of floodwaters. Rising floodwaters may surcharge the sanitary, storm, or combined sewers in an urban area thereby reversing the flow in these sewers and forcing water into the structures through basement floor drains, plumbing fixtures, and other openings connected to the sewer system. As a result of saturated soil conditions around structure foundations, water may enter through cracks or structural openings in basement walls or floors. If overland flooding occurs—that is, flood stages rise above the elevation of the ground near a particular residential, commercial, or industrial structure—

Figure 26

MEANS BY WHICH FLOODWATERS MAY ENTER A STRUCTURE



NOTE: TYPICAL AND GENERALLY PREFERABLE VARIATIONS INCLUDE DOWNSPOUTS DISCHARGING TO THE GROUND SURFACE AND FOUNDATION DRAINS CONNECTED TO STORM SEWERS OR CONNECTED TO A SUMP FROM WHICH WATER IS PUMPED TO THE GROUND SURFACE AT SOME POINT AWAY FROM THE STRUCTURE

Source: SEWRPC.

additional floodwater may enter the basement of the structure through basement doors, windows, and other structural openings. If flood stages rise high enough, floodwaters similarly may gain access to the first or main floor of a structure. In addition to the inundation damage to the structure and its contents, external hydrostatic pressures may cause the uplift and buckling of basement floors and the collapse of basement walls. Finally, floodwaters may exert hydrostatic or dynamic forces of sufficient magnitude to lift or otherwise move a structure from its foundation.

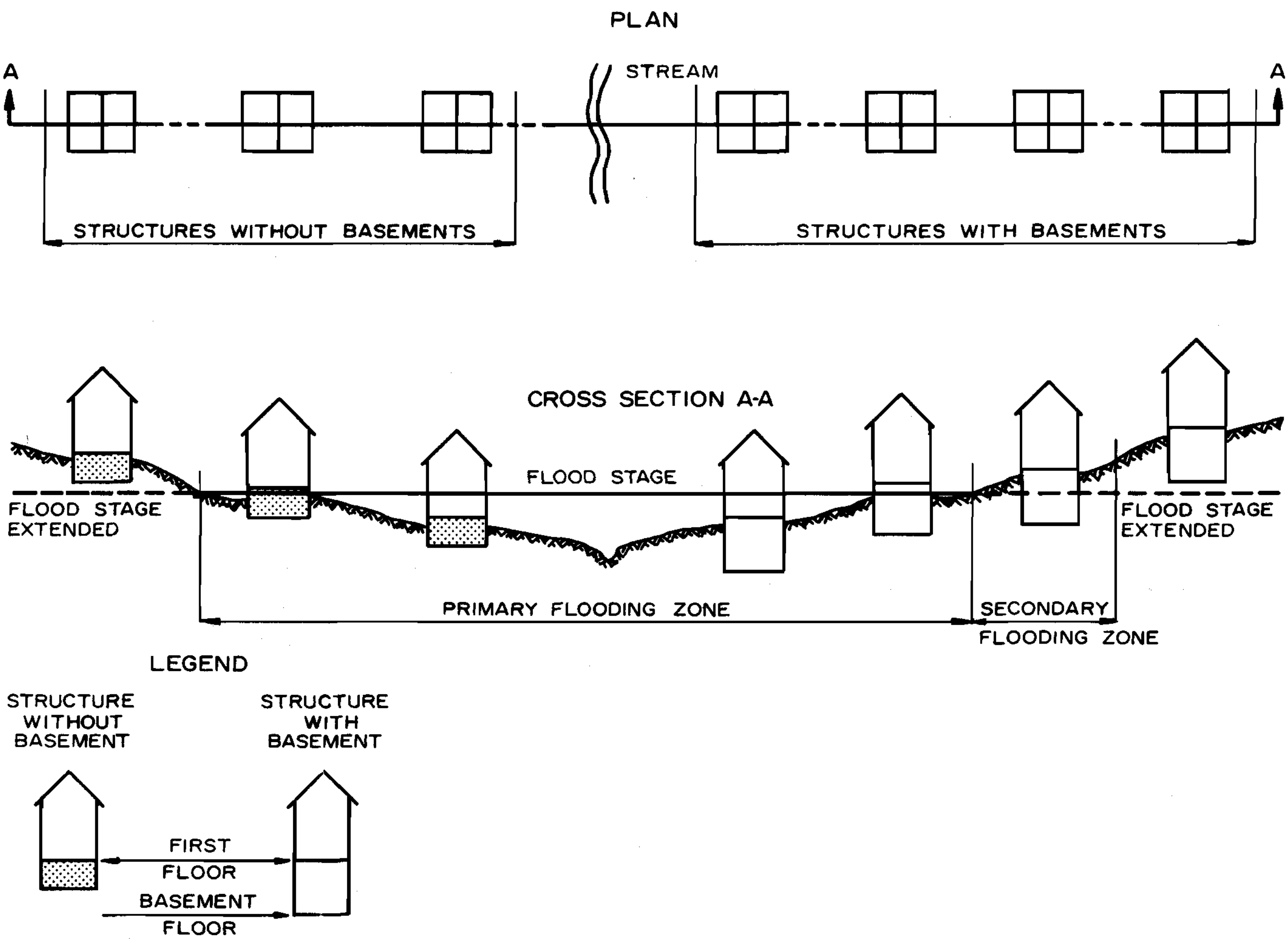
It should be noted that flood damage can occur to the basements of structures located outside of the geographic limits of the overland flooding when floodwaters gain access to basements via the hydraulic connections between the inundated area—the area of primary flooding—and basements that are provided by the sanitary, storm, or combined sewer systems. Such flooding of basements outside of, but adjacent to, the area of primary flooding is herein defined as secondary flooding. Primary and secondary flooding zones are illustrated in Figure 27.

Calibration of the Hydrologic-Hydraulic Model

Flood flows, stages, and areas of inundation throughout the watershed were developed by application of a mathematical simulation model. Sound engineering practice requires "calibration" of such a model through careful comparisons

Figure 27

PRIMARY AND SECONDARY FLOOD ZONES



Source: SEWRPC.

between the model results and reliable observations of the actual hydrologic-hydraulic behavior of the stream system. Such comparisons permit adjustments to and refinements in the model and thereby result in a more accurate representation of watershed hydrology and hydraulics. As described in Chapter VIII, "Water Resource Simulation Model," use was made of historic flood information during the model calibration process.

Computation of Monetary Flood Risk

Monetary flood risks for flood events of specified recurrence intervals, as well as average annual risks under existing and probable future land uses, must be determined for selected stream reaches in order to permit economic evaluation to be made of alternative flood control measures. The information required to compute monetary flood risks includes data: 1) on the types of agricultural land flooded, including specific crops potentially inundated; 2) on the types of structures affected; 3) on the elevation of the ground at the structure and on the elevation of the first floor; 4) on the existence of a basement; and 5) on the market value of the structure and land excluding structure contents. Damage to structure contents is determined as described later in this chapter under "Determination of Indirect Damages."

Formulation of Alternative Flood Control Measures

Alternative flood control measures include acquisition and removal of flood-prone structures, structure floodproofing, channel modification, and construction of dikes, floodwalls, and flood control reservoirs. To be technically feasible, the measures and combinations of measures formulated for each floodprone stream reach must be directed at the primary cause of the flooding. For example, earth dikes and concrete floodwalls are technically feasible solutions in river reaches that historically have been subjected to overland flooding but are not effective, if used alone, in those riverine areas that incur extensive secondary flooding. Formulation of alternative flood control measures for a particular reach, therefore, is influenced by the nature and causes of the flood problems in that reach as determined from historic flood information.

Postplan Adoption, Information, and Education

The aforementioned uses of historic flood information all relate to the preparation of comprehensive watershed plans. The sixth and last use of such information occurs during the plan implementation process after the plan is completed. Experience indicates that some segments of the public are very concerned about flood problems immediately after a severe flood event, whereas, with the passage of time—months and years—concern diminishes until the next severe event. Other segments of the public tend to the opposite extreme, that is, exaggeration of the seriousness of the flood problem in general and of specific flood events in particular.

Documented historic flood information is an effective way to bring the seriousness of flood problems into proper focus and perspective for rational, objective consideration. This information provides a common basis for understanding the nature of the problem in a particular locality and, thus, promotes implementation of the flood control recommendations contained in the adopted watershed plan. Historic flood information—in contrast with flood hazard information produced by mathematical modeling—is particularly effective in improving public understanding of the need for plan implementation, since laymen can more readily understand and relate to such graphic data as a photograph of flood damage, a peak flood stage measured from and related to a bridge, or the delineation of the lateral extent of flooding based on the deposit of debris as observed in the field. Historic flood information, accordingly, has been included in this chapter so that it will be readily and widely available to both public officials and interested citizens and thereby contribute to plan implementation.

INVENTORY PROCEDURE AND INFORMATION SOURCES

A research effort employing a variety of procedures and information sources was required to develop the account of historic flooding in the Pike River watershed as presented in this chapter. The inventory of historic flooding was initiated by reviewing engineering and planning reports previously prepared by governmental agencies and private consulting firms and addressed to flood problems in all or parts of the watershed. Records for the single continuous record streamflow gaging station and the single crest stage gage located in the Pike River watershed were obtained and analyzed to identify flood dates since 1960[1]. These

[1] *The crest stage gage is located at the STH 142 crossing of Pike Creek and has been in operation since 1960; the continuous record streamflow gaging station is located on the Pike River near the University of Wisconsin-Parkside and has been in operation since 1972.*

dates were supplemented with dates of major historic flood events in the nearby Fox River watershed as documented in the Commission comprehensive planning study for that watershed. In addition, synthetic streamflows generated for the Pike River watershed by application of the Commission's continuous process hydrologic-hydraulic simulation model were also utilized for identification of major flood events since 1940.

This initial review of published reports and data was followed by a review of newspapers and newspaper files. Although a long period of history was considered in this review, information could be assembled on each of only a few historic floods. The principal sources of information for this review were past issues of The Kenosha News and The Racine Journal Times. Paralleling the review of historic issues of these newspapers, the Commission staff contacted officials of various organizations, including officials of the Town of Mt. Pleasant, the Town of Somers, the city engineers of the Cities of Kenosha and Racine, and officials of Carthage College. Very limited historic flooding information was available, with no information whatsoever on highwater mark elevations available from these sources.

ACCOUNTS OF HISTORIC FLOODS

Method of Presentation

The historic flood information for the Pike River watershed, as obtained by means of the inventory efforts described above, is presented in this study by major flood events. Major flood events are defined herein as those known to have caused relatively heavy widespread flooding, significant damage to property, and disruption of normal community activities. Nine major flooding periods were identified beginning with the March 30, 1960 flood and extending through the September 13, 1978 flood. Although the disruption associated with each major flood may have been of several days duration, the flood event is herein identified by the date on which the highest, or peak, flood stage was known, or believed, to have occurred, or the period during which more than one flooding event occurred.

The flood problems discussed herein were selected to be representative of the kind of damage or disruption that occurred and of the locations in which it occurred. Monetary flood losses included in the descriptions of historic flooding are those reported or otherwise recorded during or shortly after each flood event and have not been adjusted to current economic levels. In addition, for some historic floods the total monetary damage was estimated in 1980 dollars for current land use and channel conditions using the Commission's flood economics submodel.

Although historic high water marks for major floods are among the best means of documenting in a detailed and definitive manner the severity of historic flooding by graphically presenting peak stages relative to the channel bottom and relative to various hydraulic structures located along a stream system, no definitive data on such marks could be discovered in the historic flood inventory other than that for two highwater marks contained in the U. S. Soil Conservation Service flood hazard study—one at the Carthage College Field House and one at the Valley Night Club on STH 32[2]—and a single high water mark recorded in Petrifying Springs Park by the Kenosha County Park Commission staff. However, photographs and reports concerning the extent of flooding for particular events within the Pike River watershed were compared to flood stages and flood inundation maps generated by data from the Commission hydrologic-hydraulic simulation submodel for similar recurrence interval floods, and relatively good agreement was found, thereby verifying the validity of the simulated flood data.

The flood stages and flood inundation maps generated by data from the Commission's hydrologic-hydraulic simulation submodel were also compared to similar data presented in the U. S. Soil Conservation Service flood hazard study report.[3] Table 33 provides a comparison of peak flood discharges and stages. A graphic summary of the comparison with respect to areas of inundation is provided on Map 32. Observed differences between these data from the two sources may be attributed to actual changes in the channels, bridges, or culverts; to the availability of additional and more current hydraulic structure data for the Commission's hydrologic-hydraulic simulation analyses; and to the more detailed information available from the large-scale topographic mapping. For stream reaches where very similar hydraulic structure data and flood

[2] *U. S. Soil Conservation Service, Flood Hazard Study, Pike River, Racine and Kenosha Counties, Wisconsin: Madison, Wisconsin, 1978.*

[3] *Ibid.*

Table 33

COMPARISON OF PEAK FLOOD DISCHARGES AND STAGES DEVELOPED FROM THE COMMISSION'S HYDROLOGIC-HYDRAULIC SIMULATION SUBMODEL TO THOSE PRESENTED IN THE U. S. SOIL CONSERVATION SERVICE FLOOD HAZARD STUDY: EXISTING LAND USE AND CHANNEL-FLOODPLAIN CONDITIONS

River Mile	Location	100-Year Recurrence Interval Discharge (cubic feet per second)		100-Year Recurrence Interval Stage (feet above NGVD)	
		Commission	U. S. Soil Conservation Service	Commission	U. S. Soil Conservation Service
	Pike River				
0.21	D/S Alford Park Drive	3720	3950	581.1	582.1
	U/S Alford Park Drive	3720	3950	583.6	585.3
1.35	D/S STH 32	3820	4600	586.2	588.7
	U/S STH 32	3820	4600	586.6	590.7
1.70	D/S Drive to Carthage College	3820	4600	587.3	590.8
	U/S Drive to Carthage College	3820	4600	588.2	591.5
1.79	D/S STH 32	3820	4600	588.2	591.5
	U/S STH 32	3820	4600	589.6	593.6
3.04	D/S Chicago & North Western Railroad	3880	4600	592.5	594.7
	U/S Chicago & North Western Railroad	3880	4600	592.8	595.2
4.61	D/S CTH A	3740	4790	599.6	599.2
	U/S CTH A	3740	4790	600.4	601.5
4.79	D/S Lathrop Avenue	3450	4570	600.7	601.5
	U/S Lathrop Avenue	3450	4570	600.9	601.6
4.88	D/S Abandoned Railroad	3450	4570	600.9	601.6
	U/S Abandoned Railroad	3450	4570	601.8	603.9
5.63	D/S CTH Y	3380	5140	603.5	605.1
	U/S CTH Y	3380	5140	606.4	608.0
6.60	D/S CTH G	3420	5140	616.0	614.1
	U/S CTH G	3420	5140	617.1	617.4
6.96	D/S CTH A	3420	5140	618.1	618.7
	U/S CTH A	3420	5140	619.3	624.1
8.26	D/S Petrifying Springs Park Road	3420	5140	630.1	631.2
	U/S Petrifying Springs Park Road	3420	5140	631.6	632.8
9.55	D/S CTH A	3320	5140	643.5	643.5
	U/S CTH A	3320	5140	644.4	646.7
10.38	D/S STH 31	2550	2970	650.8	651.2
	U/S STH 31	2550	2970	653.5	654.1
11.15	D/S CTH KR	2440	3420	656.9	657.2
	U/S CTH KR	2440	3420	657.7	657.6
12.23	D/S Braun Road	2020	3000	664.3	664.9
	U/S Braun Road	2020	3000	666.6	668.0
13.29	D/S STH 11	1660	2620	669.0	669.4
	U/S STH 11	1660	2440	669.2	669.5
13.72	D/S Chicago, Milwaukee, St. Paul & Pacific Railroad	1300	1700	669.9	669.8
	U/S Chicago, Milwaukee, St. Paul & Pacific Railroad	1300	1700	670.1	670.2
14.94	D/S STH 20	980	1340	680.1	678.3
	U/S STH 20	980	1330	680.6	680.5
	Pike Creek				
0.05	D/S STH 31	1150	2540	644.7	645.4
	U/S STH 31	1150	2540	644.8	646.2
2.13	D/S CTH E	1250	1985	663.1	664.8
	U/S CTH E	1250	1985	664.0	666.7
3.17	D/S Junkyard Road	1250	1660	671.0	673.2
	U/S Junkyard Road	1250	1660	671.5	674.2
3.29	D/S Chicago & North Western Railroad	1250	1660	671.8	673.2
	U/S Chicago & North Western Railroad	1250	1660	672.0	674.2
3.34	D/S CTH L	1250	1660	672.1	674.2
	U/S CTH L	1250	1660	672.5	674.9
4.86	D/S STH 142	740	670	675.4	676.4
	U/S STH 142	740	670	676.9	678.2
5.90	D/S STH 158	420	420	676.9	678.2
	U/S STH 158	420	420	679.9	679.3
	Sorenson Creek				
1.56	D/S CTH KR	940	745	611.2	610.9
	U/S CTH KR	940	737	617.0	617.1
1.96	D/S Abandoned Railroad	880	720	617.4	617.8
	U/S Abandoned Railroad	880	720	619.4	618.6
2.62	D/S Lathrop Avenue	810	680	625.2	627.2
	U/S Lathrop Avenue	810	680	628.8	631.6

Table 33 (continued)

River Mile	Location	100-Year Recurrence Interval Discharge (cubic feet per second)		100-Year Recurrence Interval Stage (feet above NGVD)	
		Commission	U. S. Soil Conservation Service	Commission	U. S. Soil Conservation Service
	Bartlett Branch				
0.34	D/S Chicago & North Western Railway	365	380	685.0	682.4
	U/S Chicago & North Western Railway	365	380	685.7	687.2
0.53	D/S Stuart Road	465	1176	685.8	688.0
	U/S Stuart Road	465	1102	687.3	689.0
1.21	D/S Spring Street	195	270	687.5	690.1
	U/S Spring Street	195	270	689.0	692.0
	Waxdale Creek				
0.27	D/S Chicago & North Western Railway	250	280	669.4	669.4
	U/S Chicago & North Western Railway	250	280	669.4	670.0
0.29	D/S Willow Road	250	280	669.4	670.0
	U/S Willow Road	220	280	669.4	671.0
0.47	D/S Chicago, Milwaukee, St. Paul & Pacific Railroad	220	280	669.4	671.2
	U/S Chicago, Milwaukee, St. Paul & Pacific Railroad	570	790	670.0	677.2
1.24	D/S 90th Street	420	530	685.3	687.8
	U/S 90th Street	420	530	690.9	691.3
1.89	D/S CTH H	300	310	704.8	705.2
	U/S CTH H	300	310	710.9	709.8
	Chicory Creek				
0.46	D/S Chicago & North Western Railway	140	520	672.6	672.8
	U/S Chicago & North Western Railway	140	520	674.7	678.3
1.13	D/S 90th Street	115	297	684.2	686.1
	U/S 90th Street	115	297	686.0	689.0
	Lamparek Ditch				
0.77	D/S Chicago & North Western Railway	205	205	670.2	673.5
	U/S Chicago & North Western Railway	205	626	673.8	678.0
1.56	D/S 90th Street	190	540	682.6	685.5
	U/S 90th Street	170	540	683.0	687.4
2.26	D/S Chicago, Milwaukee, St. Paul & Pacific Railroad	140	234	700.0	699.5
	U/S Chicago, Milwaukee, St. Paul & Pacific Railroad	140	243	702.8	705.0
	Somers Branch				
0.69	D/S Chicago & North Western Railway	210	500	669.7	670.0
	U/S Chicago & North Western Railway	210	895	670.6	675.8
1.11	D/S CTH EA	220	895	675.1	676.0
	U/S CTH EA	220	895	675.5	679.0
1.95	D/S Chicago, Milwaukee, St. Paul & Pacific Railroad	41	156	691.9	692.3
	U/S Chicago, Milwaukee, St. Paul & Pacific Railroad	160	600	695.2	694.8

Source: SEWRPC.

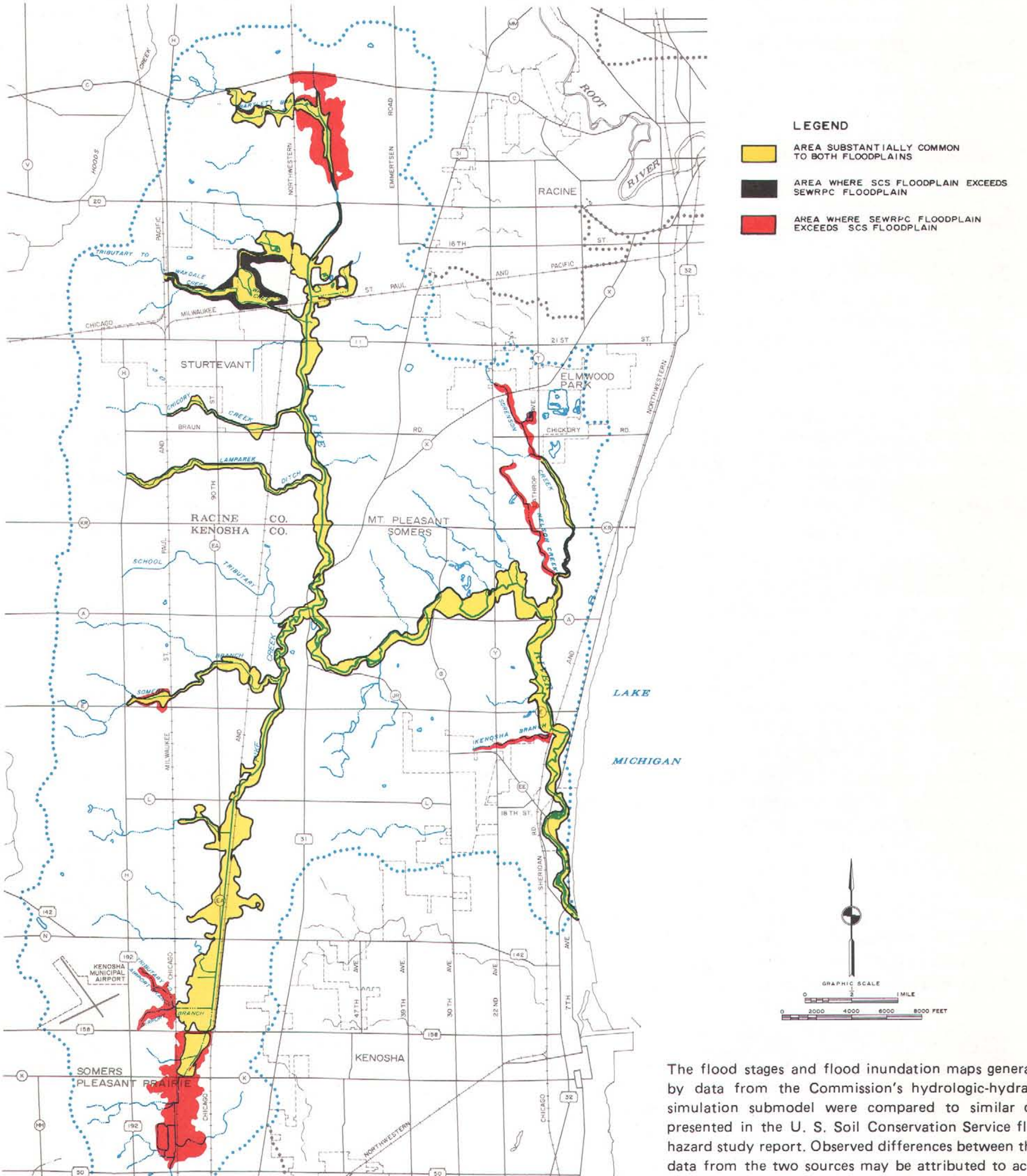
flows were used by both agencies, good agreement was found, thereby further verifying the validity of the Commission's simulated flood data.

Flood of March 30, 1960

The March 30, 1960 snowmelt-rainfall event is the largest flood in recent history in the Pike River watershed. The recurrence interval for this event ranged from about 40 years in the upper reaches of the Pike River to about 60 years at the mouth of the river in the City of Kenosha. Because the event occurred in early spring, no crop damages of significance were known to have occurred. The Kenosha County Park Commission spent 880 man-hours cleaning silt and debris off roads, parking lots, and lawn areas, and repairing washed out parking lots and a damaged footbridge at a cost of about $3,800. No other flood damage costs are available for this event. However, if another flood of the same magnitude as the 1960 flood would occur during the summer growing season, it is estimated that the damages would approximate $950,000 (1980 dollars) based upon application of the Commission flood economics submodel.

Map 32

COMPARISON OF THE 100-YEAR RECURRENCE INTERVAL FLOODPLAINS AS DELINEATED BY THE SEWRPC PIKE RIVER WATERSHED STUDY TO THOSE PRESENTED IN THE SCS FLOOD HAZARD STUDY



Source: SEWRPC.

The flood stages and flood inundation maps generated by data from the Commission's hydrologic-hydraulic simulation submodel were compared to similar data presented in the U. S. Soil Conservation Service flood hazard study report. Observed differences between these data from the two sources may be attributed to actual changes in the channels, bridges, or culverts; to the availability of additional and more current hydraulic structure data for the Commission's hydrologic-hydraulic simulation analyses; and to the more detailed information available from the large-scale topographic mapping.

Flood of March 29, 1962

The flood event of March 29, 1962 had an estimated recurrence interval of about 15 years in both the upper and lower reaches of the Pike River watershed. Little agricultural damage occurred, however, because of the timing of the event prior to spring planting. No recorded flood damage data are available, but it is estimated that had the event occurred during the growing season, flood damages in the watershed would have approximated $620,000 (1980 dollars).

Flood of April 11, 1965

The flood of April 11, 1965 had an estimated recurrence interval of about 5 years in the upper reaches of the Pike River and of about 8 years in the lower reaches. On Pike Creek, however, the 1965 flood was the second largest event recorded in the 20-year period of record at the USGS crest-stage gage located at the STH 142 crossing of the creek. Had this event occurred during the summer growing season, flood damages in the Pike River watershed would have approximated $350,000 (1980 dollars).

Flood of June 29, 1969

Heavy rains on June 29, 1969, reportedly caused severe storm damage in much of the Village of Sturtevant. During a 55-minute period, 2.5 inches of rain fell in the City of Kenosha. This storm produced the second largest flood on the Pike River during the period from 1940 through 1979, based upon the 40 years of peak streamflow data generated in the application of the Commission floodflow simulation model. The recurrence intervals for this event are estimated to have ranged from about 29 years in the Upper Pike River watershed to about 26 years in the lower part of the watershed. Estimated flood damages for this event, as determined by application of the Commission flood economics submodel, approximated $820,000 (1980 dollars). Because of the timing and magnitude of this event, the 1969 flood was probably the most costly during the period of record.

Spring and Summer Floods of 1972

Three significant floods occurred in 1972, on April 16, July 14, and September 13. The April and July events had recurrence intervals ranging between five and nine years, while the September event had a recurrence interval of about four years. The Soil Conservation Service (SCS) flood hazard study reported that heavy rains on April 16 caused "street and basement flooding, flooded fields, and washed out culverts and roads." During the spring and summer golfing season at the Kenosha Country Club, the course was reportedly flooded about 22 days. Although no historic flood damage data are available, it is estimated that at least $450,000 (1980 dollars) of flood damages occurred during the spring and summer of 1972, not including revenue losses at the Kenosha Country Club, such estimation being based on application of the Commission flood economics submodel.

Flood of April 21, 1973

Although the flood of April 21, 1973 was the largest ever recorded in some watersheds in southeastern Wisconsin, the recurrence interval for this event was only about two years throughout the Pike River watershed. In the Pike River estuary, however, significant flooding occurred caused by a combination of factors, including possible backwater effects from a storm-induced seiche on Lake Michigan aggravated by static lake levels about two feet higher than normal, and by backwater from a bar at the mouth of the Pike River at Lake Michigan (see Figure 28), as well as by the flood runoff from the watershed itself. Flooding occurred at the Carthage College campus and at the Valley Night Club on STH 32.

Figure 28

BAR AT THE MOUTH OF THE PIKE RIVER AT LAKE MICHIGAN FORMED BY THE DEPOSITION OF FLUVIAL SEDIMENT AND LITTORAL DRIFT

Water levels in the Pike River estuary have been reported to increase nearly six feet during flood flows as a result of the deposition of fluvial sediment and littoral drift, forming a bar at the mouth of the Pike River. Such blockage has resulted in flood damage to the Carthage College Campus as well as to business establishments located in the floodlands along the lower reaches of the Pike River.

Source: SEWRPC.

Flood of February 21, 1974

The winter flood of February 21, 1974, had a recurrence interval of about seven years throughout the Pike River watershed and caused a reported $106,000 damage to Alford Park in the City of Kenosha. Losses of 150 trees, sod, topsoil, and picnic equipment were attributed to this flood event. No other such historic flood damage data are available for this flood, however.

Flood of March 5, 1976

The flood of March 5, 1976 occurred after an ice and rain storm over the entire Pike River watershed. The recurrence interval for this event was about 10 years throughout the watershed. The Kenosha County Park Commission spent about $1,350 for cleanup, to resod lawns, and replace blacktop damaged during this event. No other such historic flood damage data are available for this flood, however.

Summer Floods of 1978

Four significant floods occurred in 1978, on July 2, July 21, August 19, and September 13. The September flood was the largest on record for the period 1960 through 1980 at the U. S. Geological Survey (USGS) gaging station on Pike Creek at STH 142, while the August flood was the largest on record for the period 1972 through 1980 at the USGS gaging station on the Pike River at the UW-Parkside Campus. The recurrence intervals for both of these events were about 10 years based upon the 40 years of simulated streamflow data generated by the Commission flood flow simulation model. Thirty farmers reportedly applied to the U. S. Soil Conservation Service for flood relief assistance. The Kenosha County Park Commission spent $2,430 for cleanup and repairs at Petrifying Springs Park and estimated revenue losses due to flooding of the park and the golf course are reported to have been $10,800 on July 2, July 22, July 23, August 19, September 13, and September 14, 1978. Road overtopping occurred at the intersection of Meacham Road and County Line Road during the July 1978 flooding. Damages incurred during the summer floods of 1978 were estimated to total $500,000, based upon application of the Commission's flood economics submodel.

A comparison was made of the high water mark noted above and recorded by the Petrifying Springs Park staff to the 10-year recurrence interval flood stage at this location as determined by the Commission's hydrologic-hydraulic simulation submodel. The elevation of the high water mark was approximately 638.8 National Geodetic Vertical Datum (NGVD), while the simulated flood stage was 638.4 NGVD, thus showing good agreement and thereby further verifying the validity of the simulated flood stages.

HISTORIC FLOODING: SOME OBSERVATIONS

One of the uses of historic flood information is to support public educational and informational activities after completion of the watershed plan. Much can be learned and several conclusions can be drawn from the record of historic flooding in the Pike River watershed. Some observations based on information obtained during the research on historic flooding are discussed below. The intent is that these observations may be useful to public officials and interested citizens when they face decisions directly or indirectly related to development or redevelopment in the riverine areas, particularly decisions related to flood problems.

Variety of Damage and Disruption

The historic record clearly demonstrates that floodwaters can cause physical damage to many different kinds of structures and facilities in a variety of ways. As a result of that damage, and sometimes even in the absence of actual physical damage, major floods can cause significant disruption of social and economic activities in the watershed.

The principal types of damage experienced in the Pike River watershed have been damage to croplands and damage to structures—private residences and commercial buildings—and to their contents as a result of overland and attendant secondary flooding. Bridges and culverts and sections of roadways have been damaged by the erosive action of rapidly moving floodwaters so as to require extensive repair.

A costly type of disruption associated with major flood events in the Pike River watershed has been the interruption of business activities not only during the flood events but also during the post-flood cleanup and repair period. In the public sector, the routine operations of governmental units usually are disrupted during flood events as public officials attempt to provide immediate relief to affected areas. Another form of disruption directly attributable to major flood events is the temporary closure of highways that have been inundated at a relatively low place, or as a result of damage to a river crossing. Although floodland recreational areas and facilities such as ballfields, golf courses, and picnic grounds typically incur little physical damage as a result of flooding, their use is temporarily curtailed by inundation. Such curtailment of use of the Kenosha Country Club golf course both during a major flood event and for some time thereafter is a costly exception to this general rule, due to the manner in which the Club must function as a private business.

In summary, then, the historic flood record assembled for the Pike River watershed indicates that floods cause physical damage to croplands and to many types of structures and facilities in a variety of ways, and that floods directly or indirectly disrupt the normal activities of many watershed residents. While the physical damage caused by major flood events is limited to the riverine areas, the attendant costs and disruption may be more widely borne.

The Risk to Human Life and Health

There is a tendency to consider and evaluate the damage and disruption normally accompanying flooding without due regard to the risk to human life and health that exists during every major flood event. Public officials and interested citizens should be aware of this danger as one factor to be weighed in making decisions that are directly or indirectly related to riverine areas. The historic record for the Pike River watershed contains accounts of two incidents in which a total of three people were drowned during flood events.[4]

Regardless of the rural or urban nature of a watershed, flood events are potentially hazardous to people in or near the riverine areas primarily because normally shallow, narrow, slowly moving rivers and streams become deep, wide, rapidly moving torrents that can readily entrap even an adult. For example, floodwaters at a depth of four feet and moving at a velocity of four feet per second, a condition that would be expected over much of the floodlands of the Pike River during a major flood event, would exert a dynamic force of approximately 110 pounds on an adult. If the velocity were doubled to eight feet per second, which may still be a common condition near the channel during a major flood event, the dynamic force would increase by a factor of four to about 440 pounds. Not only are these forces large, but they probably would be applied abruptly and unexpectedly to persons entrapped in the floodwaters.

An example of the risk to human life that exists during a major flood event frequently occurs within the Pike River watershed near the mouth of the Pike River, where the two above-noted drowning incidents occurred. The longshore currents of Lake Michigan deposit sediments at the mouth of the Pike River, forming a bar which significantly reduces the conveyance of the channel. When a storm event—of even a relatively small magnitude—occurs under these conditions, significant flooding occurs upstream due to the blockage at the mouth. The hydraulic head differences are reported to be on the order of 5 to 10 feet during such conditions. The flood stage upstream from the mouth continues to rise until the temporary "dam" is breached, or until the hydraulic pressure exerted on the bar becomes large enough to force a larger opening through the bar. This creates extremely high velocities in the channel near the mouth until the upstream flood waters subside, a process which reportedly occurs within from 4 to 24 hours. It is the resulting high velocities in the channel which have been the apparent cause of the drowning incidents noted above.

The threat to human life is severe in the Pike River watershed for three reasons. First, part of the watershed is highly urbanized and, therefore, many people—and particularly many children who are naturally drawn to surface waters—may be expected to be close to the stream system. Second, as a result of the storm and floodwater conveyance system that has been developed to serve urban areas of the watershed, flood discharges and stages in some stream reaches rise rapidly with little advance warning. Third, most of the watershed stream system has been subjected to major channelization. These hydraulically efficient sections will normally exhibit high, and therefore potentially dangerous, channel velocities during flood events. Results obtained with the hydrologic-hydraulic model described in Chapter VIII of this report indicate that channel velocities in channelized sections may be expected to be substantially higher than channel velocities in natural riverine areas under major flood conditions. Not only are velocities higher in channelized reaches, compared

[4] *One of the incidents occurred in August of 1980 in which two people were drowned near the mouth of the Pike River. The other incident occurred in July of 1968 in which one person was drowned, also near the mouth. In both instances the high velocity of the flood and/or ebb flows were an important contributing factor to the loss of life.*

with the conditions that exist in the channel and on the floodplain under more natural conditions, but human escape from the channelized reaches may be more difficult because of the relatively steep banks of the improved channels which in some cases are relatively free of vegetation and therefore relatively smooth.

With the exception of increasing public awareness of the danger, little can be done in most cases to mitigate the threats to human life presented by high velocity flows in channelized reaches. That threat is one of the intangible, but nevertheless significant, negative aspects of an urban development pattern that encroaches into the wide, natural floodlands of the surface water system, thereby necessitating the construction of narrow, deep, and straight artificial channels designed to effect a rapid removal of runoff during major rainfall and snowmelt events.

In summary, then, historic evidence accumulated for the Pike River watershed, supplemented with hydraulic analyses completed under the watershed study, indicates that major flood events can pose a serious threat to human life. This risk is heightened in highly urbanized portions of the watershed because of the proximity of people to the riverine areas, the "flashy" nature of some of the streams, and the high velocities and steep banks characteristic of channelized reaches.

While the threat of flooding to human life can be readily illustrated by reference to historic accounts of flood-related rescues and deaths, the threat to health is not so apparent. Nevertheless, it does exist. Floodwaters can be the medium for transporting potentially harmful substances, such as toxic materials from industrial operations and pathogenic (disease-producing) bacteria from sanitary and combined sewers, to residential areas where there is the possibility of contact with and harm to the residents.

In addition to potential physiological harm, the occurrence of floods as well as the ever-present threat of flooding can adversely affect the psychological health and well being of riverine area residents. Owners or tenants of flood-prone structures and properties are burdened with the need to be in a constant state of readiness, particularly in the urbanized areas of the watershed where major floods can occur almost any time of the year and with little warning. These owners or tenants occasionally must contend with the unpleasant task of cleaning contaminated, flood-borne sand, silt, and other materials and debris from their homes and places of business. Finally, even after the flood has passed and the cleanup and repairs have been completed, lingering odors and other evidence of the recent inundation will impose an additional psychological stress on the occupants of riverine area property.

MONETARY FLOOD LOSSES AND RISKS

Flood damage is defined herein as the physical deterioration or destruction caused by floodwaters. The term flood loss refers to the net effect of historic flood damage on the regional economy and well being, with the tangible components of the loss being expressed in monetary units. Flood risk is the probable damage, expressed either on a per flood event basis or on an average annual basis, that will be incurred as a result of future flooding with the tangible portion of the risk expressed in monetary terms. All losses resulting from historic flooding or the risk attendant to future flooding can be classified into one of three types of damage categories—direct, indirect, and intangible. Such damages can also be classified according to whether the private or the public sector incurs the losses or risks. This two-way classification of flood losses and risks is set forth in Table 34.

Flood Losses and Risks Categorized by Type

In order to promote compatibility with the policies and practices of such federal agencies as the U. S. Army Corps of Engineers and U. S. Soil Conservation Service, which may be asked to assist in the implementation of the recommended watershed plan, the following three categories of flood losses and risks were defined for the purpose of the study:

1. Direct flood losses or risks were defined as monetary expenditures required, or which would be required, to restore flood-damaged property to its preflood condition. This includes the cost of cleaning, repairing, and replacing residential, commercial, industrial, and agricultural buildings and contents and other objects and materials located outside of the buildings on the property. Direct losses and risks also encompass the cost of cleaning, repairing, and replacing roads and bridges, storm water systems, sanitary sewer systems, and other utilities; the cost of restoring damaged park and recreational lands; and the cost of replanting as well as the cost of losing all or part of the first crop.

Table 34

CATEGORIES OF FLOOD LOSSES AND RISKS

Type of Damage	Ownership	
	Private Sector	Public Sector
Direct	Cost of cleaning, repairing, or replacing residential, commercial, and industrial buildings, contents, and land Cost of cleaning, repairing, or replacing agricultural buildings and contents and cost of lost crops and livestock	Cost of repairing or replacing road segments, bridges, culverts, and dams Cost of repairing damage to storm water systems, sanitary sewerage systems, and other utilities Cost of restoring parks and other public recreational lands
Indirect	Cost of temporary evacuation and relocation Lost wages Lost production and sales Incremental cost of transportation Cost of postflood floodproofing	Incremental costs to governmental units as a result of flood fighting measures Cost of postflood engineering and planning studies
Intangible	Loss of life Health hazards Psychological stress Reluctance by individuals to inhabit flood-prone areas thereby depreciating riverine area property values	Disruption of normal community activities Reluctance by business interests to continue development of flood-prone commercial-industrial areas thereby adversely affecting the community tax base

Source: SEWRPC.

2. Indirect flood losses and risks were defined as the net monetary cost of evacuation, relocation, lost wages, lost production, and lost sales; the increased cost of highway and railroad transportation because of flood-caused detours; the costs of flood fighting and emergency services provided by governmental units, as well as the cost of postflood floodproofing of individual structures. The costs of postflood engineering and planning studies also are categorized as indirect losses and risks. Although often difficult to determine with accuracy, indirect losses and risks nevertheless constitute a real monetary burden on the economy of the Region.

3. Intangible flood losses and risks were defined as flood effects which cannot be readily measured in monetary terms. Such losses and risks include health hazards, property value depreciation as a result of flooding, and the general disruption of normal community activities. Intangible losses and risks also include the severe psychological stress experienced by owners or occupants of riverine area structures.

Flood Losses and Risks Categorized by Ownership

As already noted, flood losses and risks may also be classified on the basis of ownership into public-sector and private-sector losses and risks. Each of the three categories of flood loss—direct, indirect, and intangible—may, therefore, be further subdivided into public-sector losses as shown in Table 34. Within the direct loss category, for example, the cost of cleaning, repairing, and replacing residential buildings and their contents is a private-sector flood loss, whereas the cost of repairing or replacing damaged bridges and culverts is a public-sector loss.

Role of Monetary Flood Risks

Previous sections of this chapter identified the major historic flood events known to have occurred within the watershed and described the severity of each flood event and in some cases the reaches of the stream system affected, the types of damage and disruption that occurred, although in most cases little such historic information was available, and the relative magnitude of recorded peak flood discharges. While such a qualitative description of flooding is an effective means of communicating the characteristics of flooding, it is not adequate for sound economic analyses of alternative solutions to flood problems. Such analyses require that flood damages for the various stream reaches be quantified in monetary terms on a uniform basis throughout the watershed.

The quantitative, uniform means of expressing flood damages selected for use in the Pike River watershed study was the average annual flood damage risk expressed in 1980 dollars. Average annual flood risk was computed for flood-prone reaches to provide a monetary value that could be used, wholly or in part, as an annual benefit for comparison to annual costs of technically feasible alternative flood control measures such as acquisition and removal of flood-prone structures, structure floodproofing, channel modification, and construction of earthen dikes, concrete floodwalls, and flood control reservoirs.

Methodology Used to Determine Average Annual Flood Risks

The average annual flood damage risk for a stream reach is defined as the sum of the direct and indirect monetary flood losses resulting from floods of all probabilities, each weighted by its probability of occurrence or exceedance in any year. If a damage-probability curve is constructed, such as the graph of dollar damage versus flood probability as illustrated in Figure 29, the average annual risk is represented by the area beneath the curve. The damage-probability curve for each flood-prone reach is developed by combining the reach stage-probability relationship with the reach stage-damage curve as illustrated in Figure 29. The determination of average annual flood risk for a particular flood-prone reach, therefore, depends upon construction of the stage-probability and stage-damage relationships for the reach.

The ideal way to develop the two required relationships for a particular reach would be from a long series of stage observations which could be analyzed statistically to yield the stage-probability curve and from a similar long series of recorded direct and indirect damages actually experienced by riverine area occupants for a full range of flood stages. Inasmuch as neither the long term river stage information nor the damage information is generally available, it is necessary to develop the stage-probability and stage-damage relationships by analytical means and then to combine them to form the damage-probability relationship.

Synthesis of Reach Stage-Probability Relationships:

The stage-probability relationship for a particular reach is determined by the hydraulic characteristics of the reach, such as the shape of the floodland cross sections, the value of the Manning roughness coefficients and the presence of bridges, culverts, and other structures—all of which are to some extent determined by the activities of man—and the magnitude of flood flows expected in the reach. These flood flows are in turn a function of upstream hydraulics and hydrology which are also, because of man's activities, continuously undergoing change or have the potential to do so. It follows, therefore, that each reach does not have a unique stage-probability curve but instead there are many possible stage-probability curves, each of which is associated with a given combination of hydrologic-hydraulic conditions in and upstream of the reach in question.

Figure 29 shows an example of a stage-probability curve synthesized for a stream reach in the Pike River watershed.

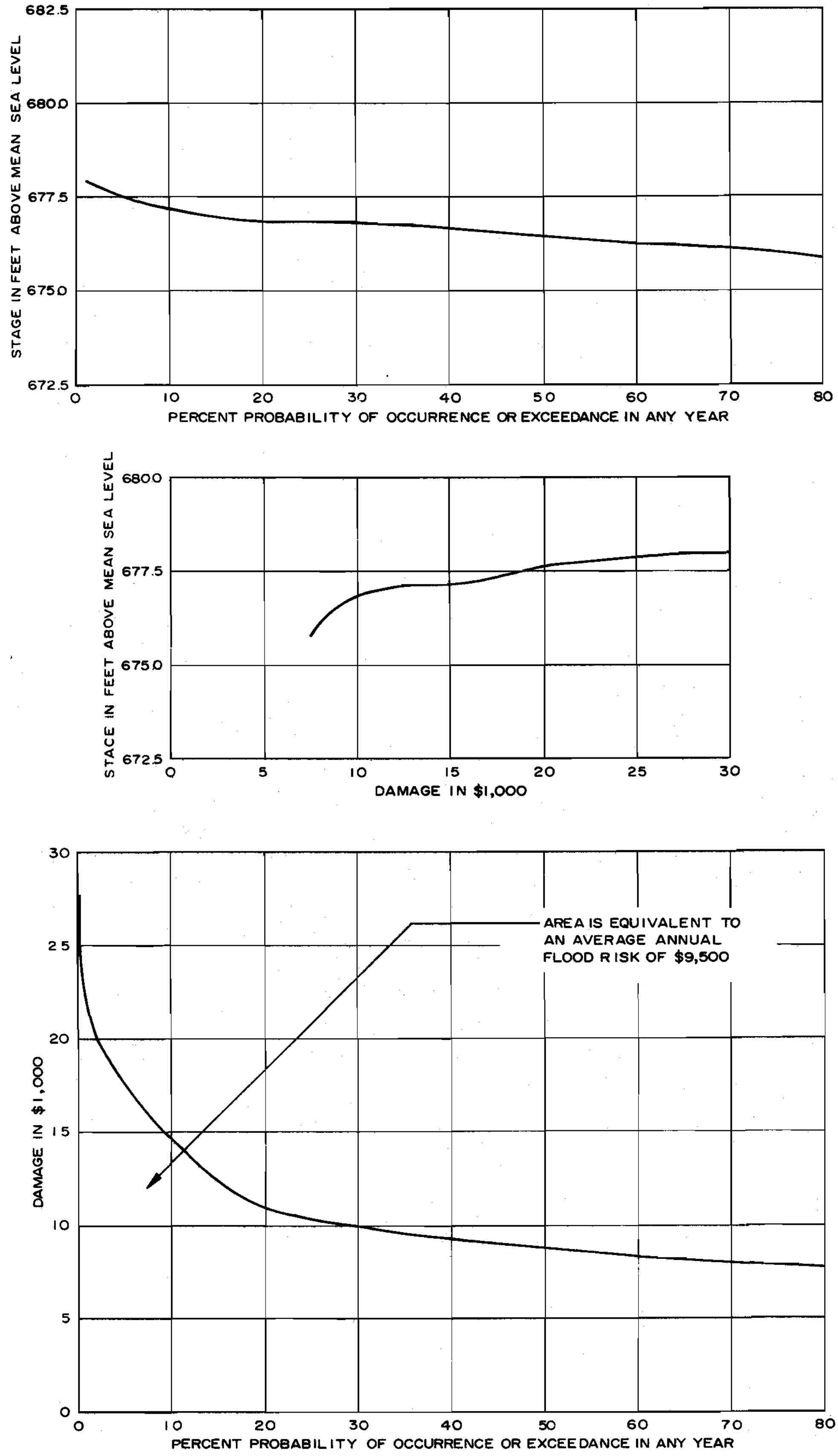
Synthesis of Reach Stage-Damage Relationships:

The stage-damage curve for a reach is determined by the nature and extent of flood-prone structures and other property contained within the reach. It follows, therefore, that there is a separate stage-damage curve for each combination of riverine area land uses. Development of the stage-damage relationship for a particular combination of riverine area land uses in a reach begins with computation of the flood losses that may be expected for an arbitrarily selected flood stage slightly above the elevation of the river channel. These flood losses consist of estimates of the direct and indirect monetary flood losses set forth in Table 34. Upon completion of the summation of flood losses at the initial flood stage, a higher stage is considered. This process is repeated so as to consider the full spectrum of flood stages from just above the river bank up to the 100-year recurrence interval flow stage. Figure 29 presents an example of a synthesized stage-damage curve for a reach.

Synthesis of reach stage-damage relationships requires the use of depth-damage relationships for the various type structures, facilities, croplands, and activities likely to be present in or to occur in floodlands. A depth-damage relationship for a particular type of structure is a graph of depth of inundation in feet relative to the first floor versus dollar damage to structure and contents expressed

Figure 29

EXAMPLE OF DETERMINATION OF AVERAGE ANNUAL FLOOD RISK FOR A RIVER REACH

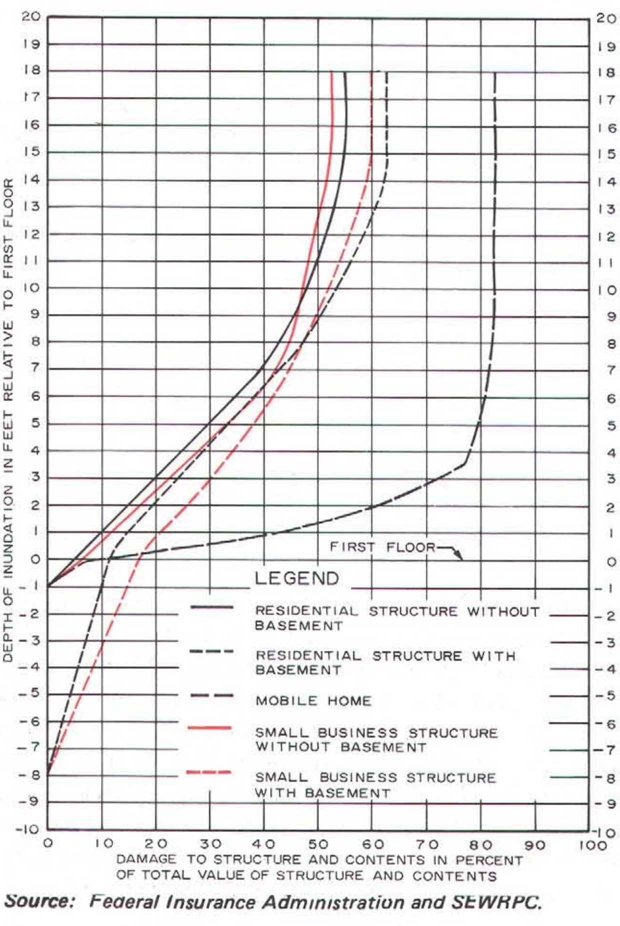


Source: SEWRPC.

as a percent of the total dollar value of the structure and its contents. The depth-damage relationships for five types of structures as used in the Pike River watershed study are shown in Figure 30. These depth-damage relationships were developed by the Commission staff using Federal Insurance Administration tables as published in 1970 and revised in 1974 and 1975. The depth-damage relationships for croplands were provided by the U. S. Soil Conservation Service (SCS) and have been used by the SCS in cost-benefit studies of proposed flood control structures in agricultural areas in southeastern Wisconsin. The SCS damage data include consideration of the net value of appropriate replacement crops, which in turn is affected by the timing of the flood event. Depth-damage data for corn, oats, hay, and pasture are shown in Table 35. Damage to truck farm vegetable crops for any depth of flooding was assumed to be total.

Figure 30

DEPTH-DAMAGE CURVES FOR SELECTED STRUCTURES



Source: Federal Insurance Administration and SEWRPC.

Determination of Indirect Damages: The above depth-damage relationships reflect the direct damage to each of the various types of structures or croplands as the function of the depth of inundation. Indirect damages, which can be a significant fraction of the total monetary losses incurred during a flood event, were computed as a percentage of the direct damages to the various types of structures. The direct damages to commercial and industrial structures were increased by 40 percent to account for indirect damages, whereas the direct damages to residential and all other types of structures were increased by 15 percent to reflect indirect damages.[5] Indirect flood damage costs due to road overtopping were based upon the incremental increase in travel distance on detour routes and upon the duration of road overtopping when depths exceeded 0.3 foot for free weir flow conditions. Durations were determined using hydrographs generated by the Hydrocomp Simulation Program for the Pike River watershed developed by the Commission.

Average Annual Flood Risks: The above methodology was used to compute average annual flood risks for selected reaches in the Pike River watershed under existing and hypothetical future floodland development-land use conditions. The voluminous computations were carried out with the flood economics submodel of the hydrologic-hydraulic simulation model described in Chapter VIII. The resulting per event and average annual flood risks for selected reaches under various floodland and nonfloodland development conditions are presented in tabular and graphic form in Chapter XII of this report. For existing land use and channel conditions it was determined by the economic submodel that the occurrence of a flood equal in magnitude to that of the 1960 flood would cause \$950,000 damage in the Pike River watershed. Similarly, the average annual flood damage was determined to be \$245,000, and the damages caused by the 10-, 50-, and 100-year recurrence interval flood events were determined to be \$450,000, \$960,000, and \$1,020,000, respectively.

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[5] *R. W. Kates, "Industrial Flood Losses: Damage Estimation in the Lehigh Valley," the University of Chicago, Department of Geography, Research Paper No. 98, 1965, pp. 15 to 17.*

Table 35

DEPTH-DAMAGE DATA FOR CROPS IN THE PIKE RIVER WATERSHED

Crop	Gross Value per Acre	Flood Depth (feet)	Percent Damage[a] per Month						
			April	May	June	July	August	September	October
Alfalfa[b]	$189	0-1	- -	41	33	22	13	6	- -
		1-3	- -	47	45	28	19	9	- -
		>3	- -	63	49	33	22	13	- -
Corn[c].	$282	0-1	- -	15	32	25	15	9	6
		1-3	- -	12	42	43	27	15	11
		>3	- -	17	51	59	34	21	21
Oats[d].	$138	0-1	36	40	53	44	28	- -	- -
		1-3	36	40	63	55	38	- -	- -
		>3	36	40	66	60	44	- -	- -
Pasture[e]	$ 40	0-1	- -	30	35	30	25	35	25
		1-3	- -	35	50	45	40	50	40
		>3	- -	45	65	60	45	65	55
Vegetables[f] . .	$800[g]	N/A[f]	- -[f]	- -[f]	- -[f]	- -[f]	- -[f]	- -[f]	- -[f]

NOTE: N/A indicates data not available.

[a]*Percent damage also includes the costs and return on planting and harvesting appropriate alternate crops after a damaging flood event occurs.*

[b]*Gross value of alfalfa hay based upon yield of 4.5 tons per acre at a value of $42.05 per ton.*

[c]*Gross value of corn based upon yield of 130 bushels per acre at a value of $2.17 per bushel.*

[d]*Gross value of oats based upon yield of 65 bushels per acre at a value of $1.43 per bushel.*

[e]*Gross value of pasture as feed based upon 120 cow-pasture days at $40 per cow per acre.*

[f]*Acreage data and depth damage data for each specific vegetable crop in the Pike River watershed were not available for evaluation of flood damage by crop. Because flooding can occur at any time during the growing season and because many vegetable crops will not tolerate flood inundation depths as shallow as even 1 foot, it was assumed that any vegetable crop experiencing any degree of flood inundation would be totally destroyed.*

[g]*Gross value of vegetables estimated based upon value per acre of onions = $1,029, lettuce = $1,832, carrots = $1,416, sweetcorn = $191, snap beans = $367, cucumbers = $907, green lima beans = $315, cabbage = $630, and potatoes = $1,270.*

Source: U. S. Soil Conservation Service and SEWRPC.

SUMMARY

An understanding of the interrelationships that exist between the flood characteristics of the watershed stream system and the uses to which the floodland and nonfloodland areas of the watershed are put is fundamental to any comprehensive watershed study. This understanding is a prerequisite to solving existing flood problems and preventing the occurrence of future flood problems. Flood damage and disruption in the Pike River watershed have been largely a consequence of the failure to recognize and account for the relationships which exist between the use of land, both within and outside of the natural floodlands of the watershed, and the flood flow behavior of the stream system of the watershed.

Historic flood information has several key applications during both the plan preparation and plan implementation processes including: 1) identification of problem areas, 2) determination of the causes of flooding, 3) calibration of the hydrologic-hydraulic model, 4) computation of monetary flood risks, 5) formulation of alternative flood control plan elements, and 6) postplan information and education purposes. Synthesized monetary flood risks are utilized during the watershed planning process to conduct cost-benefit analyses of alternative flood control measures such as acquisition and removal of flood-prone structures, structure floodproofing, channel modification, and construction of dikes, floodwalls, and flood control reservoirs.

A distinction is drawn between flooding problems, which is the intended concern of this chapter—and one of the major water resource problem areas to be addressed in the watershed planning effort—and storm water inundation problems which are beyond the scope of the Pike River watershed planning program. Flood problems are defined, for purposes of this report, as damaging inundation which occurs along well-defined rivers and streams as the direct result of water moving out of and away from those rivers and streams, and includes both overland and secondary flooding. In contrast, storm water inundation problems are defined as damaging inundation which occurs when storm water runoff en route to rivers and streams and other low-lying areas encounters inadequate conveyance or storage facilities and, as a result, causes localized ponding and surcharging of storm and sanitary sewers.

Research of the available historic records indicated the occurrence of nine major flooding periods in the Pike River watershed in the recent past. These major floods, each of which caused significant damage to property as well as disruption of normal social and economic activities in the watershed, were the floods of March 30, 1960; March 29, 1962; April 11, 1965; and June 29, 1969; the spring and summer floods of 1972; the floods of April 21, 1973; February 21, 1974; March 5, 1976; and the summer floods of 1978. The June 1969 flood caused the highest monetary damages in the watershed since 1940, with an estimated loss of $820,000 (1980 dollars). The March 1960 flood, the largest since at least 1940, did not cause significant agricultural monetary damages because it occurred prior to spring planting. Had that event occurred during the growing season, an estimated damage of $950,000 would have been incurred. Similarly, the March 1962 flood would have caused an estimated $620,000 damage had it occurred during the growing season. Information about the cause and effect of each of these floods was derived by a research process consisting of the following sequential steps: initial reconnaissance of published reports and data, review of newspaper accounts and newspaper files, examination of library and historical society holdings, and contact with community and agency officials. In addition, streamflow and crest gaging records collected in the watershed since 1960, supplemented by synthetic streamflow records generated throughout the watershed by the application of the Commission simulation model since 1940, were utilized to identify the occurrence and magnitude of major floods and the cause thereof.

Findings of the research into historic flood problems leads to the conclusion that flood problems in the urbanized portions of the Pike River watershed are relatively minor compared to flood damages in agricultural areas. It is important to note, however, that the design flood selected for the Pike River watershed planning program is the 100-year recurrence interval event as it would occur under year 2000 plan land use and floodland development conditions. A flood of this magnitude has not occurred in the watershed under existing or recent development conditions. Therefore, hydrologic-hydraulic-flood risk analyses were performed, as described in Chaper XII of this report, to quantify flood problems likely to occur in the watershed under year 2000 plan land use and floodland development conditions, and to identify flood-prone areas. Based upon these studies, it is anticipated that under a no-action alternative substantial increases in flood damages may be expected to occur in both urban and rural areas of the watershed due to increased runoff rates and volumes attributable to the effects of urbanization. Because of the primarily rural nature of the Pike River watershed, relatively few residences have been flooded in the past as compared to the highly urbanized watersheds in southeastern Wisconsin. However, uncontrolled urbanization and lack of adequate floodplain management measures could result in significant increases in flooding damage to not only existing but also future residential development in the watershed.

In addition to the quantitative data derived from the inventory of historic flooding, three observations emerge regarding the characteristics of flooding in the Pike River watershed. First, the historic record indicates that flooding has caused physical damage to many different types of structures and facilities in a variety of ways and that the disruption attendant to major floods is experienced by many watershed residents, not just those that actually occupy the floodlands. Second, the inventory of historic flooding indicates that rainfall, as opposed to snowmelt or rainfall-snowmelt combinations, has been the principal cause of major floods in highly urbanized watersheds and adjacent downstream rural areas. This is particularly significant because it means that, with the exception of the winter season, major floods can occur at any time of the year in parts of the Pike River watershed and when they do occur, they will be characterized by rapid increases in discharge and stage, thereby offering minimal opportunity for advance warning to occupants of riverine areas. Finally, the risk to human life is illustrated in the historic flood record by accounts of three drownings and of near drownings, with the threat to human life being more severe in an urban, rather than a rural, watershed.

Flood loss refers to the net effect of historic flooding on the regional economy and well being, with the tangible portions of the loss being expressed in monetary terms. Flood risk is the probable damage, expressed either on a per flood event basis or on an average annual basis, that will be incurred as a result of future flooding, with the tangible portion expressed in monetary terms. All flood losses and risks may be classified into one of three categories—direct, indirect, and intangible—or they may be classified by whether the private or public sector incurs the losses or risks.

Average annual flood damage risk expressed in monetary terms was selected as the quantitative, uniform means of expressing flood severity in the Pike River watershed. These values were derived from damage-probability curves developed for selected reaches under existing, planned, and other floodland and nonfloodland development conditions. The average annual flood damage in the watershed is estimated to be $245,000 for existing land use conditions. Of this total, $61,300 represents agricultural damages and $142,400 represents residential structure and contents damage, with the remainder representing public and private recreation area damages and miscellaneous direct and indirect damages. Revenue losses to the Kenosha Country Club are not included in these totals.

Chapter VII

SURFACE WATER QUALITY CHARACTERISTICS AND PROBLEMS

INTRODUCTION

A basic premise of the Commission watershed studies is that the activities of man affect, and are affected by, water quality. This is especially true in a mixed agricultural-urban area such as the Pike River watershed where the effects of human activities on water quality tend to overshadow natural influences. The hydrologic cycle provides the principal linkage between human activities and the quality of surface water and groundwaters, in that the cycle transports potential pollutants from man to his environment and from the environment to man.

Water resources planning efforts in general, and the Pike River watershed planning program in particular, must include an evaluation of historic, present, and anticipated future water quality conditions and the relationship of those conditions to existing and probable future land and water uses. The purpose of this chapter is to determine the extent to which surface waters in the Pike River watershed have been and are polluted, and to identify the probable causes for or sources of that pollution. More specifically this chapter discusses the concepts of water quality and pollution; summarizes the Commission recommended water use objectives and supporting water quality standards for the surface water system of the watershed as a benchmark against which historic and recent water quality may be measured; documents current surface water pollution problems in the watershed utilizing field data from a variety of water quality studies, most of which were conducted during the past two decades; explores the differences between wet and dry weather water quality phenomena; and indicates the location and type of the numerous and varied sources of wastewaters and other potential pollutants discharged to the surface water system of the watershed, describes the characteristics of the discharges from those sources and, where feasible, quantifies the pollutant contribution of each source. Data and information presented herein provide the basis for development and testing of the alternative water quality control plan elements described in Chapter XIII of this report.

The focus of this chapter is surface water quality characteristics and problems. Two related topics addressed in previous Commission comprehensive studies of watersheds are water supply from both subsurface and surface sources and groundwater quality characteristics and problems. The topics of groundwater quality and water supply are treated in this report only to the extent that they provide information about the development potential of the watershed or relate to surface water quality problems. This minimal emphasis on groundwater quality and on surface water and groundwater supply is in accordance with the objectives of the Pike River watershed planning program which are set forth in Chapter I and, briefly restated, are to: 1) prepare a floodland management plan, 2) prepare a surface water quality management plan, 3) prepare a plan for public open space preservation, and 4) refine and adjust the regional land use plan to reflect the needs and characteristics of the watershed. These planning program objectives are based on the conclusions set forth in the Pike River Watershed Planning Program Prospectus, which identified four water resource-related problems in the watershed; namely, flooding, pollution of surface waters, deterioration of the natural resource base, and changing land use. The preliminary public hearing conducted on the proposed scope and content of the watershed study[1] as well as the inventory and analysis phases of the Pike River watershed planning program did not identify any serious problems in those two water resource-related areas. With respect to water supply, a series of past decisions are accepted as given for purposes of the Pike River watershed study. As noted in Chapter III of this report, the shallow aquifer generally provides a high-quality and plentiful source of supply for isolated enclaves of urban development. Longstanding local and regional plans, and the adopted plans for the Kenosha and

[1] *Southeastern Wisconsin Regional Planning Commission Minutes of the Initial Public Hearing on the Pike River Watershed Study, February 7, 1980.*

Racine Urban Planning Districts envision that the urban service areas around the Cities of Kenosha and Racine—including the Sturtevant and Somer areas—will eventually be served by the centralized public water supply systems of Kenosha and Racine which utilize Lake Michigan as their water source. These long-term recommendations are currently being reviewed in the Kenosha County portion of the watershed in the review and reevaluation of the urban planning district plan for the Kenosha area. Therefore, the Pike River watershed study work efforts have supported the conclusion of the Prospectus that groundwater quality and surface water and groundwater supply are not serious problems in the Pike River watershed with the single exception of an isolated groundwater pollution problem—discussed in Chapter III of this report—alleged to be the result of a sanitary landfill operational problem.

The elimination of water supply as a major area of concern in the Pike River watershed planning program does not introduce any deficiencies in the systems analysis conducted under the planning program since the water supply and waste water disposal systems do not interact significantly with the surface water system of the watershed. As indicated in Chapter III of this report, most of the population of the Pike River watershed is served by public water supply systems utilizing Lake Michigan as a source. After use, this water is discharged by the user to the sanitary sewerage system through which the used water is transported back out of the watershed for treatment before being returned to the Lake. A small amount of water withdrawn from Lake Michigan by the Racine water utility is treated and discharged to the Pike River watershed from the Village of Sturtevant. The Town of Somers Utility District No. 1 is served by private wells and that spent groundwater is treated and discharged to the surface water system. These two sewerage treatment facilities are proposed to be abandoned[2] and the collection systems connected to the City of Racine and Kenosha respectively; thus the discharge attendant to these facilities will also be transported out of the Pike River watershed. Accordingly, it may be concluded that the water supply and wastewater disposal systems of the watershed are or soon will be essentially physically separate from the surface water system of the watershed.

[2] *In March 1980 the Village of Sturtevant sewage treatment plant was abandoned and the service area was connected to the City of Racine system.*

Even if groundwater problems—particularly groundwater quantity problems—do develop in the Pike River watershed, it is highly unlikely that the watershed study or an extension of the study would be a sound basis for investigating and resolving those problems. Regardless of whether the groundwater moves in the shallow or deep aquifers, that movement is essentially independent of watershed processes and watershed boundaries—particularly in a watershed as small as the Pike River watershed—being instead influenced by regional and even extraregional aquifer characteristics, recharge patterns, and groundwater pumpage. Groundwater supply problems beginning to appear in the southeastern Wisconsin area can best be resolved through a comprehensive regional water supply planning program.

WATER QUALITY AND POLLUTION: BACKGROUND

The term "water quality" refers to the physical, chemical, and biological characteristics of surface water and groundwater. Water quality is determined both by the natural environment and by the activities of man. The uses which can be made of the water resource are significantly affected by its quality, and each potential use requires a certain level of water quality.

Definition of Pollution

Pure water, in a chemical sense, is not known to exist in nature in that foreign substances, originating from the natural environment or the activities of man, will always be present. Water is said to be polluted when those foreign substances are in such a form and so concentrated as to render the water unsuitable for any desired beneficial uses such as the following: preservation and enhancement of fish and other aquatic life, water-based recreation, public water supply, industrial water supply and cooling water, wastewater disposal, and aesthetic enjoyment.

This definition of pollution does not explicitly consider the source of the polluting substance which may significantly affect the meaning and use of the term. For the purpose of this report, the causes of pollution are considered to be exclusively related to human activity and, therefore, the sources are potentially subject to control through alteration of human activity. Examples of potentially polluting discharges to the surface waters that are related to human activities include discharges of treated effluent from municipal and private sewage treatment facilities, discharges of raw sewage from separate and combined sewer overflows and from commercial and industrial establishments, and runoff from urban areas and from agricultural lands. Substances derived from natural sources that are present in such quantities as to adversely affect certain beneficial water uses would not be herein defined as pollution, but would constitute a natural condition that impairs the usefulness of the water.

Types of Pollution

As defined above, water pollution is the direct result of human activity in the tributary watershed. Water pollution may be divided into one or more of the following eight types in accordance with the nature of the substance that causes the pollution:

1. Toxic pollution, such as that caused by heavy metals and other inorganic elements or compounds in industrial wastes, domestic sewage, or runoff, some of which may be toxic to humans and to other life;

2. Organic pollution, such as that caused by oxygen-demanding organic compounds—carbonaceous and nitrogenous—in domestic sewage and industrial waste, which exerts a high oxygen demand and may severely affect fish life;

3. Nutrient pollution, such as that caused by an overabundance of plant nutrient substances such as nitrogen and phosphorus compounds in urban or agricultural runoff and in domestic sewage; this type of pollution may cause unsightly, excessive plant growths which can deplete the oxygen supply in water through respiratory and decay processes;

4. Pathogenic or disease-carrying pollution, such as that caused by the presence of bacteria and viruses in domestic sewage or in runoff, which may transmit infectious diseases from one person to another;

5. Thermal pollution, such as that caused by heated discharges, which may adversely affect aquatic flora and fauna;

6. Sediment pollution, such as that caused by lack of adequate soil conservation practices in rural areas and inadequate runoff control during construction in urban areas, which results in instream sediment accumulation that has the potential to inhibit aquatic life, interfere with navigation, impede agricultural drainage, and increase flood stages;

7. Radiological pollution, such as that caused by the presence of radioactive substances in sewage or cooling water discharges, which may adversely affect human and animal life; and

8. Aesthetic pollution, which may be associated with any combination of the other forms of pollution along with floating debris and unsightly accumulations of trash along stream banks and lakeshores.

All of the above eight types of water pollution may occur in surface waters. Groundwater pollution is normally limited to toxic, nutrient, pathogenic, and radiological pollution. With the excepton of thermal and radiological pollution, all of the above types of pollution are known to occur, or to have occurred, in the Pike River watershed as documented in this chapter.

The Relative Nature of Pollution

The determination of whether or not a particular surface water or groundwater resource is polluted is a function of the intended use of the water resource in that the water may be polluted for some uses and not polluted for others. For example, a stream that contains a low dissolved oxygen level would be classified as polluted for the use of sport fishing since the survival and propagation of fish depends upon an ample supply of dissolved oxygen. That same stream, however, may not be considered polluted when its water was used for industrial cooling. Water pollution, therefore, is a relative term, depending on the uses that the water is to satisfy and the quality of the water relative to the minimum requirements established for those uses or needs.

Water Quality Parameters

There are literally hundreds of parameters, or indicators, available for measuring and describing water quality; that is, the physical, chemical, and biological characteristics of water. A list of these parameters would include all of the physical and chemical substances in solution or suspension in water, all of the macroscopic and microscopic organisms in water, and the physical characteristics of the water itself. Only a few of these hundreds of parameters, however, are normally useful in evaluating wastewater quality and natural surface water quality and in indicating pollution. Selected parameters were employed in the Pike River watershed planning program to evaluate surface water quality by comparing it to supporting adopted water use standards, which in turn relate to specific water use objectives. These same parameters were also used to describe the quality of point discharges and diffuse source runoff and to determine the effect of those discharges on receiving streams. These parameters are temperature, dissolved solids, suspended solids, specific conductance, turbidity, hydrogen ion concentration (pH), chloride, dissolved oxygen, biochemical oxygen demand (BOD), total and fecal coliform bacteria, phosphorus and nitrogen forms, aquatic flora and fauna, heavy metals, pesticides, and polychlorinated biphenyls (PCB's).[3]

Wet and Dry Weather Conditions: An Important Distinction

A distinction is drawn in this chapter between instream water quality during dry weather (base flow) conditions and during wet weather conditions. In general a water quality sample was assumed to represent dry weather conditions if 0.10 inch or less of rainfall was recorded in the 24 hours prior to the time of sampling, assuming that the precise time of sampling is known, or if such rainfall was recorded on the day of sampling in those cases where the precise time of sampling is not known. Some water samples satisfying the general dry weather criteria were found not to represent dry weather water quality because flow was significantly higher than base flow at the time of sampling. These higher flows probably reflected delayed surface runoff from, and "interflow" discharge—from higher groundwater—to, the stream caused by earlier precipitation events. Therefore, samples taken from these high flows were not used in the dry weather water quality analysis. Dry weather instream water quality is assumed to reflect the quality of groundwater discharge to the stream plus the continuous or intermittent discharge of various point sources; for example, industrial cooling or process waters and leakage and discharge from sanitary or combined sewers. While instream water quality during wet weather conditions includes the above discharges, the dominant influence, particularly during major rainfall or snowmelt runoff events, is likely to be the soluble and insoluble substances carried into the streams by direct land surface runoff. That direct runoff moves from the land surface to the surface waters by overland routes, such as drainage swales and street and highway ditches and gutters, or by the underground storm sewer system and combined sewer system.

Until recently, water quality sampling and monitoring were most often conducted in dry weather, low flow periods such as might be expected in July, August, and September. This practice reflects a period in the development of the state of the art of water quality control when continuous and relatively uniform discharges from point sources—primarily municipal sewage treatment plant and industrial wastewater outfalls—were the dominant sources of pollution addressed in pollution abatement efforts. The impact of these kinds of "point" sources of pollutants on stream water quality was most critical when stream flows were lowest. Accordingly, most of the available water quality monitoring studies for the Pike River watershed and, therefore, most of the data presented in this chapter pertain to dry weather, low flow conditions.

In the last decade, significant progress has been made in the control of major point sources of pollution. Consequently, substances carried into the streams by land surface runoff during wet weather conditions are becoming increasingly important in terms of their impacts on water quality. Wet weather conditions are likely to be as critical in terms of adverse water quality conditions as dry weather conditions are in the Pike River watershed because of the absence of major point sources of pollution. Therefore, every effort was made to obtain and report wet weather instream water quality conditions in the Pike River watershed in order to present a balanced account of all factors influencing instream water quality.

The frequency of wet weather conditions is defined, for purposes of this chapter, as being equal to the average number of days in a year on which 0.10 inch or more of precipitation occurs. An examination of daily rainfall data for the watershed for the 37-year period from 1940 through 1976 indicates that there are an average of 63 days per year during which 0.10 inch or

[3]*For a more complete discussion of most of the cited indicators, including their significance in evaluating water quality, see Chapter V of SEWRPC Technical Report No. 17, Water Quality of Lakes and Streams in Southeastern Wisconsin: 1964-1975, June 1978.*

more of precipitation may be expected. Therefore, wet weather conditions may be expected to occur during about 17 percent of the days in any given year.

WATER USE OBJECTIVES AND SUPPORTING WATER QUALITY STANDARDS

This chapter includes an evaluation, based on field studies, of historic water quality conditions in the Pike River watershed. Chapter XIII of this report uses simulation modeling to evaluate existing and hypothetical future water quality conditions in the surface waters of the watershed. Water use objectives and supporting water quality standards are particularly relevant to these two chapters since they provide a scale against which the historic, existing, and probable future water quality of the surface water system of the Pike River watershed can be evaluated.

For purposes of the comparative water quality analyses set forth in this chapter and in Chapter XIII, the water quality standards corresponding to the "warmwater fishery and aquatic life, recreational use, and minimum standards" water use objectives established under the areawide water quality planning program for the Pike River system in conformance with the national water quality objectives cited in Public Law 92-500 have been used (see Table 80 of this report). The standards are intended to permit use of the surface waters of the Pike River watershed for full body contact recreation and to support warm water fish and aquatic life. The water use objectives and supporting water quality standards set forth in Table 80 specify a minimum dissolved oxygen level; a maximum temperature, a fecal coliform count level, a total residual chlorine level, an ammonia nitrogen level, a total phosphorus level, and a pH range. In addition, by explicit and implicit reference to federal and other reports,[4,5] the water use objectives and standards incorporate recommended maximum or minimum levels for other water quality parameters.

Although the final watershed plan may recommend stream water use objectives different from the federally mandated "fishable-swimmable" stream water use objectives in the Pike River watershed, it was deemed appropriate to use the federal objectives and corresponding standards as a point of departure and a basis for evaluating the surface water quality conditions in the Pike River watershed. The comparative analyses set forth herein and in Chapter XIII are intended to provide the information needed to determine if the "fishable-swimmable" water use objectives are, as a practical matter, achievable and, if not, to recommend the establishment of a reasonable lesser set of water use objectives and supporting standards.

Historically, water quality standards were developed for application to specified periods of low flow, such as seven day-10 year low flow conditions, in order to determine the effects of point sources. Under this historic approach it was assumed that diffuse sources of pollution had an insignificant effect on water quality conditions and that the worst water quality conditions occurred during periods of low flow. More recent studies, including those conducted by the Commission under its areawide water quality management planning program, however, indicate that the water quality standards may be violated during periods of high flow as well as during periods of low flow, particularly during rainfall events following long periods of dry weather during which a buildup of pollutants takes place on the land surface. This finding requires a new approach to the application of water quality standards, an approach which considers the assessment of the proportion of the total time that water quality conditions can be expected to be in compliance with specified standards. Under this approach, statistical analyses were conducted on the results of the continuous water quality simulation modeling to determine the percent of time a given standard may be expected to be exceeded during periods of high and moderate flows as well as during periods of low flow. A 95 percent compliance level was selected for those parameters which directly affect the survival of aquatic organisms—dissolved oxygen, temperature, ammonia nitrogen, residual chlorine, and pH. A 90 percent compliance level was selected for those parameters—phosphorus and fecal coliform—which do not directly affect aquatic organisms, but are important indirect factors and are primarily related to recreational use. The analyses indicated that if these compliance levels were met during periods other than extreme low flow conditions, the duration of a violation could be expected to

[4] *U. S. Environmental Protection Agency, Quality Criteria for Water, EPA Report No. 440/9-76-003, Washington, D. C., 1976.*

[5] *National Academy of Sciences, National Academy of Engineering, Water Quality Criteria: 1972, EPA Report No. R3-73-033, Washington, D. C., 1974.*

be relatively short and the intensity of a violation could be expected to be relatively low, and, therefore, desirable forms of aquatic life should not be adversely affected. This probabalistic approach to water quality standards interpretation was considered to be a supplement to the currently practiced method of evaluating the achievement of standards for low flow conditions which approximate the seven-day average, one-in-10 year recurrence interval low flow.

Ideally, a comparative analysis between observed surface water quality and established water quality standards should be done with full knowledge of concurrent hydrologic conditions since the water quality standards are not intended to be satisfied under all streamflow conditions. As noted above, surface water quality should satisfy the standards for specified percentages of time. Unfortunately, available historic water quality data are not sufficient to determine whether such percentages have been met. Therefore, the standards were applied to all available water quality samples for comparative purposes.

In carrying out the comparative analysis, the water quality at a sampling site was considered substandard for a given parameter if any of the water quality samples were analyzed as either above or below specified limits. That is, water quality was assessed on the basis of individual determinations made for each parameter as opposed to using values averaged over a day or period of days.

A precise comparison of observed fecal coliform bacteria concentrations to the specified standards could not be made because of the manner in which the standards are defined. For example, the state-established fecal coliform bacteria standard states that the fecal coliform count shall not exceed a monthly geometric mean of 200 colonies per 100 milliliters (ml) in more than 10 percent of all samples during the month. Inasmuch as the various water quality studies which have been carried out in the watershed did not always include the requisite number of samples taken over a one-month period, the fecal coliform bacteria standard was assumed to be violated during a particular survey at a location if any of the fecal coliform counts obtained at that location exceeded 400 colonies per 100 ml.

Standards have been recommended by the U. S. Environmental Protection Agency (EPA) for heavy metals, polychlorinated biphenyls (PCB's), and pesticides but have not, as yet, been adopted by the federal or state governments. These recommended standards are presented later in this chapter in conjunction with presentation of the limited data available for the Pike River watershed regarding heavy metals, PCB's, and pesticides.

SURFACE WATER QUALITY STUDIES: PRESENTATION AND INTERPRETATION OF DATA

A variety of data sources, based primarily on field studies and dating back to 1908, are available for use in assessing the historic and existing water quality in the surface waters of the Pike River watershed. Each of the sources used in the watershed study is cited and briefly described below in chronological order according to the initiation date of the investigation. Information about each of the water quality studies used in this chapter along with selected water quality data from these sources is set forth in Table 36, and sampling station locations are shown on Map 33. From these water quality data conclusions are drawn as to the nature and, to the extent possible, the cause of surface water pollution in the Pike River watershed. An understanding of the nature and probable causes of surface water pollution is basic to developing achievable water quality objectives and alternative pollution abatement plan elements.

Some of the data and information presented herein are based on studies conducted up to 25 years ago. These data are presented to demonstrate that some of the types of pollution problems now evident in the watershed are not of recent origin, but have existed for decades. The conclusions drawn on current water quality conditions, however, are based primarily on data obtained over the past decade.

Wisconsin Department of Natural Resources Basin Surveys: 1955, 1966-67, and 1976

As part of a statewide water quality monitoring program, the Wisconsin Department of Natural Resources and its predecessor agencies have conducted three basin surveys that have included the Pike River, Sorenson Creek, Waxdale Creek, and Somers Branch of the Pike River. The purpose of the surveys was to identify the major point sources of pollution and to determine the effects of these sources on the quality of receiving waterways. The survey findings are documented in the following reports of the Wisconsin Department of Natural Resources (DNR) and its predecessor agencies:

Table 36

SUMMARY OF WATER QUALITY SAMPLING IN THE PIKE RIVER WATERSHED: 1954 TO 1976

Data Source	Documentation	Date	Streams Sampled	Number of Stations	Sampling Time, Period, Frequency	Temperature	Suspended Sediment	Specific Conductance	Biochemical Oxygen Demand	Dissolved Oxygen	Nitrite Nitrogen	Nitrate Nitrogen	Ammonia Nitrogen	Organic Nitrogen	Total Nitrogen	Dissolved Phosphorus	Soluble Reactive Phosphorus
Wisconsin Department of Natural Resources	Fox (Ill.), Des Plaines and Root River Drainage Basin 2, 3, and 4 Stream Pollution—January 28, 1955	1954	Somers Branch of Pike Creek of Pike River Watershed	1	Two visits in September and October	X	--	--	X	X	--	--	--	--	--	--	--
Wisconsin Department of Natural Resources	Report on an Investigation of the Pollution in the Des Plaines and Pike Basin Made During 1966 and 1967	November 22, 1967	Pike River Main Stem	22	2 to 5 visits July through October 1967	X	--	--	X	X	--	--	--	--	--	--	--
			Waxdale Creek	4	2 to 5 visits July through October 1967	X	--	--	X	X	--	--	--	--	--	--	--
			Pike Creek	2	2 to 5 visits July through October 1967	X	--	--	X	X	--	--	--	--	--	--	--
			Somers Branch	6	2 to 5 visits July through October 1967	X	--	--	X	X	--	--	--	--	--	--	--
Wisconsin Department of Natural Resources	A Drainage Basin Report November 1976	November 1976	Pike River Main Stem	22	3 visits June, August, October 1973	X	--	--	X	X	--	--	--	--	--	--	--
			Somers Tributary	7	3 visits June, July, October, November 1973	X	--	--	X	X	--	--	--	--	--	--	--
			Waxdale Creek	4	3 to 4 visits June, August, October 1973	X	--	--	X	X	--	--	--	--	--	--	--
			Pike Creek	4	3 visits June, July, October 1973	X	--	--	X	X	--	--	--	--	--	--	--
			Sorenson Creek	1	3 visits June, July, October	X	--	--	X	X	--	--	--	--	--	--	--
			Tributary to South Branch Pike River (tributary to Pike Creek)	2	3 visits June, July October	X	--	--	X	X	--	--	--	--	--	--	--
			Somers Branch	4	3 visits June, July, October	X	--	--	X	X	--	--	--	--	--	--	--
SEWRPC	SEWRPC Water Quality Studies: 1964-1965 and 1968-1976	1964	Pike River Main Stem	2	January 30, 1964 through August 20, 1975	X	--	X	--	X	X	X	X	X	X	X	--
			Pike Creek	2	February 19, 1964 through August 20, 1975	X	--	X	--	X	X	X	X	X	X	X	--
Wisconsin Department of Natural Resources	Wisconsin Department of Natural Resources Drainage Basin Surveys of Toxic and Hazardous Substance 1975-1976	1978	Pike Creek	1	June 6, 1973 through October 23, 1973	--	--	--	--	--	--	--	--	--	--	--	--
			Pike River	1	October 30, 1973	--	--	--	--	--	--	--	--	--	--	--	--
			Pike River	1	June 13, 1973 through October 30, 1973	--	--	--	--	--	--	--	--	--	--	--	--
			Pike Creek	1	June 5, 1973 through November 6, 1973	--	--	--	--	--	--	--	--	--	--	--	--
			Pike River	1	July 30, 1973 through October 30, 1973	--	--	--	--	--	--	--	--	--	--	--	--
			Pike River	1	June 12, 1973	--	--	--	--	--	--	--	--	--	--	--	--
			Waxdale Creek	1	June 13, 1973 through October 29, 1973	--	--	--	--	--	--	--	--	--	--	--	--
SEWRPC	Index Site Water Quality Data	1976	Pike River Main Stem	2	34 Samples September 6, 1976 through October 7, 1976	X	--	X	X	X	X	X	X	X	X	X	X
Wisconsin Department of Natural Resources	Report on an Investigation of the Des Plaines and Pike River Basin Made During 1966 and 1967	November 22, 1967	Pike River	7	October 29, 1966	--	--	--	--	--	--	--	--	--	--	--	--
			Pike Creek	2	October 25, 1966	--	--	--	--	--	--	--	--	--	--	--	--
			Somers Branch	1	October 25, 1966	--	--	--	--	--	--	--	--	--	--	--	--
Wisconsin Department of Natural Resources	A Drainage Basin Report November 1976	November 1976	Pike River	9	One sample at each location December 11, 1973 or December 13, 1973	--	--	--	--	--	--	--	--	--	--	--	--
			Sturtevant Tributary (Waxdale Creek tributary)	1	December 11, 1973	--	--	--	--	--	--	--	--	--	--	--	--
			Pike Creek	2	November 30, 1973	--	--	--	--	--	--	--	--	--	--	--	--
			Somers Tributary	1	November 30, 1973	--	--	--	--	--	--	--	--	--	--	--	--

Table 36 (continued)

Data Source	Documentation	Date	Streams Sampled	Number of Stations	Sampling Time, Period, Frequency	Total Phosphorus	Phosphate Phosphorus	Chloride	Total Dissolved Solids	Fecal Coliform	Coliform	pH	Bottom Organisms	Turbidity	Cadmium	Chromium	Copper	Lead	Mercury
Wisconsin Department of Natural Resources	Fox (Ill.), Des Plaines and Root River Drainage Basin 2, 3, and 4 Stream Pollution—January 28, 1955	1954	Somers Branch of Pike Creek of Pike River Watershed	1	Two visits in September and October	--	--	--	--	--	X	X	X	--	--	--	--	--	--
Wisconsin Department of Natural Resources	Report on an Investigation of the Pollution in the Des Plaines and Pike Basin Made During 1966 and 1967	November 22, 1967	Pike River Main Stem	22	2 to 5 visits July through October 1967	--	--	--	--	--	X	X	--	--	--	--	--	--	--
			Waxdale Creek	4	2 to 5 visits July through October 1967	--	--	--	--	--	X	X	--	--	--	--	--	--	--
			Pike Creek	2	2 to 5 visits July through October 1967	--	--	--	--	--	X	X	--	--	--	--	--	--	--
			Somers Branch	6	2 to 5 visits July through October 1967	--	--	--	--	--	X	X	--	--	--	--	--	--	--
Wisconsin Department of Natural Resources	A Drainage Basin Report November 1976	November 1976	Pike River Main Stem	22	3 visits June, August, October 1973	--	--	--	--	X	--	X	--	--	--	--	--	--	--
			Somers Tributary	7	3 visits June, July, October, November 1973	--	--	--	--	X	--	X	--	--	--	--	--	--	--
			Waxdale Creek	4	3 to 4 visit June, August, October 1973	--	--	--	--	X	--	X	--	--	--	--	--	--	--
			Pike Creek	4	3 visits June, July, October 1973	--	--	--	--	X	--	X	--	--	--	--	--	--	--
			Sorenson Creek	1	3 visits June, July, October	--	--	--	--	X	--	X	--	--	--	--	--	--	--
			Tributary to South Branch Pike River (tributary to Pike Creek)	2	3 visits June, July October	--	--	--	--	X	--	X	--	--	--	--	--	--	--
			Somers Branch	4	3 visits June, July, October	--	--	--	--	X	--	X	--	--	--	--	--	--	--
SEWRPC	SEWRPC Water Quality Studies: 1964-1965 and 1968-1976	1964	Pike River Main Stem	2	January 30, 1964 through August 20, 1975	X	--	X	--	X	X	X	--	--	--	--	--	--	--
			Pike Creek	2	February 19, 1964 through August 20, 1975	X	--	X	--	X	X	X	--	--	--	--	--	--	--
Wisconsin Department of Natural Resources	Wisconsin Department of Natural Resources Drainage Basin Surveys of Toxic and Hazardous Substance 1975-1976	1978	Pike Creek	1	June 6, 1973 through October 23, 1973	--	--	--	--	--	--	--	--	--	X	X	X	X	X
			Pike River	1	October 30, 1973	--	--	--	--	--	--	--	--	--	X	X	X	X	X
			Pike River	1	June 13, 1973 through October 30, 1973	--	--	--	--	--	--	--	--	--	X	X	X	X	X
			Pike Creek	1	June 5, 1973 through November 6, 1973	--	--	--	--	--	--	--	--	--	--	--	--	--	--
			Pike River	1	July 30, 1973 through October 30, 1973	--	--	--	--	--	--	--	--	--	--	--	--	--	--
			Pike River	1	June 12, 1973	--	--	--	--	--	--	--	--	--	--	--	--	--	--
			Waxdale Creek	1	June 13, 1973 through October 29, 1973	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SEWRPC	Index Site Water Quality Data	1976	Pike River Main Stem	2	34 Samples September 6, 1976 through October 7, 1976	X	--	--	--	--	--	--	--	--	--	--	--	--	--
Wisconsin Department of Natural Resources	Report on an Investigation of the Des Plaines and Pike River Basin Made During 1966 and 1967	November 22, 1967	Pike River	7	October 29, 1966	--	--	--	--	--	--	--	X	--	--	--	--	--	--
			Pike Creek	2	October 25, 1966	--	--	--	--	--	--	--	X	--	--	--	--	--	--
			Somers Branch	1	October 25, 1966	--	--	--	--	--	--	--	X	--	--	--	--	--	--
Wisconsin Department of Natural Resources	A Drainage Basin Report November 1976	November 1976	Pike River	9	One sample at each location December 11, 1973 or December 13, 1973	--	--	--	--	--	--	--	X	--	--	--	--	--	--
			Sturtevant Tributary (Waxdale Creek tributary)	1	December 11, 1973	--	--	--	--	--	--	--	X	--	--	--	--	--	--
			Pike Creek	2	November 30, 1973	--	--	--	--	--	--	--	X	--	--	--	--	--	--
			Somers Tributary	1	November 30, 1973	--	--	--	--	--	--	--	X	--	--	--	--	--	--

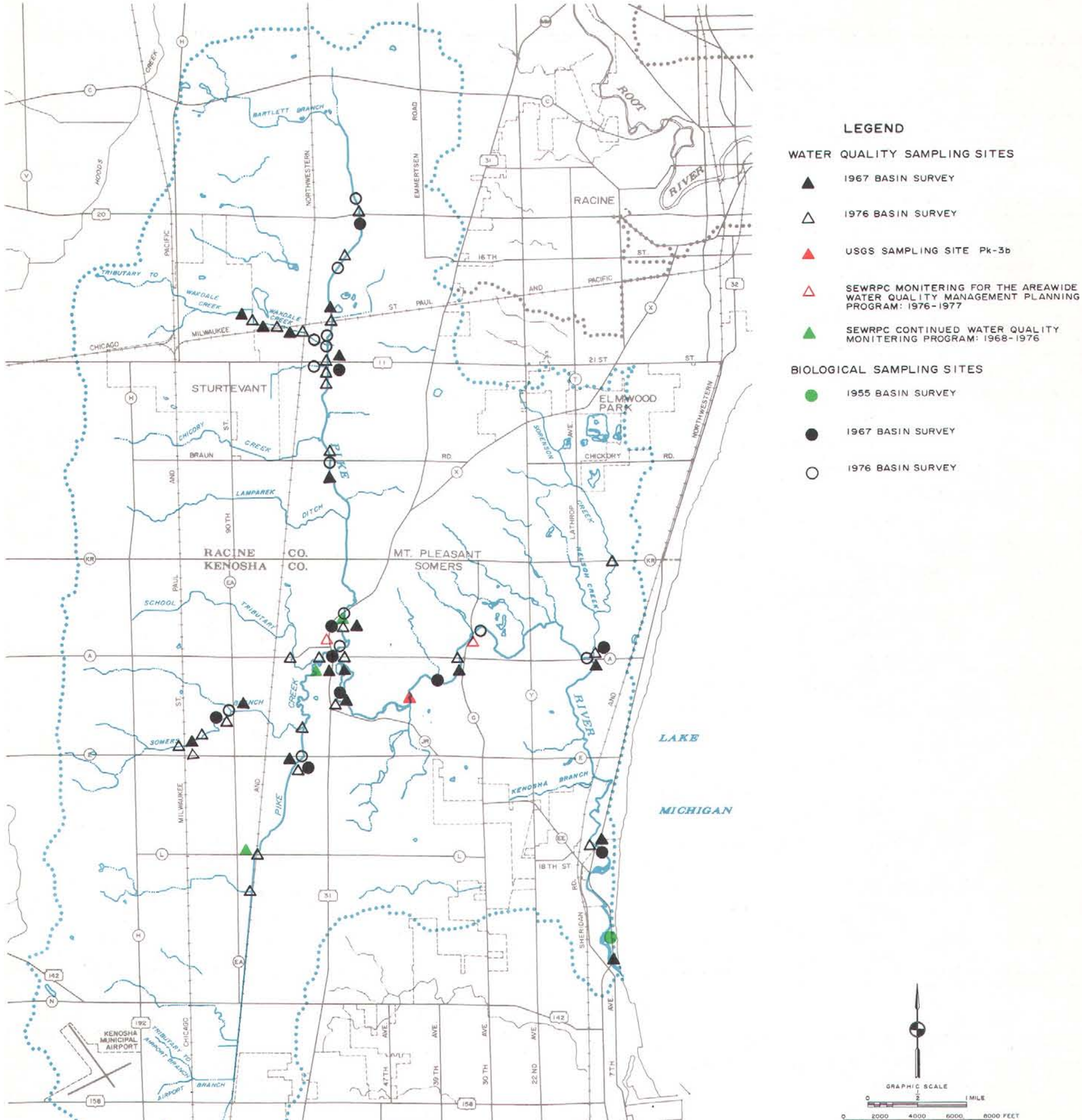
Table 36 (continued)

Data Source	Documentation	Date	Streams Sampled	Number of Stations	Sampling Time, Period, Frequency	Nickel	Zinc	PCB	DDT	DDE	DDD	Aldrin	Heptachlor	Heptachlor Epoxide	Lindane	Dieldrin	Methoxychlor	Phthalate	Atrazine	Simazine
Wisconsin Department of Natural Resources	Fox (Ill.), Des Plaines and Root River Drainage Basin 2, 3, and 4 Stream Pollution—January 28, 1955	1954	Somers Branch of Pike Creek of Pike River Watershed	1	Two visits in September and October	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
Wisconsin Department of Natural Resources	Report on an Investigation of the Pollution in the Des Plaines and Pike Basin Made During 1966 and 1967	November 22, 1967	Pike River Main Stem	22	2 to 5 visits July through October 1967	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
			Waxdale Creek	4	2 to 5 visits July through October 1967	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
			Pike Creek	2	2 to 5 visits July through October 1967	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
			Somers Branch	6	2 to 5 visits July through October 1967	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
Wisconsin Department of Natural Resources	A Drainage Basin Report November 1976	November 1976	Pike River Main Stem	22	3 visits June, August, October 1973	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
			Somers Tributary	7	3 visits June, July, October, November 1973	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
			Waxdale Creek	4	3 to 4 visits June, August, October 1973	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
			Pike Creek	4	3 visits June, July, October 1973	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
			Sorenson Creek	1	3 visits June, July, October	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
			Tributary to South Branch Pike River (tributary to Pike Creek)	2	3 visits June, July October	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
			Somers Branch	4	3 visits June, July, October	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
SEWRPC	SEWRPC Water Quality Studies: 1964-1965 and 1968-1976	1964	Pike River Main Stem	2	January 30, 1964 through August 20, 1975	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
			Pike Creek	2	February 19, 1964 through August 20, 1975	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
Wisconsin Department of Natural Resources	Wisconsin Department of Natural Resources Drainage Basin Surveys of Toxic and Hazardous Substance 1975-1976	1978	Pike Creek	1	June 6, 1973 through October 23, 1973	X	X	X	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
			Pike River	1	October 30, 1973	X	X	X	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
			Pike River	1	June 13, 1973 through October 30, 1973	X	X	X	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
			Pike Creek	1	June 5, 1973 through November 6, 1973	- -	- -	- -	X	X	X	X	X	X	X	X	X	X	- -	- -
			Pike River	1	July 30, 1973 through October 30, 1973	- -	- -	- -	X	X	X	X	X	X	X	X	X	X	- -	- -
			Pike River	1	June 12, 1973	- -	- -	- -	X	X	X	X	X	X	X	X	X	X	- -	- -
			Waxdale Creek	1	June 13, 1973 through October 29, 1973	- -	- -	- -	X	X	X	X	X	X	X	X	X	X	- -	- -
SEWRPC	Index Site Water Quality Data	1976	Pike River Main Stem	2	34 Samples September 6, 1976 through October 7, 1976	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
Wisconsin Department of Natural Resources	Report on an Investigation of the Des Plaines and Pike River Basin Made During 1966 and 1967	November 22, 1967	Pike River	7	October 29, 1966	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
			Pike Creek	2	October 25, 1966	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
			Somers Branch	1	October 25, 1966	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
Wisconsin Department of Natural Resources	A Drainage Basin Report November 1976	November 1976	Pike River	9	One sample each location December 11, 1973 or December 13, 1973	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
			Sturtevant Tributary (Waxdale Creek tributary)	1	December 11, 1973	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
			Pike Creek	2	November 30, 1973	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
			Somers Tributary	1	November 30, 1973	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -

Source: SEWRPC.

Map 33

STREAM WATER QUALITY SAMPLING STATIONS IN THE PIKE RIVER WATERSHED



Source: SEWRPC.

A variety of data sources are available for use in assessing the historic and existing water quality in the Pike River and its tributaries and for identifying the cause of surface water pollution. These data are derived from long-term monitoring studies such as the cooperative effort carried out since 1964 by SEWRPC and the Wisconsin Department of Natural Resources and from special-purpose studies such as the SEWRPC monitoring for the areawide water quality management plan.

1. Fox (Ill.), Des Plaines and Root River Drainage Basins 2, 3, and 4: Stream Pollution, January 28, 1955.

2. Report on an Investigation of the Pollution in the Des Plaines and Pike Basin Made During 1966 and 1967. Division of Resource Development, November 22, 1967.

3. Southeastern Wisconsin River Basin—A Drainage Basin Report, Division of Environmental Standards, November 1976.

Findings of the 1955 Basin Survey: Limited chemical water quality sample data is presented in the 1955 Basin Survey. Two samples were taken at a location on the Somers Branch of Pike Creek at County Trunk Highway (CTH) EA. These samples were taken during dry weather conditions, and indicated satisfactory dissolved oxygen levels. Some biological sampling was conducted on the lower reaches of the Pike River at locations about 200 yards above the upper Alford Drive bridge and about 600 yards above the lower Alford Drive bridge in the City of Kenosha. The samples were taken during low flow conditions with stagnant water on both sites of the bridges concerned. The study showed that 16 organisms per square foot of a tolerant variety were found at the upper Alford Drive site, and no organisms were found at the lower Alford Drive sample site. The report rated the upper location as semi-polluted and the lower location as polluted.

Findings of the 1966-1967 Basin Survey: Table 37 displays the water quality results of sample data obtained for the 1966-67 Basin Survey. The sample data indicates that dissolved oxygen characteristics are extremely variable. The variable results may be largely attributed to temporal and spatial variations in stream flow, channel geometry, water temperature, and cloud cover in the watershed. Flow conditions in the watershed can range from warm stagnant water during dry weather to full channel flow conditions during cold wet weather, resulting in a wide range of hydraulic conditions and oxygen saturation levels that vary the aeration rate of the stream system, causing seemingly inconsistent dissolved oxygen sample results. Dissolved oxygen levels are generally high during cold or wet weather conditions on the main stem and lower during dry weather conditions. Temporal and spatial variations in cloud cover affect the rate of photosynthesis by aquatic plants and consequently the rate of oxygen production by these plants. Large, rapid changes in dissolved oxygen concentrations can be caused solely by changes in cloud cover which affect the rate of photosynthesis. Pike Creek dissolved oxygen levels were on the average above standard over the record period. Tributaries to the Pike River and Pike Creek showed consistently low dissolved oxygen levels. High total coliform counts—in excess of 10,000,000 colonies per 100 milliliters (ml)—were observed on two or more sampling days and at five sample locations throughout the watershed. The high total coliform counts found suggest that the fecal coliform level of 400 colonies per 100 ml was probably exceeded in many samples. Table 37 indicates that the standards for temperature and pH presented in Table 80 generally were not violated during this sample period.

Biological samples collected on the Pike River and its tributaries (see Table 38) indicate some pollution intolerant benthic community development at three locations in the watershed. A trace of intolerant benthic organisms indicating desirable water quality conditions was found at State Trunk Highway (STH) 20 and at 13th Avenue below the Kenosha Country Club on the main stem of the Pike River and at CTH E on Pike Creek. Two of these sites—STH 20 and CTH E—have no known upstream point sources of pollution and a potential local aeration exists through riffle currents upstream from the sampling sites. Point sources of pollution exist upstream from the 13th Avenue site. These sources are, however, located a substantial distance from the sampling site and a potential aeration exists. Benthic organisms very tolerant of polluted conditions were found at all locations where samples were taken and were the only species found at STH 31 on Pike Creek and STH 31 on the Pike River. These two locations were described as having odorous slime growth on bottom materials. Two locations, one at CTH EA and one about 100 feet below the Petrifying Springs Lagoon were not sampled for benthic organisms, however the sites were described as having stagnant water conditions with odorous sludge accumulations and slime.

Findings of the 1976 Basin Report: Table 39 displays the water quality data obtained in the 1976 Basin Report. The sample data indicate that the dissolved oxygen levels, while variable, were generally above the minimum dissolved oxygen standard of 5 milligrams per liter (mg/l). One sample taken at each of two sites on the Pike River—above Petrifying Springs Park and at the

Table 37

SUMMARY OF WATER QUALITY DATA FOR THE PIKE RIVER WATERSHED FROM THE WISCONSIN DEPARTMENT OF NATURAL RESOURCES BASIN SURVEY: 1966-1967

Sampling Station				Water Quality Indicators					Concurrent and Antecedent Moisture Conditions as Indicated by Precipitation Observations: Daily Precipitation in Inches		Characterization of Sampling Conditions	
Stream	Location	River Mile	Date[a]	Temperature (°C)	pH (standard units)	Dissolved Oxygen (mg/l)	Biochemical Oxygen Demand (mg/l)	Total Coliform Count (MFCC per 100 ml)	On Day 1 and 1	Before Day 2 Sampling 2	Dry Weather[b]	Wet Weather
Pike River	Highway 20 bridge	14.7	July 6, 1966	27.5	8.1	11.4	2.7	40,000	0.0	0.0	X	--
			August 4, 1966	19.0	7.5	2.2	4.6	35,000	0.0	0.0	X	--
			October 18, 1966	9.0	7.8	4.6	9.5	1,600,000	0.0	0.0	X	--
			October 25, 1966	8.0	8.1	7.5	9.5	90,000	0.06	0.16	--	X
			February 23, 1967	0.0	7.4	8.3	1.2	48,000	0.0	0.03	X	--
	Railroad bridge north of Highway 11	13.5	November 17, 1966	12.5	8.4	15.1	7.1	100,000	0.0	0.0	X	--
	Highway 11 bridge	13.1	July 6, 1966	27.5	8.0	6.3	39.8	11,000,000	0.0	0.0	X	--
			August 4, 1966	24	7.6	1.0	12.3	2,700,000	0.0	0.0	X	--
			October 18, 1966	14	7.7	2.5	43.0	14,000,000	0.0	0.0	X	--
			October 25, 1966	15	8.4	10.3	>45.7	3,000,000	0.06	0.16	--	X
			February 23, 1967	0	7.6	6.9	14.6	700,000	0.0	0.03	X	--
	Chicory Road bridge	12.0	July 6, 1966	25	8.2	11.1	22.9	4,100,000	0.0	0.0	X	--
			August 4, 1966	23	7.6	1.1	3.5	2,600,000	0.0	0.0	X	--
	Highway 31 bridge above Petrifying Springs Park	10.25	July 6, 1966	25	7.5	0.7	41.3	3,100,000	0.0	0.0	X	--
			August 4, 1966	19	7.6	2.1	4.0	180,000	0.0	0.0	X	--
			October 25, 1966	10	8.1	11.1	11.1	320,000	0.06	0.16	--	X
			February 22, 1967	0	7.5	6.1	21.4	380,000	0.0	0.0	X	--
	CTH A bridge at inlet to Petrifying Springs Park	9.5	July 6, 1966	25	7.5	0.4	10.8	10,000	0.0	0.0	X	--
			August 4, 1966	19.5	7.6	1.7	4.9	170,000	0.0	0.0	X	--
			October 25, 1966	9	7.7	3.3	12.9	360,000	0.07	0.12	--	X
			February 22, 1967	0	7.6	6.8	19.8	20,000	0.0	0.0	X	--
	Petrifying Springs Park lagoon outlet	9.0	July 6, 1966	26	7.4	0.0	108.0	170,000	0.0	0.0	X	--
			August 4, 1966	20	7.6	7.2	3.1	70,000	0.0	0.0	X	--
			October 25, 1966	11	7.6	14.0	17.8	50,000	0.07	0.12	--	X
	CTH A below Petrifying Springs Park	6.95	July 6, 1966	27	7.8	0.0	67.9	320,000	0.0	0.0	X	--
			August 4, 1966	20.5	7.8	7.2	3.8	60,000	0.0	0.0	X	--
			October 25, 1966	12	8.2	14.0	1.8	10,000	0.07	0.12	--	X
	13th Avenue below Kenosha Country Club	4.75	July 6, 1966	27	8.4	10.8	3.0	6,000	0.0	0.0	X	--
			August 4, 1966	20	7.8	6.8	2.0	20,000	0.0	0.0	X	--
			October 25, 1966	12	8.5	16.0	1.5	10,000	0.07	0.12	--	X
			February 22, 1967	0	7.5	4.35	1.8	20,000	0.0	0.0	X	--
	Highway 32 at Alford Park Drive and Sheridan Road intersection	1.7	July 6, 1966	26	8.3	2.7	3.0	13,000	0.0	0.0	X	--
			August 4, 1966	21	7.6	0.2	5.5	400,000	0.0	0.0	X	--
			October 25, 1966	9	7.4	8.1	0.9	<10,000	0.07	0.12	--	X
			February 22, 1967	0	7.5	3.55	1.9	30,000	0.0	0.0	X	--
	Highway 32 at Alford Park Drive above lake	0.1	July 6, 1966	27	7.8	2.8	5.9	30,000	0.0	0.0	X	--
			August 4, 1966	23	7.4	1.7	4.6	29,000	0.0	0.0	X	--

Braun Road bridge—were slightly below standard. Low dissolved oxygen levels were also found in Pike Creek, Waxdale Creek, and the Somers Branch of Pike Creek. High fecal coliform counts in excess of 5,000 colonies per 100 ml were found in upstream reaches of the Pike River and in Pike Creek and Waxdale Creek. The sample data indicate that generally excessive levels of fecal coliform bacteria existed throughout the stream system of the watershed, with the possible exception of the downstream reaches of the Pike River near Kenosha, where levels appear to be within the limits of the standard. Table 39 indicates that temperature and pH levels were not a problem during the sample period. Only one sample, recording a pH of 9.1, on Waxdale Creek was found to exceed the pH standard.

Biological samples collected on the Pike River and its tributaries indicated traces of intolerant benthic community development at three locations in the watershed (see Table 40). Pollution intolerant benthic organisms were found to exist on the Pike River downstream of the confluence with Pike Creek, and at two sites on Pike Creek above and below the confluence with Somers Branch. Benthic

Table 37 (continued)

Sampling Station				Water Quality Indicators					Concurrent and Antecedent Moisture Conditions as Indicated by Precipitation Observations: Daily Precipitation in Inches		Characterization of Sampling Conditions	
Stream	Location	River Mile	Date[a]	Temperature (°C)	pH (standard units)	Dissolved Oxygen (mg/l)	Biochemical Oxygen Demand (mg/l)	Total Coliform Count (MFCC per 100 ml)	On Day 1 and 1	Before Day 2 Sampling 2	Dry Weather[b]	Wet Weather
Waxdale Creek	Sewage treatment plant at outfall	0.7	July 6, 1966	21	--	--	43.4	--	0.0	0.0	X	--
			August 4, 1966	21	7.6	--	13.1	--	0.0	0.0	X	--
			October 12, 1966	15	7.6	--	54.5	--	0.0	0.0	X	--
			October 18, 1966	--	7.55	--	43.1	--	0.0	0.0	X	--
			February 23, 1967	5	7.6	--	73	--	0.0	0.03	X	--
	Above S. C. Johnson & Son, Inc., outfall	0.5+	October 12, 1966	16	7.8	4.6	43.9	81,000,000	0.0	0.0	X	--
			October 18, 1966	14	7.8	4.2	42.2	80,000,000	0.0	0.0	X	--
	Willow Road	0.3	July 6, 1966	27	7.5	0.8	65.2	14,000,000	0.0	0.0	X	--
			August 4, 1966	25	7.5	2.4	20.7	27,000,000	0.0	0.0	X	--
			October 12, 1966	19	7.6	1.1	93	18,000,000	0.0	0.0	X	--
			October 18, 1966	17.5	7.7	2.5	88.6	16,000,000	0.0	0.0	X	--
			February 23, 1967	5	7.6	3.8	2.14	7,100,000	0.0	0.03	X	--
Pike Creek	CTH E above Somers Branch	2.1	August 3, 1966	21	7.8	7.5	2.0	100,000	0.0	0.0	X	--
			October 25, 1966	8	7.5	1.0	4.0	3,000	0.07	0.12	--	X
	Highway 31 bridge below Somers Branch	0.1	July 6, 1966	26	7.8	3.2	5.8	40,000	0.0	0.0	X	--
			August 3, 1966	21	8.0	9.0	1.8	110,000	0.0	0.0	X	--
			October 25, 1966	9	7.6	2.9	35.6	690,000	0.07	0.12	--	X
			February 22, 1967	0	7.4	7.05	0.9	500	0.0	0.0	X	--
Somers Branch	Above Sewage Treatment Plant Outfall	1.6+	July 6, 1966	30	4.3	0.0	2,690	110,000	0.0	0.0	X	--
			August 3, 1966	28	6.4	0.0	264	120,000,000	0.0	0.0	X	--
			September 12, 1966	24	6.8	0.0	581	39,000,000	0.0	0.0	X	--
	CTH EA bridge	1.0	July 6, 1966	27	7.0	0.0	--	690,000,000	0.0	0.0	X	--
			August 3, 1966	21.5	7.8	2.3	--	33,000,000	0.0	0.0	X	--
			September 12, 1966	20.5	8.1	2.5	--	2,700,000	0.0	0.0	X	--
			October 25, 1966	11	7.8	0.0	--	2,000,000	0.07	0.12	--	X
			February 22, 1967	0	7.2	7.15	--	1,300,000	0.0	0.0	X	--

[a] Sampling time not available.

[b] Precipitation of 0.10 inch or less on day of sampling.

Source: Wisconsin Department of Natural Resources.

organisms very tolerant of polluted conditions were found at all sample locations and were the only benthic organisms found at the Braun Road bridge and at STH 31, both on the main stem of the Pike River. These two locations were described as grossly polluted.

SEWRPC Water Quality Study: 1964-1965

During the 14-month period extending from January 1964 through February of 1965, the Commission conducted an extensive stream water quality sampling program during which almost 4,000 water samples were collected at 87 sampling stations established in 43 streams in the Region. Under this program, samples were taken at four sampling station locations in the Pike River watershed—the Pike River at STH 31, the Pike River at STH 32, Pike Creek at 81th Street and Pike Creek at STH 31—the sampling stations being identified as Pk-1, Pk-4, Pk-2, and Pk-3, respectively. Stream water samples were taken under dry weather conditions on a monthly basis at these stations from April of 1964 to February of 1965 and were analyzed for selected chemical, physical, and biological characteristics in order to determine the then-existing condition of stream water quality in relation to pollution sources, land use, and population distribution and concentration. The study procedure and results are described in SEWRPC Technical Report No. 4, Water Quality and Flow of Streams in Southeastern Wisconsin: 1966.

Findings of the Study: Table 41 presents a synopsis of dry weather water quality conditions in the Pike River and Pike Creek, as determined by the 1964 and 1965 sampling. Survey results for dissolved oxygen, temperature, total coliform bacteria, pH, specific conductance and chloride, as set forth in Table 41 are discussed below.

Dissolved Oxygen: During the sampling period, the dissolved oxygen levels in the watershed were found to range from 0.1 to 13.2 milligrams per liter (mg/l), with the average values for the Pike

Table 38

BENTHIC ORGANISM DATA FROM THE WISCONSIN DEPARTMENT OF NATURAL RESOURCES BASIN SURVEY: 1967

Stream	Station Location	River Mile	Date	Waste Source	Bottom Type	Current	Benthic Invertebrate Organisms: Intolerant: Number of Species	Intolerant: Total Population	Tolerant: Number of Species	Tolerant: Total Population	Very Tolerant: Number of Species	Very Tolerant: Total Population	Remarks
Pike River	Highway 20 bridge 1.6 miles above Sturtevant Tributary (Waxdale Creek) and above Town of Mt. Pleasant outfall tile	12.4	10/25/1966	None known	Rock, Gravel, Sand	Riffle	1	2	3	520	2	1,815	Black odorous sludge and slimes noted immediately below outfall tile
	Highway 11, 0.2 mile below Sturtevant Tributary (Waxdale Creek)	10.6	10/25/1966	Sturtevant STP and S. C.Johnson & Son, Inc.	Rock and Gravel	Riffle	0	0	2	2	1	55	Slimes and algae on rocks. Bottom material black and odorous
	Highway 31, 3.0 miles below Sturtevant Tributary (Waxdale Creek)	7.8	10/25/1966	Sturtevant STP and S. C. Johnson & Son, Inc.	Gravel	Riffle	0	0	0	0	1	315	Slimes and algae on rocks. Bottom material black and odorous
	100 feet below Petrifying Springs Lagoon outlet below confluence with Pike Creek	6.5	10/25/1966	Skokie Canning Company, Somers STP, Sturtevant STP, and S. C. Johnson & Son, Inc.	Large Rocks	Riffle	--[a]	--	--	--	--	--	Bottom material black and odorous. Slimes and filamentous algae on rocks. Duckweed heavy
	1.2 miles below Petrifying Springs Park	5.3	10/25/1966	Skokie Canning Company, Somers STP, Sturtevant STP, and S. C. Johnson & Son, Inc.	Gravel	Riffle	0	0	7	827	5	718	--
	13th Avenue below Kenosha Country Club	4.3	10/25/1966	Skokie Canning Company, Somers STP, Sturtevant STP, and S. C. Johnson & Son, Inc.	Rock, Sand, Gravel	Riffle	1	14	4	160	2	120	Algae and duckweed noted
	Highway 32 at Alford Park Drive and Sheridan Road	1.6	10/25/1966	Skokie Canning Company, Somers STP, Sturtevant STP, and S. C. Johnson & Son, Inc.	Rock and Gravel	Riffle	0	0	8	100	3	179	--
Pike Creek	CTH E above Somers Branch		10/25/1966	None Known	Rock and Gravel	Slow	1	84	4	318	3	62	--
	Highway 31 below Somers Branch	0.1	10/25/1966	Skokie Canning Company and Somers STP	Gravel	Riffle	0	0	0	0	2	217	Slime growths and dead minnows noted. Bottom materials odorous
Somers Branch	CTH EA 0.6 mile below Skokie Canning Company and Somers STP	1.0	10/25/1966	Skokie Canning Company and Somers STP	Sludge	Slow	--[a]	--	--	--	--	--	Almost no flow. Odorous sludge accumulations and slime noted

NOTE: STP is abbreviation for sewage treatment plant.

[a]*No sample was taken at this site.*

Source: Wisconsin Department of Natural Resources and SEWRPC.

River and Pike Creek being 5.3 and 6.0 mg/l, respectively. Although the average concentration of dissolved oxygen was 5.3 mg/l for the Pike River, several instances of substandard levels were noted at the two sampling stations on the Pike River. At station Pk-1, the concentration of dissolved oxygen was below 5 mg/l for 10 of the 13 samples. Since the nearest sanitary wastewater discharge was located 5.0 miles upstream from sampling station Pk-1, as indicated on Map 34, a more likely source for oxygen depleting substances may have been runoff from the agricultural land which then comprised 76 percent of the land use in the watershed. Samples taken at Station Pk-4, located on the Pike River downstream from Pk-1 and Pike Creek, exhibited substandard levels of dissolved oxygen in five of 14 samples, twice during late summer and three times during the months of January and February. The concentration of dissolved oxygen was found to be higher than at Pk-1 for all sampling surveys. The distance between sampling stations Pk-1 and Pk-4 was 8.1 miles and, apparently, the absence of any significant sanitary sewage and industrial waste discharges between these two locations allowed the stream to reestablish its dissolved oxygen content to some extent, as indicated by the apparent increased dissolved oxygen concentrations at Pk-4.

Pike Creek, which joins the Pike River about one-half mile downstream from Pk-1, had two sampling stations, one located upstream at CTH L and one downstream at STH 31 from the Somers Branch tributary to Pike Creek. The tributary carries effluent from the sewage treatment plant operated by the Town of Somers Utility District No. 1.

Table 39

SUMMARY OF WATER QUALITY DATA FOR THE PIKE RIVER WATERSHED FROM THE WISCONSIN DEPARTMENT OF NATURAL RESOURCES BASIN SURVEY: 1976

Sampling Station				Water Quality Indicators						Concurrent and Antecedent Moisture Conditions as Indicated by Precipitation Observations		Characterization of Sampling Conditions	
										Daily Precipitation in Inches			
Stream	Location	River Mile	Date[a]	Flow	Temperature °C	Dissolved Oxygen (mg/l)	pH (standard units)	Fecal Coliform Count (MFFCC per 100 ml)	Biochemical Oxygen Demand (mg/l)	On Day 1 and 1	Before Day 2 Sampling 2	Dry Weather[b]	Wet Weather
Pike River	10 feet below STH 20 bridge	14.7	June 7, 1973	0.6	17	--	8.1	400	2.8	0.0	0.52	--	X
			August 2, 1973	0.7	11	10.4	8.0	180	5.2	0.0	0.0	X	--
			October 29, 1973	0.9	8	12.8	8.2	15,000	1.5	0.0	0.0	X	--
	N-S Road, East of Case High School	14.3	August 2, 1973	0.7	19	16.0	8.2	150	1.2	0.0	0.0	X	--
			October 29, 1973	1.8	9	7.9	7.9	8,900	4.6	0.0	0.0	X	--
			November 6, 1973	0.7	1	14.0	8.2	810	1.5	0.0	0.0	X	--
	Near Oaks & Son Contractor	13.8	June 7, 1973	8.4	17	14.3	8.1	6,800	5.7	0.0	0.52	--	X
			August 2, 1973	2.9	22	16.2	8.6	350	0.9	0.0	0.0	X	--
			October 29, 1973	1.9	13	10.1	8.0	14,000	4.3	0.0	0.0	X	--
	STH 11 bridge	13.1	June 7, 1973	21.6	18	9.8	8.1	800	18.0	0.0	0.52	--	X
			August 1, 1973	10.8	22	8.6	8.0	140	4.3	0.07	0.0	X	--
			October 29, 1973	10.0	13	7.6	8.4	3,900	>25.0	0.0	0.0	X	--
	At Braun Road bridge	12.0	June 11, 1973	17.9	25	15.0	8.5	550	2.5	0.0	0.0	X	--
			August 1, 1973	11.7	21	12.4	8.4	1,200	3.4	0.07	0.0	X	--
			October 30, 1973	8.0	15	4.6	8.2	100	5.5	0.0	0.0	X	--
	Near STH 31 bridge	10.25	June 12, 1973	30.2	25	13.6	8.5	600	< 0.3	0.0	0.0	X	--
			August 1, 1973	12.9	20	7.2	7.8	300	1.8	0.07	0.0	X	--
			October 30, 1973	9.3	15	5.0	7.8	6,300	> 2.4	0.0	0.0	X	--
	Northwest entrance to Petrifying Springs Park	9.5	June 12, 1973	20.7	21	6.2	7.9	3,900	3.3	0.0	0.0	X	--
			August 1, 1973	16.1	21	4.7	8.2	450	3.1	0.0	0.0	X	--
			October 30, 1973	22.6	13	5.0	7.8	1,100	> 25.0	0.03	0.0	X	--
	Near concessions at Petrifying Springs Park	8.9	June 12, 1973	33.0	23	5.8	7.9	920	5.8	0.0	0.0	X	--
			August 1, 1973	9.8	20	7.0	7.8	120	3.4	0.0	0.0	X	--
			October 30, 1973	16.9	13	7.0	7.6	1,600	> 25.0	0.03	0.0	X	--
	At CTH A	6.95	June 12, 1973	13.7	24	6.4	8.4	500	4.5	0.0	0.0	X	--
			July 30, 1973	8.6	19	9.5	8.3	360	2.1	0.0	0.0	X	--
			October 30, 1973	13.5	12	7.4	7.8	250	> 25.0	0.03	0.0	X	--
	At 13th Avenue bridge	4.75	June 12, 1973	14.9	25	7.8	8.4	270	3.3	0.0	0.0	X	--
			July 30, 1973	13.1	26	11.6	8.2	520	1.5	0.0	0.11	--	X
			October 30, 1973	12.5	12	12.0	8.0	70	14.0	0.03	0.0	X	--
	At STH 32 bridge	1.7	June 12, 1973	--	26	5.4	8.4	40	2.5	0.0	0.0	X	--
			July 30, 1973	--	26	11.8	8.1	140	3.1	0.0	0.11	--	X
			October 30, 1973	--	11	7.8	8.0	50	2.5	0.03	0.0	X	--
School Tributary	Near confluence with Pike Creek	0.0	June 12, 1973	1.7	20	8.4	8.5	4,300	4.5	0.0	0.02	X	--
			August 1, 1973	0.2	17	7.7	8.2	150	1.5	0.0	0.54	--	X
			October 30, 1973	0.5	11	8.2	7.8	100	4.3	0.03	0.0	X	--
Sorenson Creek	Near CTH KR	1.3	June 13, 1973	15.2	22	11.2	8.4	440	2.5	0.35	0.0	X	--
			July 30, 1973	1.0	31	17.1	9.0	200	4.9	0.0	0.04	X	--
			October 30, 1973	0.5	14	14.2	8.6	1,200	4.0	0.0	0.0	X	--

The dissolved oxygen concentrations at CTH L were above 5.0 mg/l on nine out of 13 samples taken during the 1964-1965 sampling survey. On the other hand, at STH 31, downstream from the Somers Branch, only five out of 13 samples indicated dissolved oxygen levels above 5.0 mg/l. Five of the 13 samples had less than 3.0 mg/l of dissolved oxygen. The apparent decrease in water quality at STH 31 probably may be due, at least in part, to the discharge of the treated effluent from the Town of Somers Utility District No. 1. In 1972 the Wisconsin Department of Natural Resources issued revised standards for Pike Creek in Kenosha County and for the Pike River in Racine County. These less stringent standards supported only restricted use and under these standards the dissolved oxygen concentrations were not to fall below 2.0 mg/l. Actual instream concentrations of dissolved oxygen were found to be below 2.0 mg/l at Pk-2 (at STH 31) on four out of 13 samples.

Temperature: During the 1964-1965 sampling, the temperature of water samples from Pike River and Pike Creek ranged between 32°F and 40°F during the months of December through April and

Table 39 (continued)

Sampling Station				Water Quality Indicators						Concurrent and Antecedent Moisture Conditions as Indicated by Precipitation Observations: Daily Precipitation in Inches		Characterization of Sampling Conditions	
Stream	Location	River Mile	Date[a]	Flow	Temperature °C	Dissolved Oxygen (mg/l)	pH (standard units)	Fecal Coliform Count (MFFCC per 100 ml)	Biochemical Oxygen Demand (mg/l)	On Day 1 and 1	Before Day 2 Sampling 2	Dry Weather[b]	Wet Weather
Waxdale Creek	25 feet above sewage treatment plant outfall	0.7	June 11, 1973	1.4	21	14.8	8.4	520	>0.9	0.0	0.0	X	--
			August 2, 1973	--	22	20.0	7.8	1,400	9.2	0.0	0.0	X	--
			October 30, 1973	0.4	11	10.0	7.8	450	3.1	0.0	0.0	X	--
	Above S. C. Johnson & Son, Inc., outfall	0.5	June 11, 1973	4.1	17	9.0	7.9	10	16.0	0.0	0.0	X	--
			August 2, 1973	1.5	22	4.6	7.2	10,000	2.6	0.0	0.0	X	--
			October 29, 1973	--	16	--	9.1	6,400	>24.0	0.0	0.0	X	--
			October 30, 1973	--	14	5.4	7.8	2,100	27.0	0.0	0.0	X	--
	Near Willow Road bridge	0.3	June 11, 1973	14.3	20	9.6	7.8	90	16.0	0.0	0.0	X	--
			August 2, 1973	6.3	25	7.6	7.6	1,600	2.8	0.0	0.0	X	--
			October 29, 1973	5.5	17	7.6	8.6	1,000	>24.0	0.0	0.0	X	--
Pike Creek	At CTH EA	3.6	June 12, 1973	3.0	20	11.6	7.9	1,500	4.5	0.0	0.02	X	--
			July 31, 1973	0.5	24	8.0	8.1	1,200	11.4	0.0	0.0	X	--
			October 30, 1973	0.7	14	17.0	8.6	840	2.5	0.03	0.0	X	--
	Near CTH L bridge	3.2	June 12, 1973	12.7	18	4.2	7.5	390	3.3	0.0	0.02	X	--
			July 31, 1973	2.5	21	4.8	7.7	750	2.8	0.0	0.0	X	--
			October 30, 1973	0.9	10	6.0	7.6	620	6.1	0.03	0.0	X	--
	Near CTH E bridge	2.1	June 12, 1973	0.6	19	7.8	7.8	950	3.3	0.0	0.02	X	--
			July 31, 1973	0.6	19	4.5	8.0	780	2.8	0.0	0.0	X	--
			October 30, 1973	1.2	10	7.6	7.8	24,000	4.3	0.03	0.0	X	--
	Near STH 31 bridge	0.1	June 12, 1973	--	21	8.0	8.1	2,900	3.3	0.0	0.02	X	--
			July 31, 1973	--	21	6.9	8.4	260	1.5	0.0	0.0	X	--
			October 30, 1973	4.7	11	7.6	7.8	110	2.5	0.03	0.0	X	--
Somers Branch	50 feet above sewage treatment plant outfall	1.6	June 12, 1973	--	17	2.8	7.0	2,500	3.7	0.0	0.02	X	--
			July 31, 1973	0.0	--	--	--	150	1.5	0.0	0.0	X	--
			October 30, 1973	0.0	--	--	--	--	--	0.03	0.0	X	--
	25 feet below sewage treatment plant outfall	1.6	June 12, 1973	--	16	3.5	7.2	3,600	18.0	0.0	0.02	X	--
			July 31, 1973	0.1	15	2.6	7.6	10	8.4	0.0	0.0	X	--
			October 30, 1973	0.2	14	1.6	7.2	2,400	15.0	0.03	0.0	X	--
	300 feet below sewage treatment plant outfall	1.5	July 31, 1973	--	25	--	8.1	3,000	49.0	0.0	0.0	X	--
			October 31, 1973	--	16	--	7.6	660	9.2	0.0	0.73	--	X
	Near CTH EA bridge	0.8	June 12, 1973	2.8	23	9.8	8.4	4,300	8.6	0.0	0.02	X	--
			July 31, 1973	0.2	24	15.6	8.9	40	3.4	0.0	0.0	X	--
			October 30, 1973	0.5	12	11.0	8.2	490	8.6	0.03	0.0	X	--
	Near confluence with Pike Creek	0.0	June 12, 1973	1.0	20	7.0	8.1	2,400	7.4	0.0	0.02	X	--
			July 31, 1973	0.1	21	16.0	8.8	70	1.8	0.0	0.0	X	--
			October 30, 1973	0.5	11	9.8	8.2	780	4.9	0.03	0.0	X	--

[a] *Sampling time not available.*

[b] *Precipitation of 0.10 inch or less on day of sampling.*

Source: Wisconsin Department of Natural Resources.

between 43°F and 75°F during the months of May through November. These temperature variations may be attributed primarily to the seasonal changes. Consequently, the discharges of cooling water into the main stem or the tributaries of Pike River from the J. I. Case Company, Rexnord, Inc., S. C. Johnson & Son, Inc., and the Ametek-Lamb Electric plants, all located in the Town of Mt. Pleasant, appear not to be increasing the normal temperature of the stream water above the prescribed standard of 89°F.

Total Coliform Bacteria: During the 1964-1965 sampling, membrane filter fecal coliform counts (MFFCC) varied from 1,200 to 1,800,000 MFFCC per 100 milliliters (MFFCC/100 ml) with the average values for the Pike River and Pike Creek being, respectively, 260,000 and 35,000 MFFCC/100 ml. The highest total coliform counts occurred during the month of December in the Pike River at station Pk-1. Since the high coliform counts were not observed throughout the year, it is likely that the pollution sources were intermittent, consisting of wastes from domestic animal raising operations, effluent from malfunctioning septic tank systems, or wildlife excretions.

Hydrogen-Ion Concentration (pH): During the 1964-1965 sampling, pH values at all sampling sites in the Pike River watershed generally ranged from 6.9 to 8.2 standard units. At no location within the watershed was the pH found to be outside the

Table 40

BENTHIC ORGANISM DATA FROM THE WISCONSIN DEPARTMENT OF NATURAL RESOURCES BASIN SURVEY: 1976

Sampling Station		River Mile	Date	Waste Source	Bottom Type	Current	Benthic Invertebrate Organisms						Remarks
							Intolerant		Tolerant		Very Tolerant		
Stream	Location						Number of Species	Total Population	Number of Species	Total Population	Number of Species	Total Population	
Pike River-Main Stem	30 feet above STH 20 bridge	13.5	December 11, 1973	36-foot culvert and private sewer discharges	Sand	Moderate	--	--	4	944	1	68	Unbalanced-algae
	150 feet above Oaks Road culverts	12.5	December 11, 1973	36-foot culvert and private sewer	Sand	Moderate	--	--	8	1,886	2	54	Unbalanced-H_2S odor
	20 feet above Sturtevant tributary (Waxdale Creek) confluence with main stem	11.9	December 11, 1973	Nonpoint sources	Sandy, loam, silt	Moderate	--	--	4	378	3	1,773	Polluted
	30 feet above J. I. Case and Metals Lab sewer discharge	11.8	December 11, 1973	Sturtevant tributary (Waxdale Creek) J. I. Case, Metal Labs	Sand, silt, gravel	Moderate-Slow	--	--	8	11,893	4	343	Polluted-oil noted
	20 feet above STH 11 bridge	11.7	December 11, 1973	J. I. Case and Metal Labs	Sand, silt, gravel, rock	Moderate	--	--	8	9,505	4	13	Polluted-oil noted
	200 feet above Braun Road bridge	10.6	December 11, 1973	Rexnord, McGraw-Edison	Gravel, sand, rock	Fast	--	--	--	--	5	5,680	Grossly polluted-algae
	150 feet above STH 31 bridge	8.8	December 11, 1973	All the above sources	Gravel, sand, rock	Fast	--	--	--	--	3	764	Grossly polluted-algae
	75 feet below CTH G bridge	4.5	December 13, 1973	Below Pike Creek and main stem confluence	Gravel, sand, rock	Fast	--	--	9	597	2	198	Semi-polluted
	10 feet below 13th Street bridge	2.4	December 13, 1973	Below Pike Creek and main stem confluence	Gravel, sand, rock	Fast	1	10	7	260	2	19	Unbalanced
Sturtevant Tributary (Waxdale Creek)	120 feet above confluence with Pike River-main stem	0.1	December 11, 1973	S. C. Johnson & Son, Sturtevant sewage treatment plant	Sand, gravel, rock	Moderate	--	--	1	7	4	9,474	Grossly polluted-slime growth and sludge deposits
Pike Creek	Based south side of CTH E bridge	1.4	November 30, 1973	0.3 mile above Somers sewage treatment plant tributary (Somers Branch)	Sand, gravel, rock	Riffle	1	16	8	69	3	76	Clean-much debris
	50 feet above confluence of Pike Creek junction CTH A and STH 31	0.1	November 30, 1973	Somers sewage treatment plant tributary (Somers Branch)	Sand, gravel, rock	Riffle	2	14	5	47	4	135	Clean-much debris
Somers Tributary (Somers Branch) to Pike Creek	200 feet below CTH EA bridge	0.8	November 30, 1973	Somers sewage treatment plant	Gravel, sand, rock	Fast	--	--	6	39	8	2,492	Polluted

Source: Wisconsin Department of Natural Resources and SEWRPC.

range of the 6.0 to 9.0 standard units prescribed for recreational use, the maintenance of fish and aquatic life, and restricted use—the major water use objectives for the Pike River and its tributaries.

Specific Conductance: During the 1964-1965 sampling, the specific conductance of water samples from the Pike River and Pike Creek ranged from 522 to 1,330 micromhos per centimeter at 25°C. The specific conductance is an approximate measure of the dissolved ions present in water, the increased specific conductance normally being due to the presence of increased amounts of such substances as sulfates, bicarbonates, and chlorides. The source of sulfates and bicarbonates in the Pike River system is likely to be soil erosion since the watershed is covered by largely calcareous soils. Wastewater treatment plants are probably the major source of chlorides in the Pike River system.

Chloride: During the 1964-1965 sampling, the chloride concentrations throughout the watershed varied from 35 milligrams per liter (mg/l) to 90 mg/l with the average values for the Pike River and Pike Creek being 65 mg/l each. The chloride levels in the watershed were high compared to background levels of 10 mg/l as measured from the average groundwater chloride concentrations.[6] The chloride concentrations remained high throughout the year in the Pike River and Pike Creek. The sustained high chloride concentrations in the streams

[6] *C.L.R. Holt and E. L. Skinner, "Groundwater Quality in Wisconsin Through 1972," UW-Extension Information Circular No. 22, 1973.*

Table 41

DRY WEATHER WATER QUALITY CONDITIONS OF THE PIKE RIVER AND TRIBUTARIES: 1964-1965

Station Sampled	Parameter	Numerical Value			Number of Analyses
		Maximum	Average	Minimum	
Pike River Pk-1, Pk-4	Chloride (mg/l)	90	65	35	17
	Dissolved Solids (mg/l)	905	600	380	17
	Dissolved Oxygen (mg/l)	11.8	5.3	0.1	27
	Total Coliform Count (MFFCC/100 ml)	1,800,000	260,000	2,000	27
	Temperature (^oF)	75	49	32	27
Pike Creek Pk-2, Pk-3	Chloride (mg/l)	90	65	35	15
	Dissolved Solids (mg/l)	840	620	505	15
	Dissolved Oxygen (mg/l)	13.2	6.0	0.4	25
	Total Coliform Count (MFFCC/100 ml)	300,000	35,000	1,200	25
	Temperature (^oF)	71	49	32	25

Source: SEWRPC.

of the Pike River watershed indicate continuing contribution of chlorides from a source other than groundwater. The Village of Sturtevant sewage treatment facility, the St. Bonaventure Seminary sewage treatment facility, and the Town of Somers Utility District No. 1 sewage treatment facility located in the watershed, discharging into the Pike River and Pike Creek were likely to be major sources of chloride in the stream waters.

Concluding Statement: The 1964-1965 dry weather survey indicated water quality consistently satisfying the temperature and pH standards established for the surface waters of the Pike River watershed. The sample data indicate that the dissolved oxygen standard and the fecal coliform bacteria standard were frequently violated. High chloride levels throughout the year are probably attributable chiefly to sewage treatment facilities that represent a relatively constant source of chloride transport to the surface waters.

SEWRPC Continuing Water Quality Monitoring Program: 1968-1976

In 1968, the Commission entered into a cooperative agreement with the Wisconsin Department of Natural Resources for the execution of a continuing stream water quality monitoring program within the Region. The objective of the program was to provide, on a continuing basis, the water quality information necessary to assess the long-term trends in water quality within the rapidly urbanizing seven-county Region.

The continuing monitoring program was designed to build upon the benchmark stream water quality data base established by the Commission in the initial 1964-1965 stream water quality study and, accordingly, the monitoring network included the four Pike River watershed sampling stations. During 1968 and 1969, the SEWRPC stream water quality monitoring program involved twice-yearly sampling at all stations during periods of both high and low flow, with the samples being analyzed for dissolved oxygen, temperature, fecal and total coliform, nitrate nitrogen, nitrite nitrogen, dissolved phosphorus, pH, chloride, and specific conductance.

To provide additional information on the diurnal fluctuations of stream water quality, the monitoring program was revised in 1970 to provide for the collection of six stream water samples over a 24-hour period once yearly during the period of low streamflow at each sampling station, with each sample being analyzed for the following five parameters: dissolved oxygen, temperature, pH, chloride, and specific conductance. In addition, for one sample obtained during the 24-hour period the samples were analyzed for the following four parameters; fecal coliform, nitrate nitrogen, nitrite nitrogen, and dissolved phosphorus.

In order to obtain regional information on additional water quality indicators, the Commission and the Department of Natural Resources agreed to a further revision of the program beginning with the 1972 survey. The overall continuity of the sampling program was maintained by continuing to monitor those parameters included in previous surveys with the following changes: a decrease from six to four per day in the frequency of dissolved oxygen, temperature, and specific conductance measurements; a decrease from six to two per day in the frequency of chloride determinations; an increase from one to two per day in the frequency of fecal coliform, nitrate nitrogen, nitrite nitrogen, ammonia nitrogen, and dissolved phosphorus measurements; and the addition of two determinations per day of organic nitrogen, ammonia nitrogen, and total phosphorus. The addition of these latter three parameters was prompted by the need for more regional information on nutrients, and an increased interest in both the oxygen demand exerted by ammonia nitrogen and the toxic effect of ammonia nitrogen.

Thus, the stream water quality monitoring program, as revised in 1972 and as continued through 1976, provided for four measurements over a 24-hour period once yearly. Four measurements were made during the period of low flow at each of the 87 stations for each of the following three parameters: dissolved oxygen, temperature, and specific conductance. Two determinations were made at each station over the same 24-hour period for each of the following nine parameters: pH, chloride, fecal coliform, nitrate nitrogen, nitrite nitrogen, ammonia nitrogen, organic nitrogen, dissolved phosphorus, and total phosphorus.

Findings of the Study: A summary of the results of sample data collected by the Commission for the four sample stations in the Pike River watershed—Pk-1, Pk-2, Pk-3, and Pk-4—for the period from 1968 through 1975 is set forth in Tables 42, 43, 44, and 45, respectively. The location of these sample station sites are shown on Map 33.

Dissolved Oxygen: For the watershed as a whole, the range of dissolved oxygen concentrations measures in the Pike River stream system during

Table 42

WATER QUALITY CONDITIONS OF THE PIKE RIVER AT STH 31—SAMPLING STATION PK-1: 1968-1975

Parameter	Recommended Level/Standard	Numerical Value			Number of Analyses	Number of Times the Recommended Standard/Level Was Not Met
		Maximum	Average	Minimum		
Chloride (mg/l)	--	45.0	24.5	16.0	23	--
Dissolved Oxygen (mg/l)	5.0	11.0	5.9	2.2	30	13[a]
Ammonia Nitrogen (mg/l)	0.02[b]	1.49	0.47	0.03	8	--
Organic Nitrogen (mg/l)	--	2.22	0.81	0.27	8	--
Total Nitrogen (mg/l)	--	6.49	3.33	1.24	8	--
Specific Conductance (μmhos/cm at 25°C)	--	928	525	313	29	--
Nitrite Nitrogen (mg/l)	--	0.33	0.18	0.04	13	--
Nitrate Nitrogen (mg/l)	--	3.81	1.84	0.60	13	--
Soluble Orthophosphate-P (mg/l)	--	0.83	0.35	0.07	13	--
Total Phosphorus (mg/l)	0.1	0.80	0.34	0.10	8	8
Fecal Coliform (MFFCC/100 ml)	400	1,700	597	40	13	7
Temperature (°F)	89	80.0	68.9	48.0	31	0
Hydrogen-Ion Concentrations (pH) (standard units)	6-9	9.0	7.9	7.5	23	0

[a] *The concentrations were below the water quality standard of 5.0 mg/l for dissolved oxygen.*

[b] *The recommended standard applies to un-ionized ammonia nitrogen. The numerical values shown are total ammonia nitrogen levels.*

Source: SEWRPC.

Table 43

WATER QUALITY CONDITIONS OF PIKE CREEK AT 18TH STREET—SAMPLING STATION PK-2: 1968-1975

Parameter	Recommended Level/Standard	Numerical Value			Number of Analyses	Number of Times the Recommended Standard/Level Was Not Met
		Maximum	Average	Minimum		
Chloride (mg/l)	- -	90.0	51.1	25.0	23	- -
Dissolved Oxygen (mg/l)	5.0	16.1	5.8	1.5	31	15[a]
Ammonia Nitrogen (mg/l)	0.02[b]	0.21	0.14	0.03	8	- -
Organic Nitrogen (mg/l)	- -	1.89	0.98	0.51	8	- -
Total Nitrogen (mg/l).	- -	7.28	3.30	1.31	8	- -
Specific Conductance (μmhos/cm at 25°C)	- -	1,455	1,099	840	29	- -
Nitrite Nitrogen (mg/l)	- -	0.28	0.08	0.03	13	- -
Nitrate Nitrogen (mg/l).	- -	4.90	2.24	0.66	13	- -
Soluble Orthophosphate-P (mg/l) . . .	- -	0.46	0.21	0.14	13	- -
Total Phosphorus (mg/l)	0.1	0.37	0.22	0.14	8	8
Fecal Coliform (MFFCC/100 ml) . . .	400	3,500	816	90	13	9
Temperature (°F)	89.0	81.5	68.8	46.0	31	0
Hydrogen-Ion Concentrations (pH) (standard units)	6-9	8.3	7.8	7.5	23	0

[a] *The concentrations were below the water quality standard of 5.0 mg/l for dissolved oxygen.*

[b] *The recommended standard applies to un-ionized ammonia nitrogen. The numerical values shown are total ammonia nitrogen levels.*

Source: SEWRPC.

Table 44

WATER QUALITY CONDITIONS OF PIKE CREEK AT STH 31—SAMPLING STATION PK-3: 1968-1975

Parameter	Recommended Level/Standard	Numerical Value			Number of Analyses	Number of Times the Recommended Standard/Level Was Not Met
		Maximum	Average	Minimum		
Chloride (mg/l)	- -	82.0	34.1	22.0	23	- -
Dissolved Oxygen (mg/l)	5.0	11.7	7.4	3.9	31	3[a]
Ammonia Nitrogen (mg/l)	0.02[b]	0.43	0.19	0.03	8	0
Organic Nitrogen (mg/l)	- -	1.14	0.65	0.20	8	- -
Total Nitrogen (mg/l).	- -	4.08	2.26	0.95	8	- -
Specific Conductance (μmhos/cm at 25°C)	- -	1,069	619	440	29	- -
Nitrite Nitrogen (mg/l)	- -	0.15	0.09	0.04	13	- -
Nitrate Nitrogen (mg/l).	- -	3.55	1.47	0.39	13	- -
Soluble Orthophosphate-P (mg/l) . . .	- -	0.61	0.30	0.10	13	- -
Total Phosphorus (mg/l)	0.1	0.54	0.25	0.11	8	8
Fecal Coliform (MFFCC/100 ml) . . .	400	12,000	1,684	10	13	7
Temperature (°F)	89.0	76.5	68.5	48.0	31	0
Hydrogen-Ion Concentrations (pH) (standard units)	6-9	8.7	8.1	7.7	23	0

[a] *The concentrations were below the water quality standard of 5.0 mg/l for dissolved oxygen.*

[b] *The recommended standard applies to un-ionized ammonia nitrogen. The numerical values shown are total ammonia nitrogen levels.*

Source: SEWRPC.

Table 45

WATER QUALITY CONDITIONS OF THE PIKE RIVER AT STH 32—SAMPLING STATION PK-4: 1968-1975

Parameter	Recommended Level/Standard	Numerical Value			Number of Analyses	Number of Times the Recommended Standard/Level Was Not Met
		Maximum	Average	Minimum		
Chloride (mg/l)	--	51.0	34.6	24.0	23	--
Dissolved Oxygen (mg/l)	5.0	14.2	6.9	3.2	31	5[a]
Ammonia Nitrogen (mg/l)	0.02[b]	0.34	0.13	0.03	8	0
Organic Nitrogen (mg/l)	--	1.42	0.94	0.48	8	--
Total Nitrogen (mg/l).	--	4.50	2.31	1.15	8	--
Specific Conductance (µmhos/cm at 25°C)	--	956	616	445	29	--
Nitrite Nitrogen (mg/l)	--	0.13	0.05	0.02	13	--
Nitrate Nitrogen (mg/l).	--	2.85	1.43	0.37	13	--
Soluble Orthophosphate-P (mg/l) . . .	--	0.55	0.30	0.06	13	--
Total Phosphorus (mg/l)	0.1	0.34	0.19	0.05	8	6
Fecal Coliform (MFFCC/100 ml) . . .	400	2,100	680	20	13	6
Temperature (°F).	89	81.5	71.4	50.0	31	0
Hydrogen-Ion Concentrations (pH) (standard units)	6-9	8.9	8.3	7.5	23	0

[a] *The concentrations were below the water quality standard of 5.0 mg/l for dissolved oxygen.*

[b] *The recommended standard applies to un-ionized ammonia nitrogen. The numerical values shown are total ammonia nitrogen levels.*

Source: SEWRPC.

August for the years 1968 through 1975 was 2.2 to 16.1 mg/l. The average dissolved oxygen concentrations were 5.9, 5.8, 7.4, and 6.9 mg/l for the Pike River stations Pk-1, Pk-2, Pk-3, and Pk-4, respectively. Although the eight-year average dissolved oxygen concentrations were above 5.0 mg/l for all locations during August, the dissolved oxygen level was found to be lower than 5 mg/l for a portion of time at every sampling location during the study period. At sampling station Pk-1 on the Pike River, the average dissolved oxygen concentrations were below 5.0 mg/l during seven out of eight sampling years. Samples collected at station Pk-4 on the Pike River had less than 5.0 mg/l dissolved oxygen during two out of eight sampling years, during six out of eight sampling years at station Pk-2, and during one of eight sampling years at station Pk-3.

A comparison of dissolved oxygen concentrations found in April and August of 1964, 1968, and 1969 indicates higher dissolved oxygen concentrations in April of each year than in August of the same year. The August dissolved oxygen levels were approximately 8.0 mg/l lower than those found in the April samples.

Chloride: The average chloride concentrations of the multiple samples taken on the sampling dates in eight summer sampling surveys during the years 1968 through 1975 ranged from 16 to 90 mg/l at the four stations in the Pike River watershed. The average chloride concentrations of the samples at sampling stations Pk-1 and Pk-4 on the Pike River were 25 mg/l and 35 mg/l respectively, significantly higher than the area groundwater concentration of approximately 10 mg/l. The chloride concentrations at Pike Creek sampling stations Pk-2 and Pk-3, with averages of 51 and 34 mg/l respectively, were also significantly higher than the groundwater chloride levels. These higher levels found throughout the watershed are probably associated with the discharges of the sewage treatment plants operated by the Town of Somers

Utility District No. 1 and the Village of Sturtevant, since the dry weather flow at Pike Creek during the summer consists mainly of the sewage treatment plant effluent.

Fecal Coliform Bacteria: The samples collected on the Pike River from 1968 to 1975 at Station Pk-1 produced a range of 40 to 1,700 MFFCC/100 ml. The downstream station on the Pike River designated as Pk-4, produced a similar range of 20 to 2,100 MFFCC/100 ml. Sample data collected on Pike Creek over the same time period at Stations Pk-2 (upstream) and Pk-3 produced average monthly ranges of 90 to 3,500 and 10 to 12,000 MFFCC/100 ml, respectively. The only trend apparent in the fecal coliform counts over the eight sets of samples collected in the month of August during the period from 1968 through 1975 is a general reduction in 1970 and the following years upon installation of disinfection facilities at the Village of Sturtevant sewage treatment plant, the largest in the watershed.

Hydrogen-Ion Concentration (pH): As indicated in Tables 42 through 45, the pH values of the watershed surface water system have generally been within the range of 6.0 to 9.0 standard units prescribed for recreational use, maintenance of fish and aquatic life, and restricted use. No trend in pH variation of the samples collected from 1968 through 1975 was apparent.

Specific Conductance: Specific conductance, a measure of total dissolved ions in water, was found to be in the range of 313 to 1,455 micromhos per centimeter (μmhos/cm) at 25°C at the four sampling locations over the period from 1968 through 1975. The highest specific conductance value was found at sampling station Pk-2 in August 1970. With the exception of the samples collected during or after a rain—i.e., in 1968, 1969, and 1972—the samples indicated an apparent slight decrease in specific conductance over the past eight years at the Pike River stations Pk-1, and Pk-4, as well as the Pike Creek sampling station Pk-3, located near the confluence point of the Creek with the Pike River. At Pike Creek location Pk-2, the specific conductance values remained the highest within the watershed in each year. No trend in specific conductance values was found over the past eight years at sampling station Pk-2.

Temperature: As indicated in Tables 42 through 45, the temperature of the stream water of the watershed remained below the 89°F standard, established for fish and aquatic life, over the entire eight year sampling period from 1968 through 1975. No trend in temperature variation was observed from 1968 through 1975, although seasonal fluctuations were noted.

Soluble Orthophosphate and Total Phosphorus: Water samples collected in eight sampling periods from the four Pike River watershed sampling station locations from 1968 through 1975 were analyzed for soluble orthophosphate concentrations, and a range of 0.06 to 0.83 mg/l of soluble orthophosphate, measured as phosphorus, was found. During the years 1972 through 1975, the water samples also were analyzed for total phosphorus and a range of 0.05 to 0.80 mg/l was obtained. The high ratio—ranging from 0.7 to 1.0—of soluble orthophosphate to total phosphorus in the water samples indicates that most of the phosphorus is readily available for the growth of aquatic plants. Although not enough samples were available in the four years of data to characterize the trends in total phosphorus concentrations over time—especially since the 1972 sample was taken after a heavy rain—the concentrations are many times higher than the threshold for excessive algae growth. It is generally felt that total phosphorus concentrations must be held to a maximum of 0.10 mg/l in flowing streams in order to prevent nuisance growth of algae and other aquatic plants. Of the 32 water samples collected from Pike Creek and the Pike River over the eight-year period, 30 samples had total phosphorus levels higher than 0.10 mg/l.

Although no streamflow information is available for the sampling sites on the days water samples were collected, there is continuous record flow data available at the U. S. Geological Survey gaging station on the Pike River at a location two miles downstream from sampling station Pk-1. Total phosphorus loadings from the watershed were determined utilizing these flow data and measured sample data from station Pk-1. Total phosphorus loadings to the watershed as determined from land use information are discussed in Chapter VI of Technical Report No. 21, Sources of Water Pollution in Southeastern Wisconsin: 1975. Both the Technical Report No. 2 data and the measured data are presented in the following section on nonpoint sources of pollution.

Nitrogen: The total nitrogen concentrations in the Pike River water samples collected in August during the period from 1972 through 1975 were found to be in the range of 0.95 to 7.28 mg/l and, of these levels, 1 to 13 percent were found to be present as nitrite nitrogen, 2 to 25 percent as ammonia nitrogen, 36 to 70 percent as nitrate nitrogen, and 14 to 50 percent as organic nitrogen. Thus 38 to 95 percent of the total nitrogen content of the Pike River water samples was in the readily available forms of nitrate nitrogen and ammonia nitrogen. Nitrates are obtained as the end product of aerobic degradation of proteinaceous materials—organic nitrogen amd nitrite nitrogen are the byproducts of bacteriological action upon ammonia and nitrogenous substances; and ammonia is the chief decomposition product from plant and animal proteins. The presence of ammonia nitrogen in the stream water constitutes chemical evidence of organic pollution of recent origin. In the presence of oxygen, ammonia is transformed into nitrite and ultimately into nitrate. The level of ammonia nitrogen considered to be dangerous to fish and aquatic life is 0.02 mg/l of un-ionized ammonia. The actual toxicity level, however, is a function of the instream pH, temperatures and total ammonia concentration. According to the sample records, the concentration of un-ionized ammonia was not found to be in excess of 0.02 mg/l at any of the sample stations over the eight year period.

Nitrate nitrogen concentrations in the Pike River watershed were found to range from 0.37 to 4.9 mg/l. Surface runoff from fields where there have been excessive or improper applications of natural or artificial fertilizers can contribute significant quantities of nitrate to surface waters. Nitrates also are present in treated municipal wastes and enter the receiving streams with the discharged sewage treatment plant effluent. For the samples collected at sampling locations Pk-1 through Pk-4 on the Pike River and Pike Creek, the concentrations of nitrate nitrogen remained higher than 0.30 mg/l in all of the samples collected in August from 1968 through 1975.

Organic nitrogen accounts for 14 to 50 percent of the total nitrogen in the samples collected in the Pike River watershed, and is contributed by amino acids, proteins, and polypeptides, all products of biological processes. The presence of organic nitrogen is directly related to the discharge of organic wastes such as sewage or plant and animal decay products. The average organic nitrogen content of the samples collected over the eight-year period was approximately 0.845 mg/l at all four sampling station locations. Therefore, organic nitrogen apparently has little effect on dissolved oxygen concentrations in the Pike River.

Concluding Statement: The Commission's continuing water quality monitoring program for the period 1968 through 1975 indicated that of the available sampling data, water quality in the Pike River watershed apparently satisfied the pH and temperature standard all of the time, the dissolved oxygen standard about 68 percent of the time, the fecal coliform bacteria standard about 44 percent of the time, and the total phosphorus standard about 6 percent of the time.

Wisconsin Department of Natural Resources Basin Surveys of Toxic and Hazardous Substances: 1975-1976

There is a growing awareness on the part of scientists, engineers, and the general public of the potentially harmful effects on animal and human life of certain substances not formerly considered in water quality management studies. Because of this growing awareness, the available data on the levels of these toxic and hazardous substances in the streams and lakes of the Region as obtained under the Wisconsin Department of Natural Resources drainage basin study programs were assembled by the Commission under the areawide water quality management program. Data extracted from that collation for the Pike River watershed are presented and the significance of the data is discussed herein.

Toxic and Hazardous Substances—Background: The general category of toxic and hazardous materials consists of the three subcategories: heavy metals, pesticides, and polychlorinated biphenyls (PCB's). All of these materials tend to accumulate in the environment as a result of man's activities. Heavy metals such as cadmium, chromium, cobalt, copper, lead, mercury, nickel, and zinc are metals which have a specific gravity greater than four. Such metals have several oxidation states, and readily form complex ions. Pesticides are organic chemicals utilized by man to control or destroy undesirable forms of plant and animal life. Pesticides encompass all forms of insecticides, herbicides, fungicides, fumigants, nematocides, algicides, and rodenticides. Polychlorinated biphenyls—PCB's—are a class of compounds produced by chlorination of biphenyls and are registered in the United States under the trade name of Arochlor. PCB's are slightly soluble in water, relatively nonflammable, and have desirable heat exchange and dielectric properties. They are used principally in the electrical industry in capacitors and transformers and were formerly used in the production of papers used for printed self-copying forms not requiring carbon paper.

Heavy metals, pesticides, PCB's, and other toxic and hazardous substances generally do not present the gross aesthetic or olfactory offense of some other water pollutants, but may present a serious and insidious health hazard to animal and human population. Reported adverse effects of heavy metals, pesticides, and PCB's on humans include liver and kidney disorders, carcinogenic effects, nervous system damage, skin lesions, and disruption of reproductive processes. PCB's can also affect reproduction in animals and can cause physical and mental disabilities which impede survival. Not only are these toxic and hazardous materials taken up by rooted plants, but certain of these materials have the innate ability to enter the food chain at the lowest levels of vegetative growth and then gradually move up the food chain and accumulate in the fleshy tissue of fish, which in turn are available for human consumption.

Heavy metals, pesticides, and PCB's may potentially be transported into the surface waters of the Pike River watershed directly via storm water runoff as well as through industrial and municipal wastewater outfalls or by groundwater discharge if groundwaters were to become contaminated with these materials. Potential diffuse sources of heavy metals, pesticides, and PCB's in the Pike River watershed include atmospheric fallout and washout; washoff from streets, highways, parking lots, rooftops, lawns, and other pervious and impervious surfaces; organic and inorganic fertilizers for agricultural and lawn and garden purposes; pesticides that have been sprayed or spread; and discharges of sanitary sewerage system flow relief devices.

Findings of the Study: Dry weather heavy metal concentrations and PCB levels found in the selected surface water quality samples taken by the Wisconsin Department of Natural Resources from sampling stations located on the Pike River and Pike Creek from June 1973 through October 1973 are summarized in Table 46. The results of dry weather pesticide data obtained by the Department for the Pike River, Pike Creek, and Waxdale Creek from June 1973 through November 1973 are summarized in Table 47. The criteria recommended by the U. S. Environmental Protection Agency are noted in Tables 46 and 47 for each substance for which data are available. A notable omission is recommended criteria for certain pesticide compounds.

Surface Waters: Generally the data presented in Tables 46 and 47 do not indicate the presence of a toxic substances pollution problem in the surface waters of the Pike River watershed. Some indication of potential problems are worthy of note, however, and are described here. These findings are generalized because of the very limited number of sampling sites and water samples available. As indicated in Table 46, of the seven heavy metals for which data are available, mercury is the only one found to occur at any sampling site in the watershed in concentrations in excess of the recommended standard. Of the five samples taken throughout the watershed four were found to contain less than 0.2 microgram per liter (µg/l) of mercury, and one sample was found to contain 2.2 µg/l of mercury, a level 45 times the recommended level of 0.05 µg/l. It is important to note that in the above analyses, the lowest level of mercury which the laboratory conducting the test was able to detect was 0.2 µg/l, which is higher than the recommended standard 0.05 µg/l. Therefore, the actual mercury concentration present in the sample, while lower than 0.2 µg/l, could still be higher than the recommended level. As with mercury, the sensitivity of the tests used to analyze the samples for the presence of PCB's—0.1 µg/l—was significantly higher than the recommended standard level of 0.001 µg/l. Therefore, it is difficult to assess the actual number of samples in excess of the recommended standard in the surface waters of this basin.

With regard to observed pesticide concentrations of the pesticides for which criteria have been recommended—namely DDT, DDE, DDD, Aldrin, Heptachlor, Heptachlor Epoxide, Lindane, Dieldrin, Methoxychlor, and Phthalate—the limited data available indicate that the concentrations of DDT, DDE, Heptachlor Epoxide and Dieldrin present in the samples exceeded the standard, while Lindane, Methoxychlor, and Phthalate did not. For the remaining five pesticides, there were no determinant samples available to compare with the recommended instream levels.

Sediment: No information is available on the concentration of heavy metals, PCB's, and pesticides in bottom sediments of the Pike River watershed.

Table 46

DRY WEATHER HEAVY METAL AND PCB CONCENTRATIONS IN PIKE RIVER WATERSHED: 1973

Location	Date	Cadmium 12 µg/l a	Cadmium 12 µg/l b	Chromium 100 µg/l a	Chromium 100 µg/l b	Copper 145 µg/l a	Copper 145 µg/l b	Lead 4,820 µg/l a	Lead 4,820 µg/l b
Pike Creek 52nd Street	06/06/73-10/23/73	2.0(2)	--	15.(2)	--	15.(2)	--	165.(2)	--
Pike Creek at STH 31	10/30/73	--	< 0.2(1)	3.(1)	--	2.(1)	--	--	< 4.(1)
Pike Creek at STH 32	06/13/73-10/30/73	8.(1)	< 0.2(1)	6.5(2)	--	6.(2)	--	40.(1)	< 4.(1)

Location	Date	Mercury 0.05 µg/l a	Mercury 0.05 µg/l b	Nickel 100 µg/l a	Nickel 100 µg/l b	Zinc 334 µg/l a	Zinc 334 µg/l b	Polychlorinated Biphenyls (PCB's) 0.001 µg/l a	Polychlorinated Biphenyls (PCB's) 0.001 µg/l b
Pike Creek 52nd Street	06/06/73-10/23/73	--	< 0.2*(2)	20.(1)	< 10.(1)	37.(2)	--	--	< 0.05*(4)
Pike River at STH 31	10/30/73	--	< 0.2*(1)	40.(1)	--	20.(1)	--	--	--
Pike River at STH 32	06/13/73-10/30/73	2.2(1)	< 0.2*(1)	27.(2)	--	25.(1)	--	--	< 0.05*(1)

NOTE: All values are presented in micrograms per liter.

[a] *Average of determinate sample results (number of samples averaged).*

[b] *Indeterminate sample results (number of samples averaged). Asterisk (*) indicates those sample results of less than detectable (sensitivity) limits of the laboratory analysis.*

Source: Wisconsin Department of Natural Resources and SEWRPC.

Concluding Statement: The limited data available indicate that excessive mercury, DDT, DDE, Heptachlor Epoxide and Dieldrin have existed in the surface waters of the Pike River under dry weather conditions. Excessive concentrations of other heavy metals and of pesticides may also have existed during dry weather sampling periods but the data are inconclusive because of the limited number of samples and the sensitivity limits of the laboratory analyses. Conclusions cannot be drawn concerning wet weather condition heavy metal, PCB, and pesticide levels since the available data pertain only to dry weather conditions. Heavy metals and PCB's tend to accumulate in the bottom sediments of the watershed, and the average concentrations of these substances in sediment generally range from about 1,000 to 20,000 times the concentrations measured in the flowing streams. During wet weather conditions, some of the substances contained within bottom sediments may be brought into suspension and transported from the watershed.

SEWRPC Monitoring for the Areawide Water Quality Management Planning Program: 1976-1977

In 1976 the Commission entered into a cooperative agreement with the Wisconsin Department of Natural Resources and the U. S. Geological Survey for the execution of a short-term stream water quantity and quality monitoring program within

Table 47

DRY WEATHER PESTICIDE CONCENTRATIONS IN PIKE RIVER WATERSHED: 1973

Location	Date	Substance and EPA Recommended Instream Level											
		DDT[a] 0.001 µg/l		DDE[a] 0.001 µg/l		DDD[a] 0.001 µg/l		Aldrin[a] 0.003 µg/l		Heptachlor 0.001 µg/l		Heptachlor Epoxide 0.001 µg/l	
		c	d	c	d	c	d	c	d	c	d	c	d
Pike Creek 52nd Street West of 16th Avenue	06/05/73-11/06/73	--	<0.010*(4)	--	<0.020(4)	--	<0.010(4)	--	<0.005*(3)	--	<0.005*(4)	--	<0.005*(4)
Pike River at STH 32 Bridge	07/30/73-10/30/73	0.02(1)	<0.010*(1)	0.007(1)	<0.005(1)	--	<0.008(2)	--	<0.001(1)	--	<0.002*(2)	0.045(1)	<0.002*(1)
Pike River at STH 32 and 7th Avenue	06/12/73	--	<0.010*(1)	0.010(1)	--	--	<0.010(1)	--	--	--	<0.005*(1)	0.360(1)	--
Sturtevant Tributary Near Willow Road Bridge	06/13/73-10/29/73	--	<0.040*(2)	--	<0.005(2)	--	<0.040(2)	--	<0.002(1)	--	<0.010*(2)	--	<0.010*(2)

Location	Date	Substance and EPA Recommended Instream Level											
		Lindane 0.01 µg/l		Dieldrin[a] 0.003 µg/l		Methoxychlor 0.03 µg/l		Phthalate 3 µg/l		Atrazine[b] µg/l		Simazine[b] µg/l	
		c	d	c	d	c	d	c	d	c	d	c	d
Pike Creek 52nd Street West of 16th Avenue	06/05/73-11/06/73	--	<0.005(4)	--	<0.50*(4)	--	<0.040*(4)	--	<0.5(3)	--	--	--	--
Pike River at STH 32 Bridge	07/30/73-10/30/73	--	<0.005(2)	0.013(2)	--	--	<0.020(2)	--	<0.5(2)	--	--	--	--
Pike River at STH 32 and 7th Avenue	06/12/73	--	<0.002(1)	--	<0.010*(1)	--	<0.010(1)	--	<0.5(1)	--	--	--	--
Sturtevant Tributary Near Willow Road Bridge	06/13/73-10/29/73	0.010(1)	<0.010(1)	0.050(1)	--	0.020(1)	<0.040*(1)	--	--	--	--	--	--

NOTE: All values are presented in microgram per liter.

[a] *Since the publication of Criteria for Water Quality, 1976, the U. S. Environmental Protection Agency has promulgated toxic pollutant effluent standards for ambient water quality criterion in navigable waters for aldrin, diedrin, DDE, DDD, and DDT at the maximum concentrations as they appear above and as cited in the Federal Register, Volume 42, No. 8, January 12, 1977.*

[b] *No recommended criteria established.*

[c] *Average of determinate sample results (number of samples averaged).*

[d] *Indeterminate sample results (number of samples averaged). Asterisk (*) indicates those sample results of less than detectable (sensitivity) limits of the laboratory analysis.*

Source: Wisconsin Department of Natural Resources and SEWRPC.

the Region that included two locations within the Pike River watershed. The objective of this monitoring program, which was carried out under the areawide water quality management planning program, was to provide discharge and flow data at selected locations in the Region for a continuous period of time encompassing both periods of dry weather low flow and periods of wet weather high flow. The data were intended to be used to assess the impact of rainfall and rainfall-snowmelt events on instream water quality and to provide a suitable continuous data series for calibration of the hydrologic-hydraulic water quality model being used under the areawide water quality management planning program—the same model used under the Pike River watershed planning program.

One sampling station, Pk-A, was located at the CTH G bridge of the Pike River—river mile 6.6—in U. S. Public Land Survey Section 1, Township 3 North, Range 22 East, in the Town of Somers, Kenosha County. The second sampling station, Pk-1, was located at the STH 31 bridge of the Pike River—river mile 10.3—in Section 2, Township 3

North, Range 22 East, in the Town of Somers, Kenosha County. The location of sampling sites are shown on Map 33.

As shown on Figure 31, stream water quality determinations for both stations were made at approximately one-day intervals for the period beginning September 7, 1976 and extending through October 5, 1976. In addition, on those days on which runoff occurred as the result of rainfall events, several water quality samples were taken for the purpose of preparing instream pollutographs. A significant rainfall event occurred on October 4 and 5 when about 1.5 inches of rainfall fell on the watershed during a 28-hour period from about 9:00 p.m. on October 4 to 12:00 p.m. on October 5. Such a rainfall event may be expected to occur one or more times each year.

The data collected at the two stations in the Pike River watershed during September and October of 1976 are different from the data collected in all of the other monitoring efforts reported herein for two reasons. First, most of the data collected under other studies were single samples collected generally during dry weather conditions and, although some limited wet weather data were available, they generally were not sufficient to characterize the water quality impacts of runoff events. The 1976 data include both water quantity and quality information for rainfall runoff events, thus permitting a characterization of the water quality impact of such events. Second, the 1976 data are for a continuous time period, thus permitting a characterization of water quality changes occurring at a given location over a period of time in response to varying meteorologic conditions.

Findings of the Study: Figure 31 is a graphic summary of water quantity and quality conditions in the Pike River at CTH G and at STH 31 during the period from September 7 through October 6 of 1976. A summary of dry and wet weather concentration and transport of biochemical oxygen demand, fecal coliform bacteria, chloride, orthophosphate, total phosphorus, and total nitrogen is presented in Table 48 for these stations.

Temperature: All of the water temperature measurements were less than the maximum allowable standard of 89°F. Air temperature appears to be the primary determinant of water temperature during the dry weather periods in that the water temperature, like the air temperature, exhibits a diurnal fluctuation, with the highest water temperatures occurring during the afternoon hours and the lowest temperatures occuring during the early morning hours. There is a slight lag between water temperatures and air temperatures. For example, air temperatures tend to exceed water temperatures by several degrees in the late morning hours, whereas air and water temperatures are approximately equal in the late afternoon. Air temperatures then drop below water temperatures in the evening and early morning hours. During the October 4, 1976 rainfall event, surface water temperatures were relatively uniform and slightly lower than the coincident air temperatures.

Dissolved Oxygen: All of the dissolved oxygen level measurements at the downstream station—Pk-A at CTH G—were above the standard of 5.0 mg/l, with an average dry weather concentration of 8.4 mg/l. Considerably lower levels of dissolved oxygen were observed at the upstream station—Pk-1 at STH 31—probably reflecting an effect from the Sturtevant sewage treatment facility. The average dry weather concentration of dissolved oxygen at the upstream station was 4.3 mg/l. Dissolved oxygen level concentrations were not significantly depressed during rainfall runoff events at the two stations, suggesting that the oxygen demand exerted by organic matter washed from the land surface was offset by oxygen entrained in the storm water runoff, or that the reaction time was too brief for significant dissolved oxygen reduction to occur. An earlier analysis of the dissolved oxygen content in runoff from various land uses in the Menomonee River watershed indicated near saturation conditions, and suggests that wet weather condition runoff is generally rich in dissolved oxygen regardless of land use and antecedent conditions.[7]

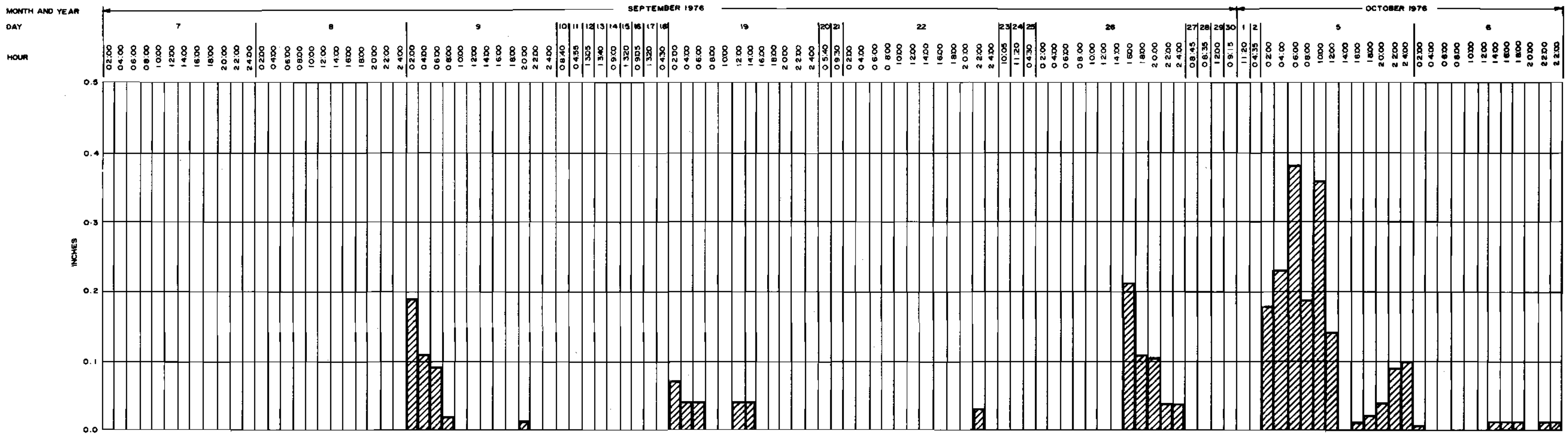
Biochemical Oxygen Demand: The average dry weather biochemical oxygen demand (BOD) found at both sample stations was 3.4 mg/l. The sample results indicate that the biochemical oxygen demand in the surface waters is influenced by runoff events. For example,the instream biochemical oxygen demand loading during the October rainfall event was about 8 times the dry weather average loading. The concentrations of biochemical

[7] *See SEWRPC Planning Report No. 26, A Comprehensive Plan for the Menomonee River Watershed, Volume One, Inventory Findings and Forecasts, October 1976, pp. 249-250.*

Figure 31

SURFACE WATER QUALITY (DRY AND WET WEATHER) OF THE PIKE RIVER AT CTH G—PK-A—AND AT STH 31—PK-1: SEPTEMBER 7-OCTOBER 6, 1976

HOURLY PRECIPITATION: KENOSHA



HOURLY PRECIPITATION: RACINE

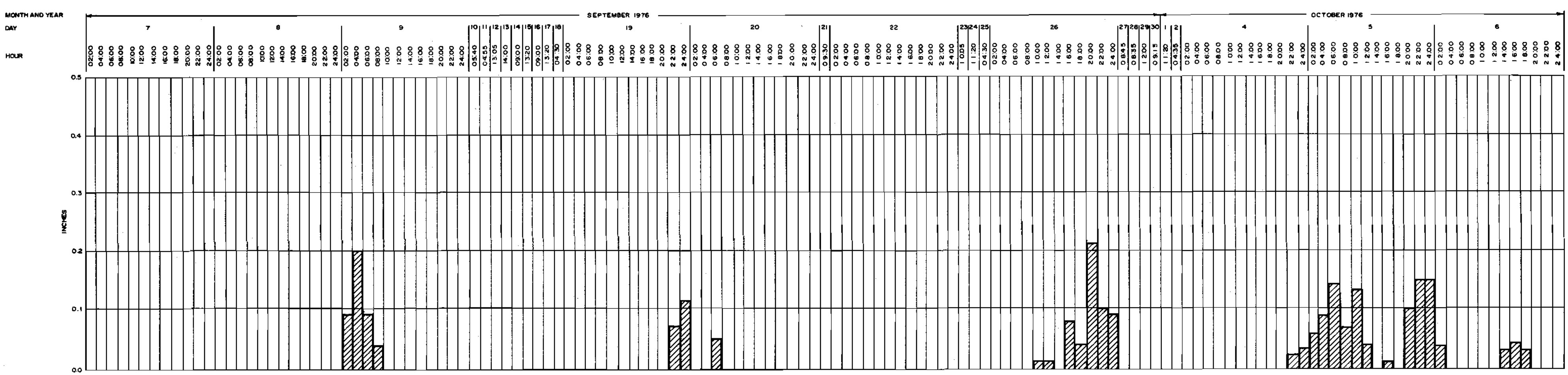
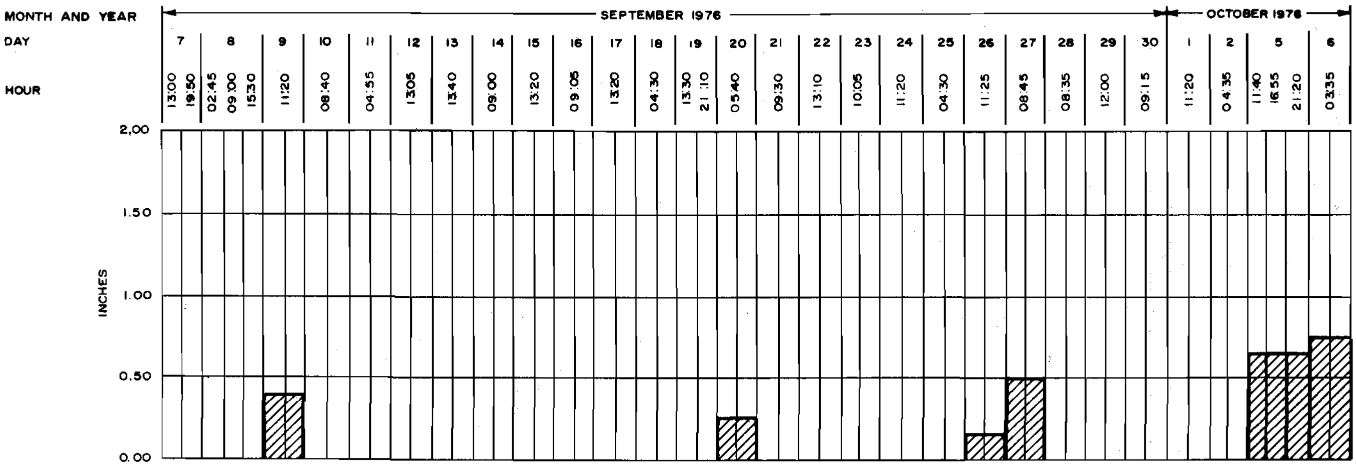


Figure 31 (continued)

DAILY PRECIPITATION: RACINE



DAILY PRECIPITATION: KENOSHA

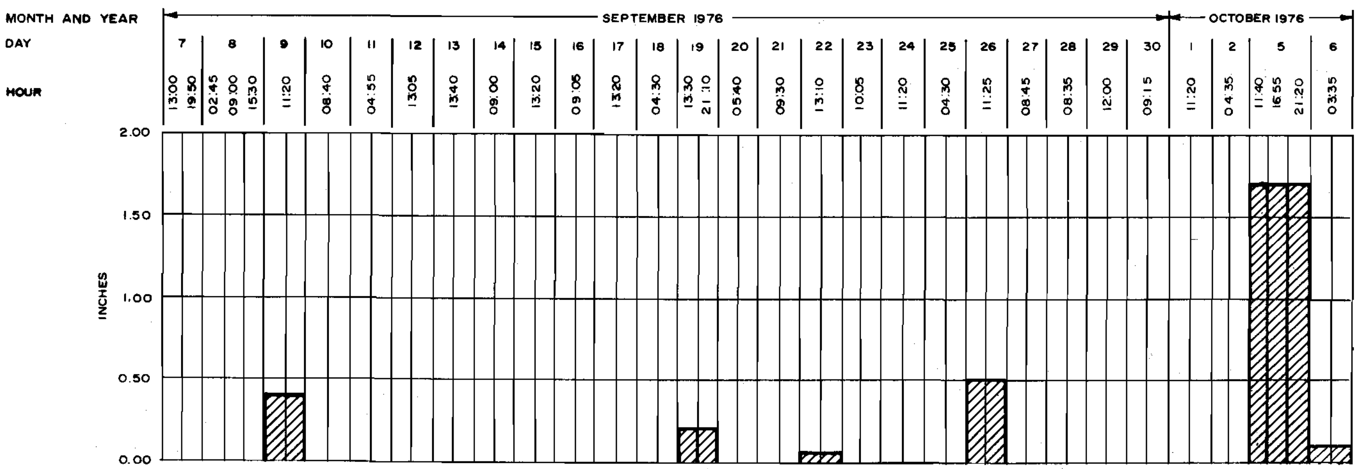
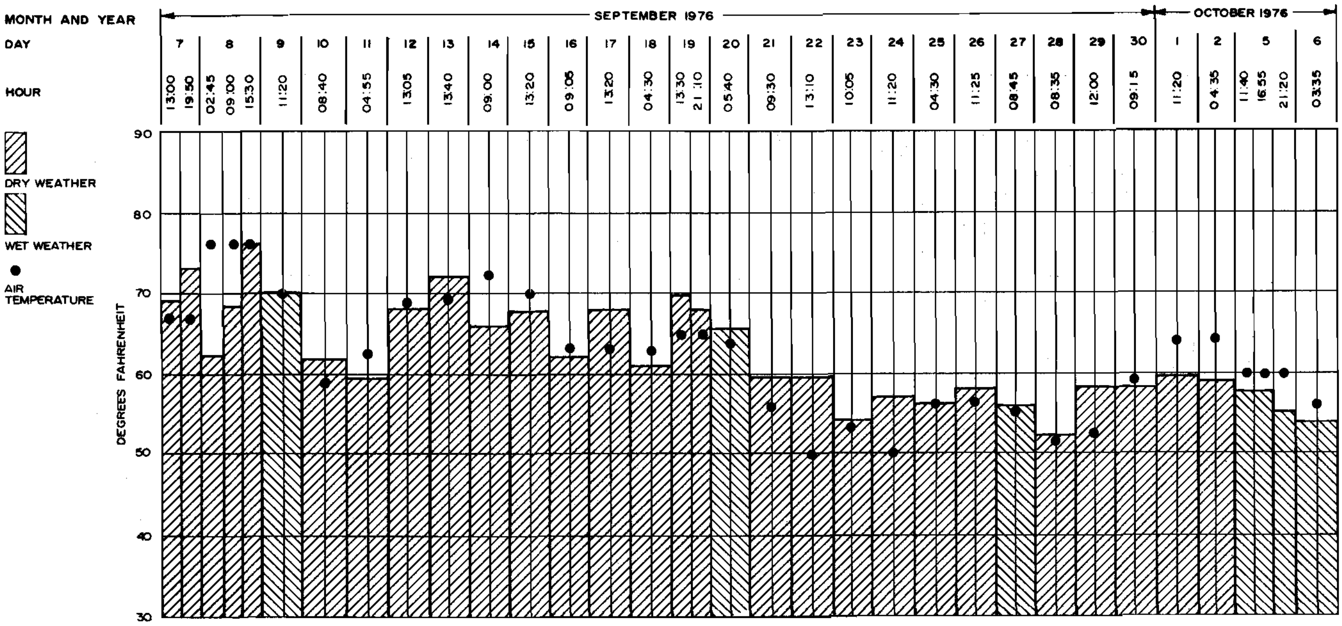


Figure 31 (continued)

AIR AND WATER TEMPERATURE: PK-A



AIR AND WATER TEMPERATURE: PK-1

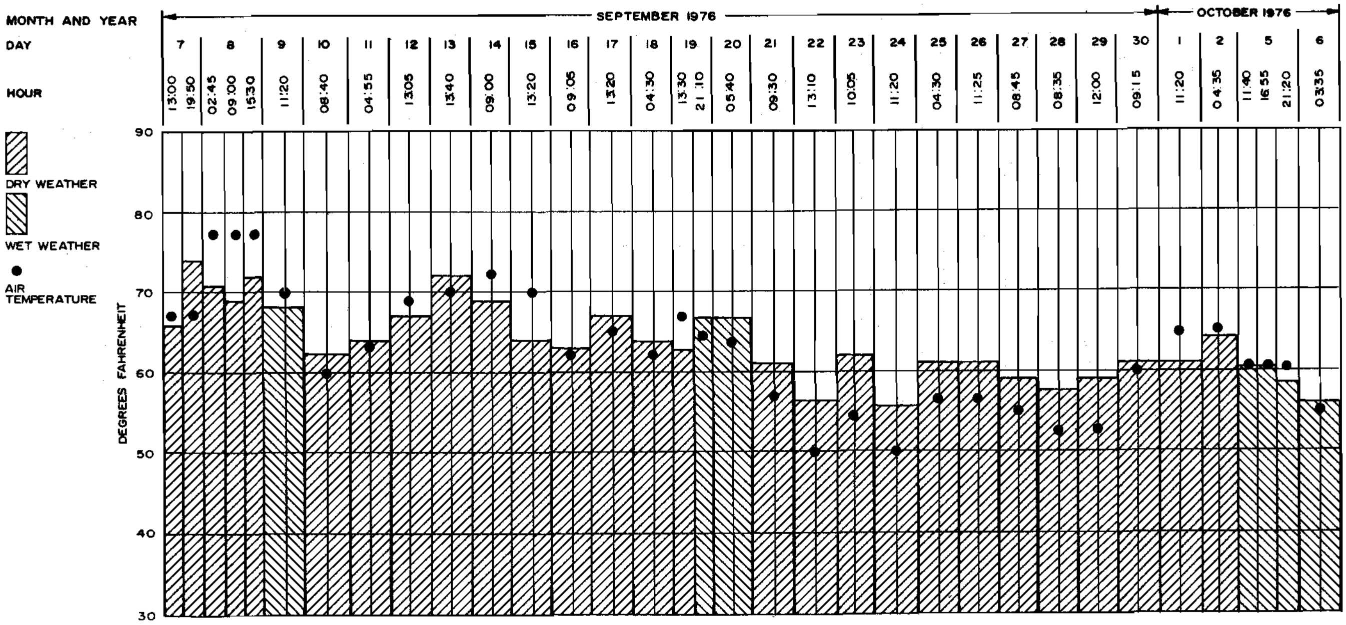
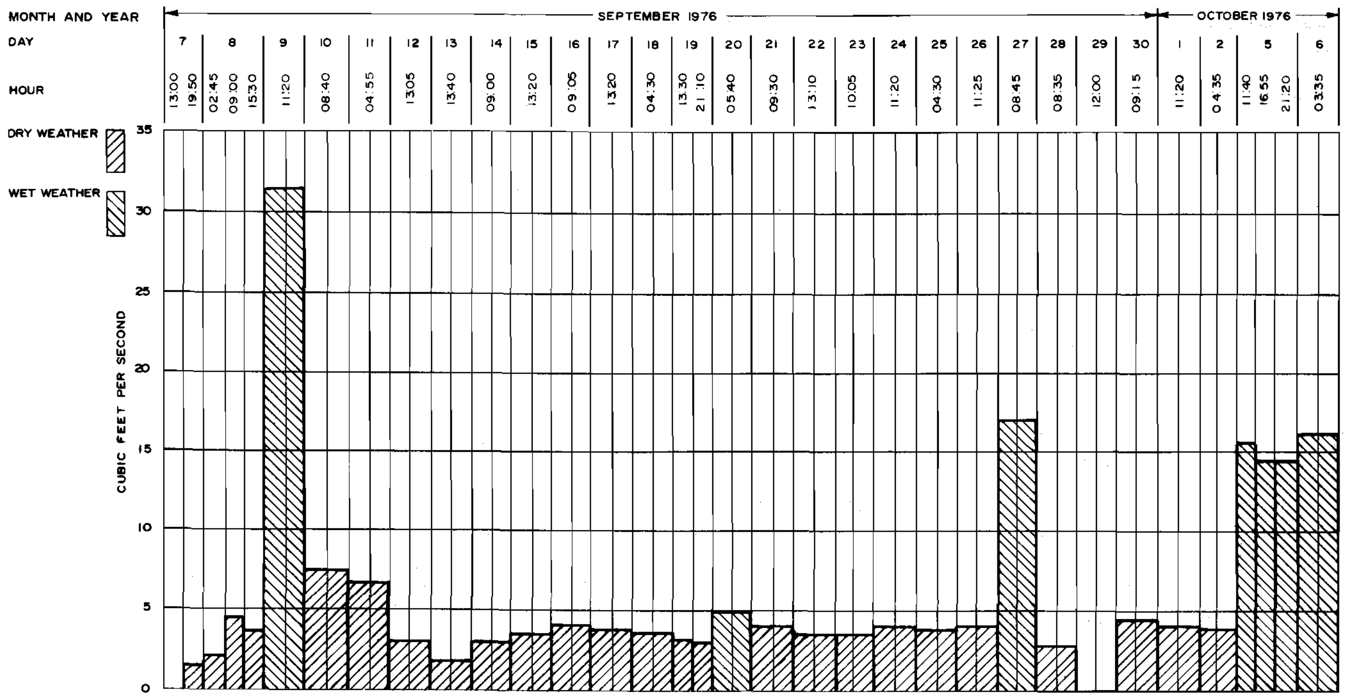


Figure 31 (continued)

STREAMFLOW: PK-A



STREAM FLOW: PK-1

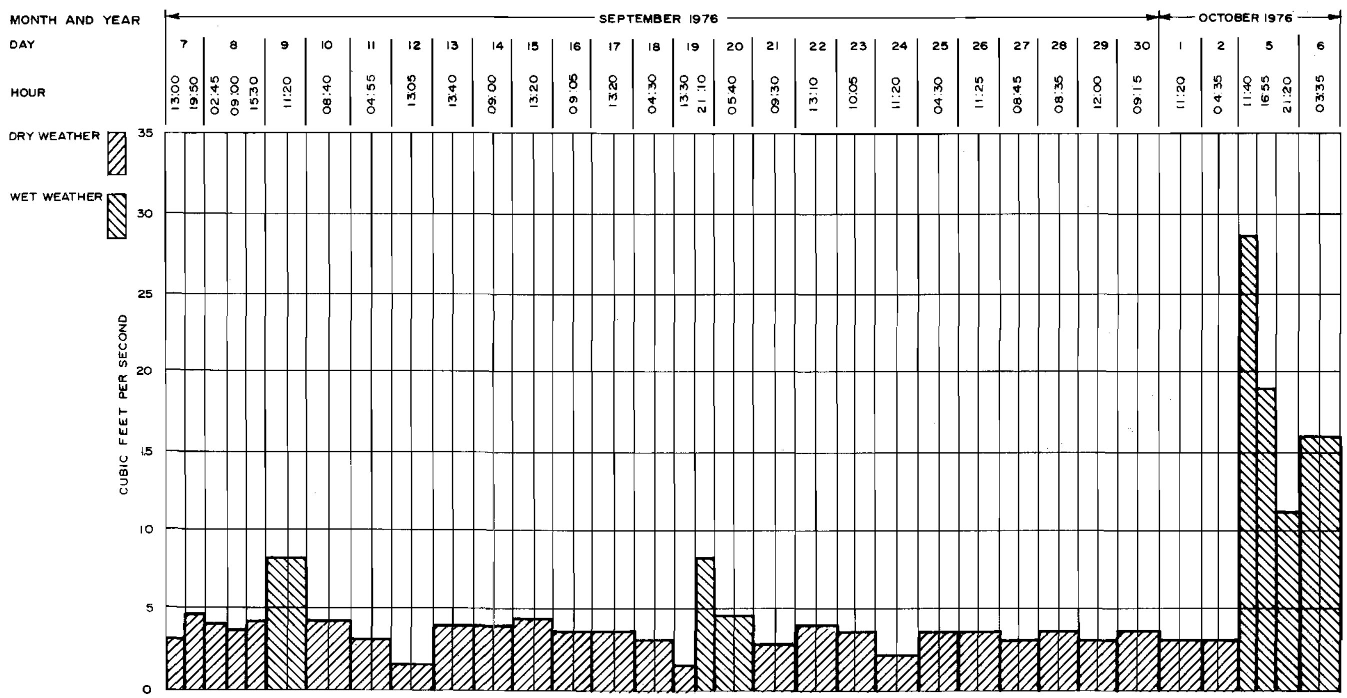
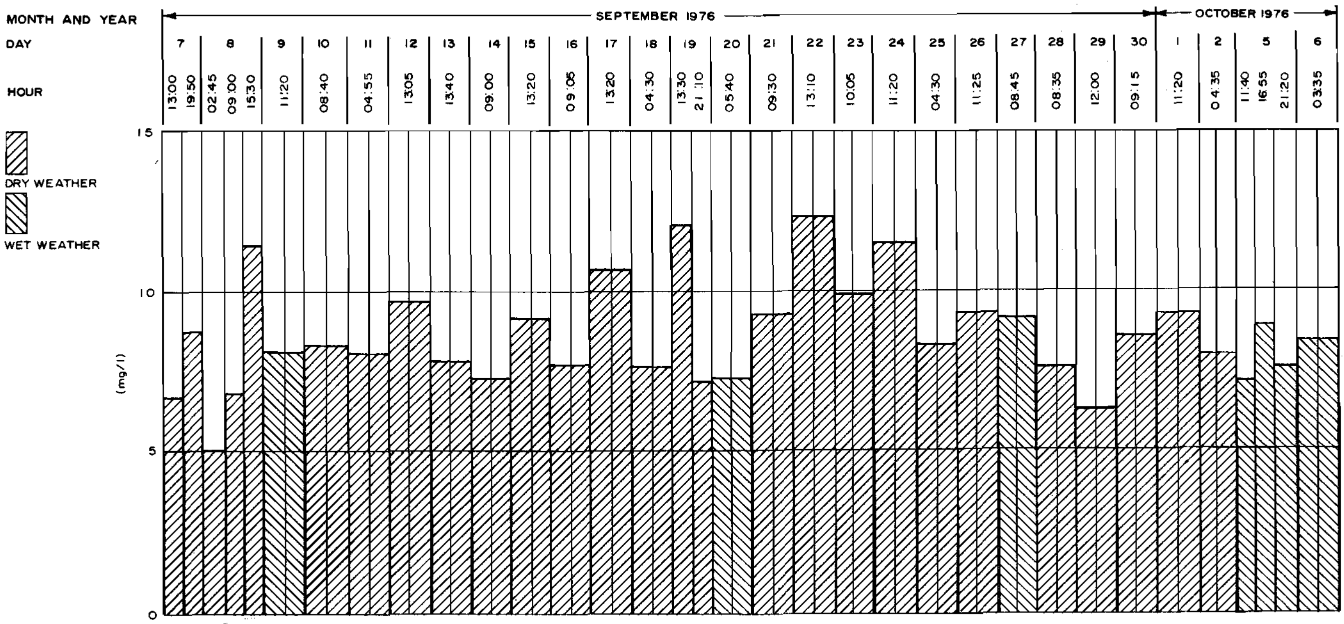


Figure 31 (continued)

DISSOLVED OXYGEN: PK-A



DISSOLVED OXYGEN: PK-1

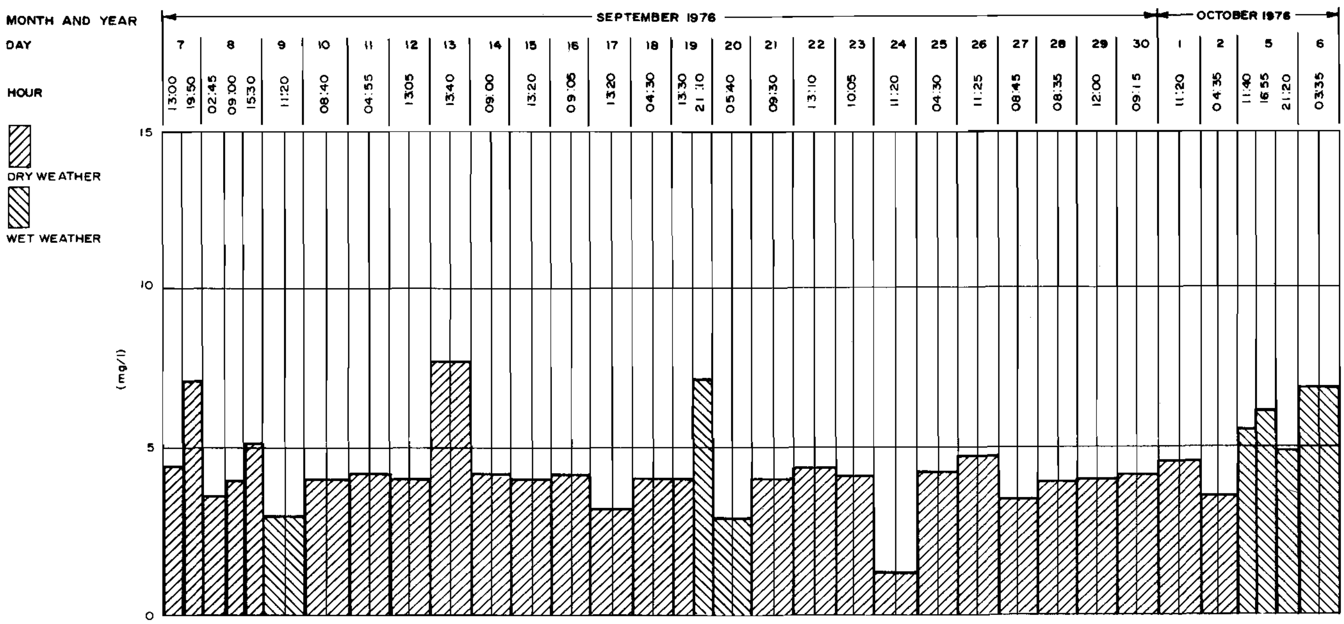
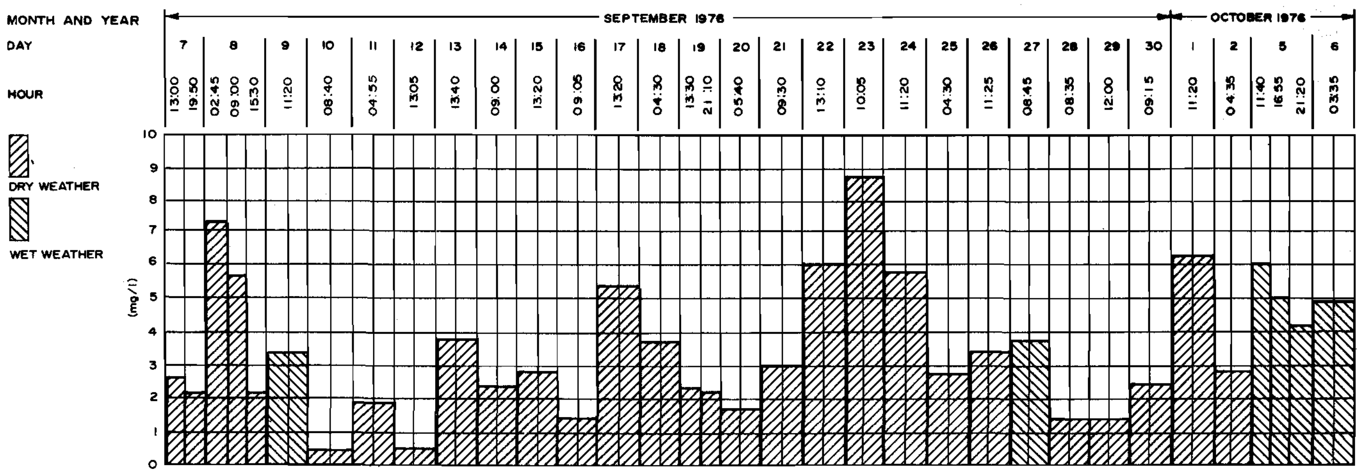


Figure 31 (continued)

BIOCHEMICAL OXYGEN DEMAND: PK-A



BIOCHEMICAL OXYGEN DEMAND: PK-1

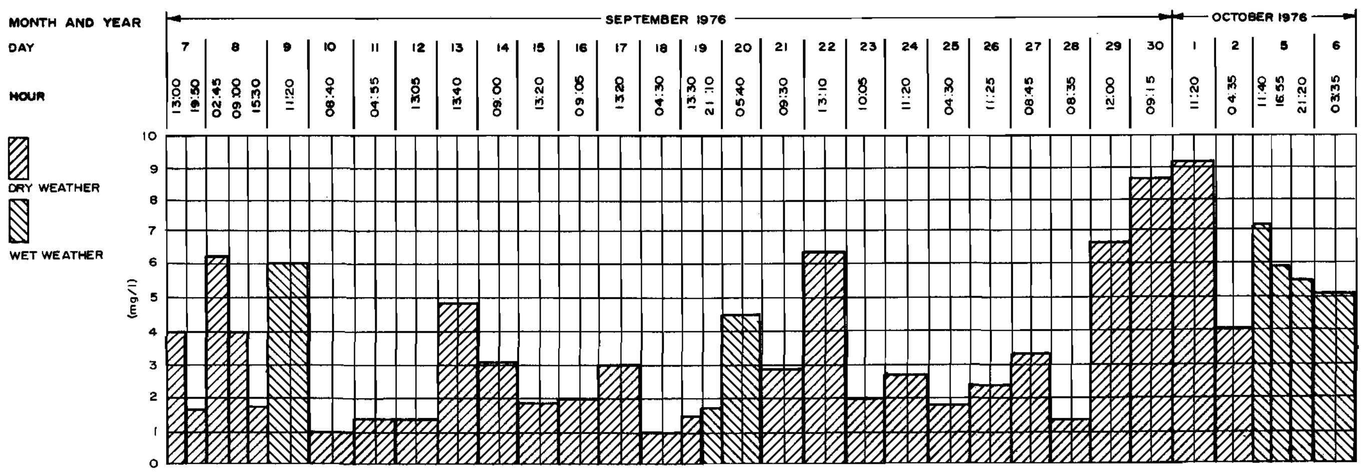
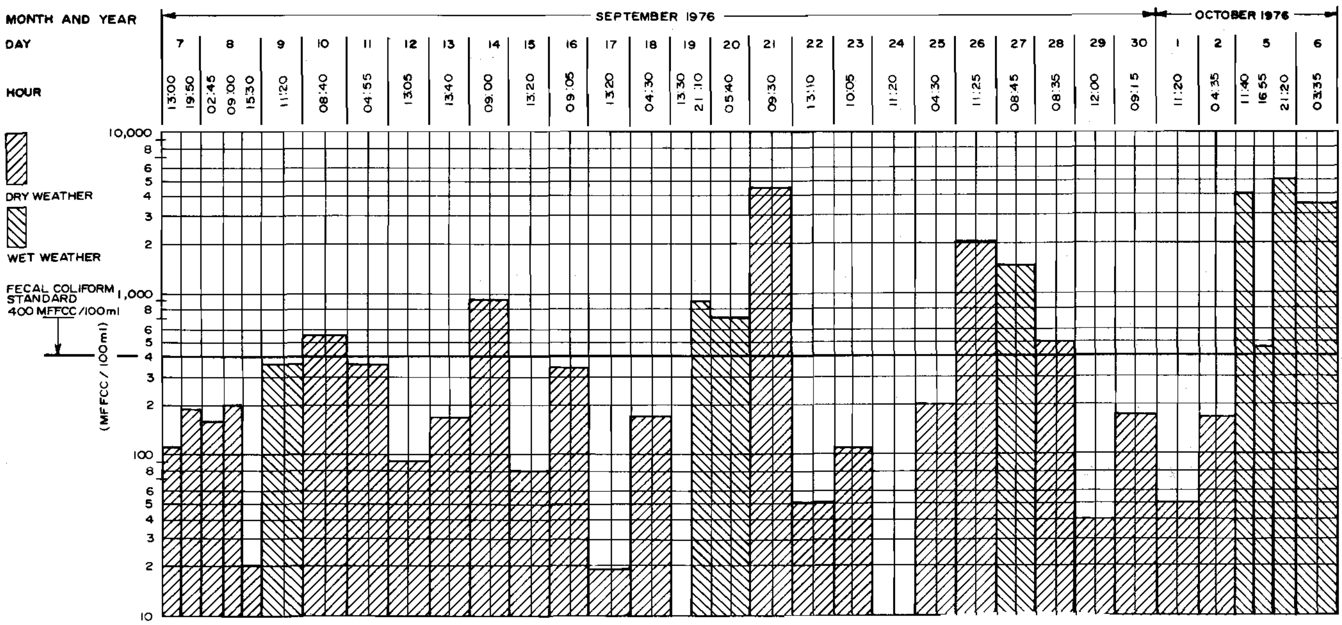


Figure 31 (continued)

FECAL COLIFORM: PK-A



FECAL COLIFORM: PK-1

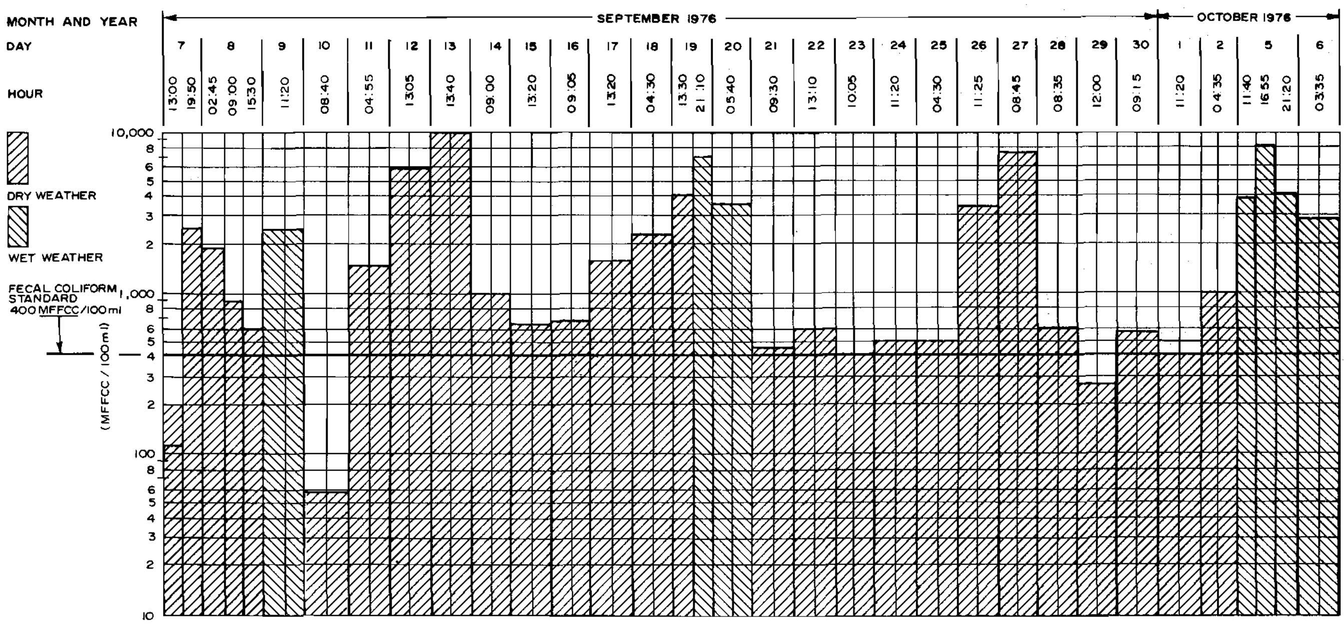
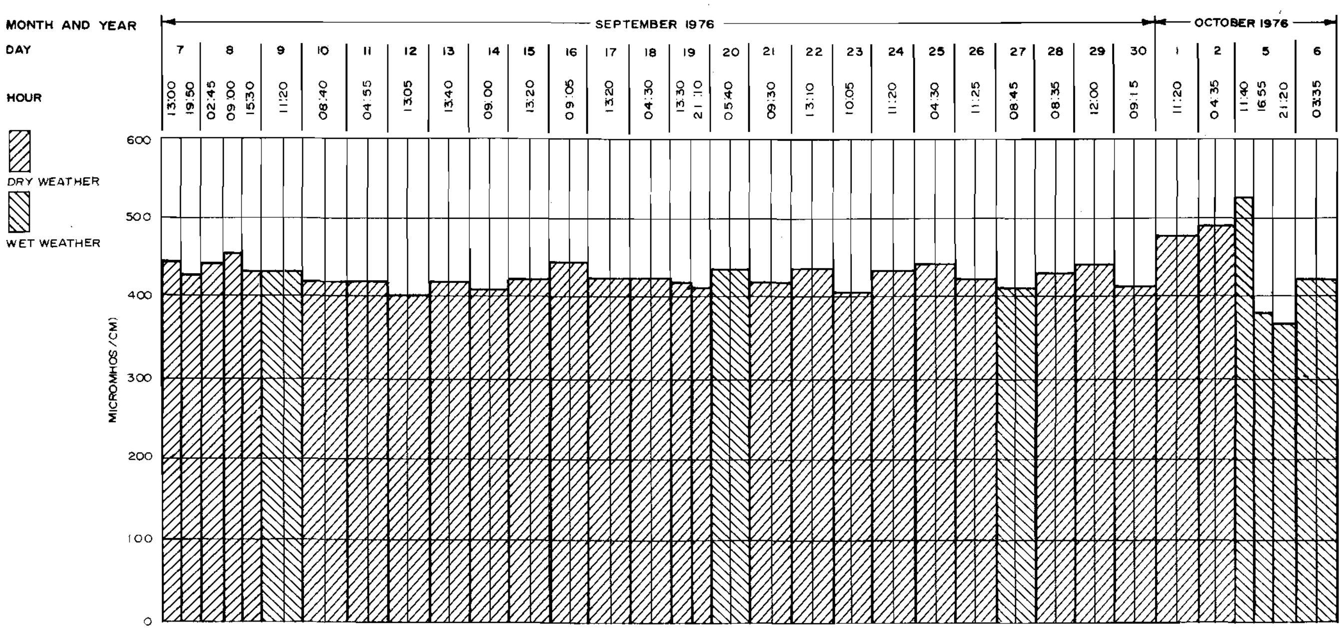


Figure 31 (continued)

SPECIFIC CONDUCTANCE: PK-A



SPECIFIC CONDUCTANCE: PK-1

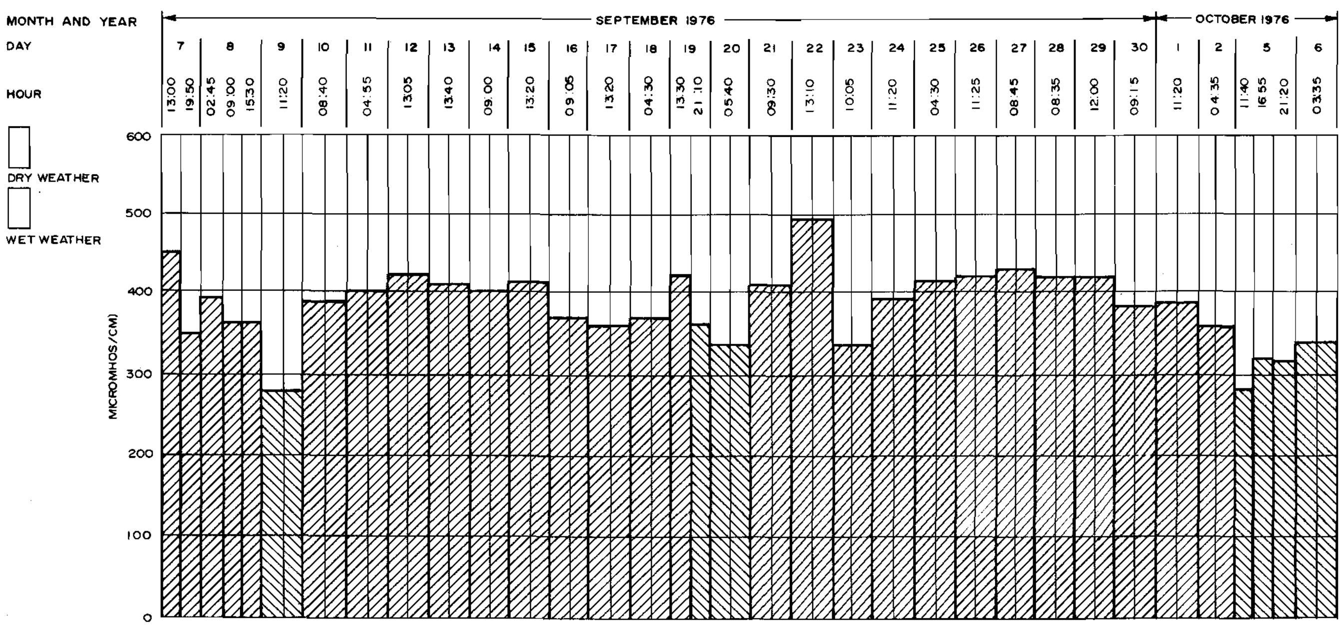
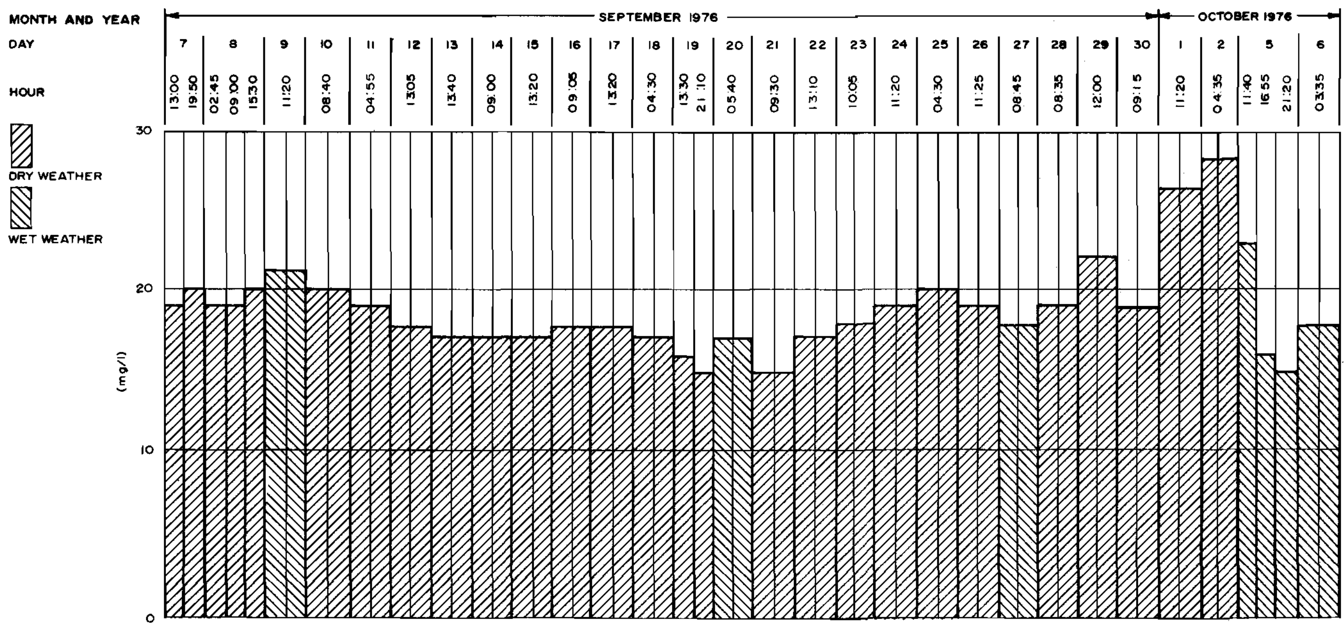


Figure 31 (continued)

CHLORIDE: PK-A



CHLORIDE: PK-1

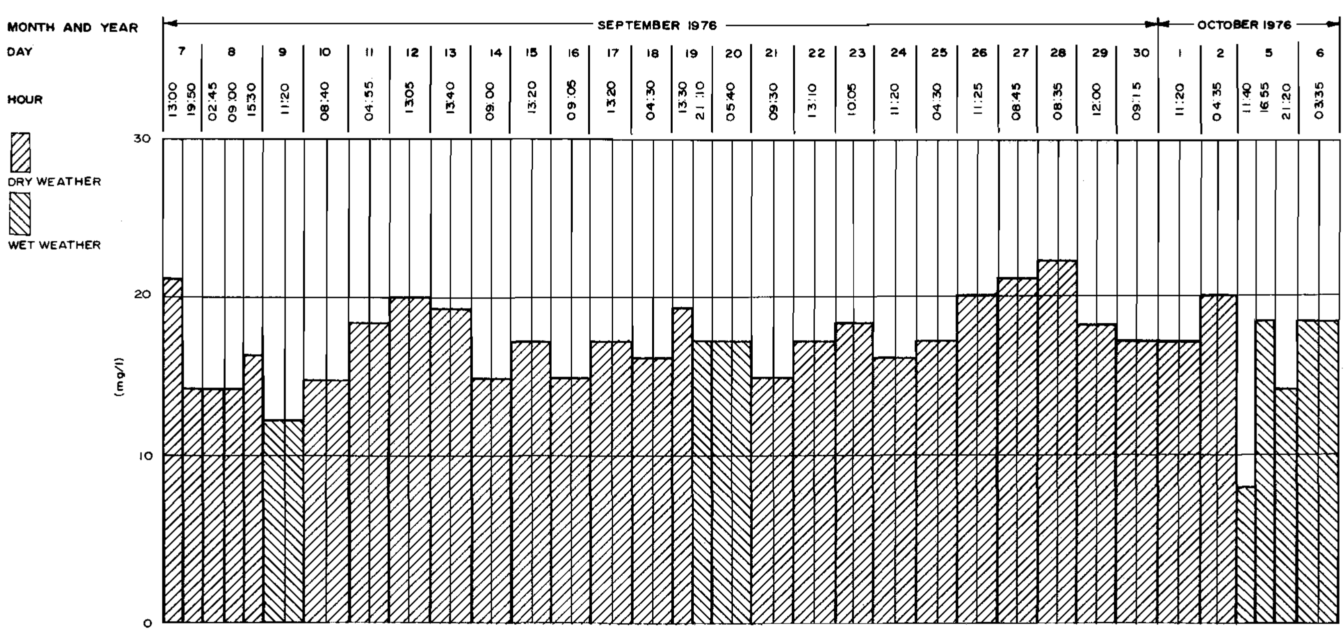
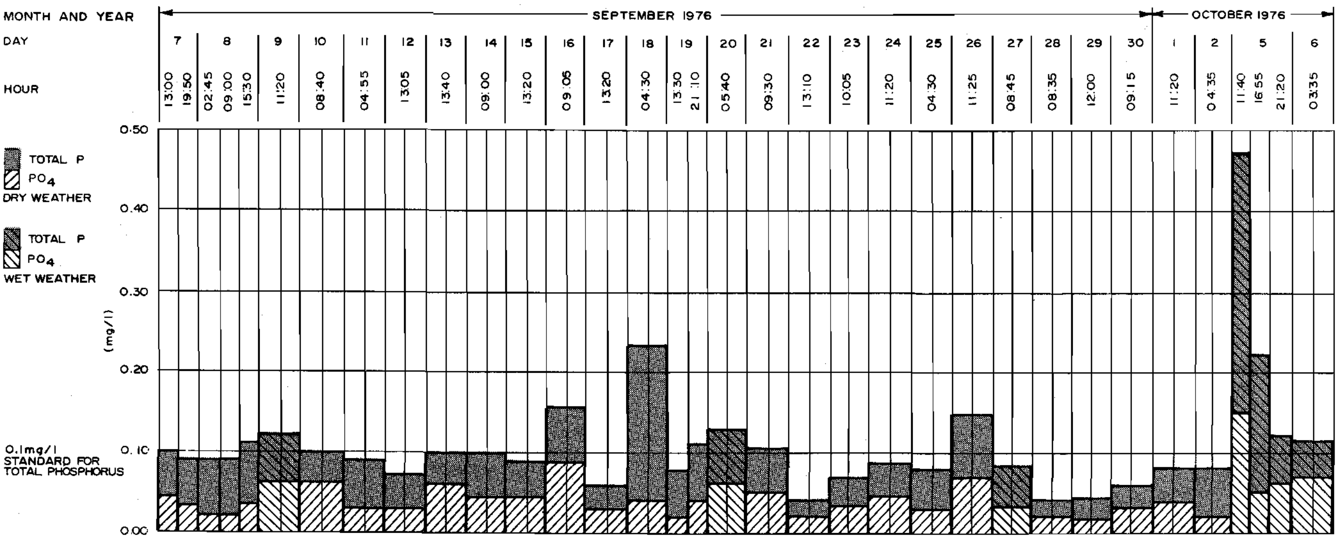


Figure 31 (continued)

PHOSPHORUS FORMS: PK-A



PHOSPHORUS FORMS: PK-1

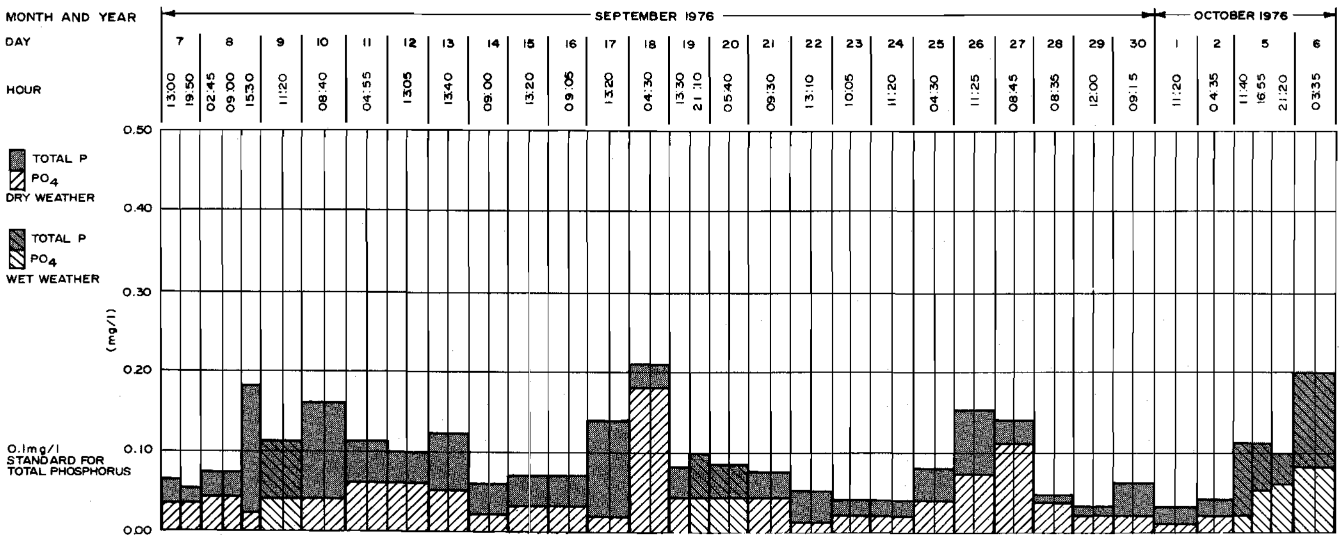
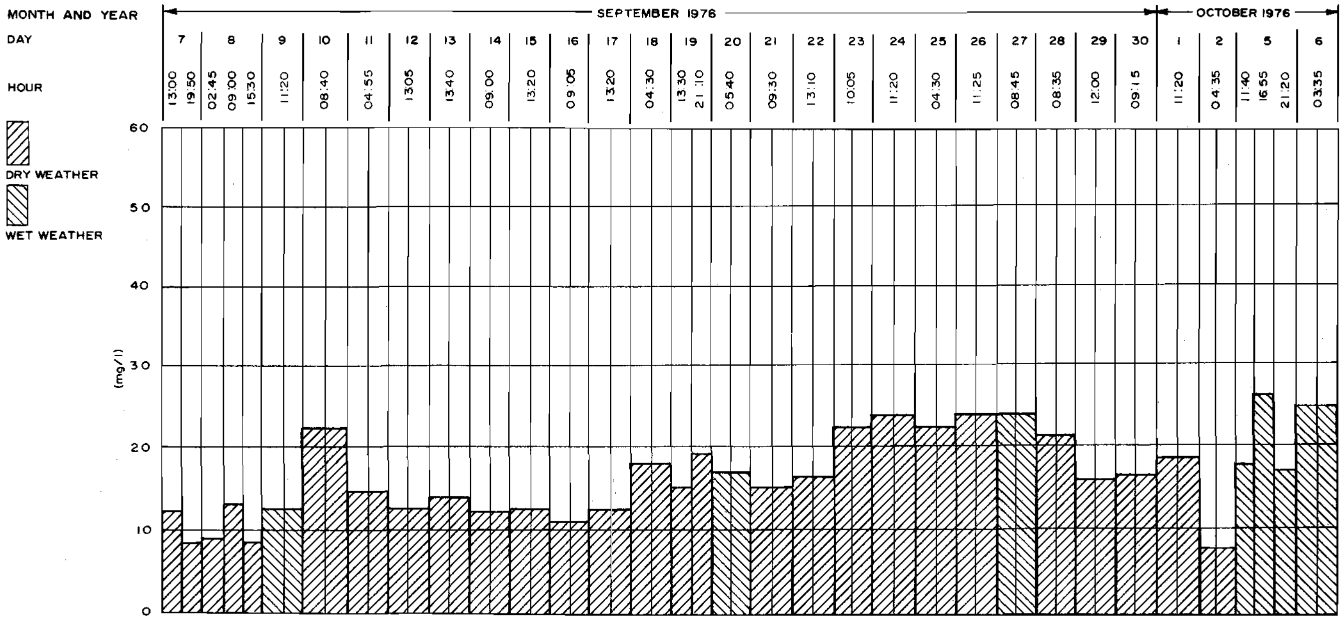
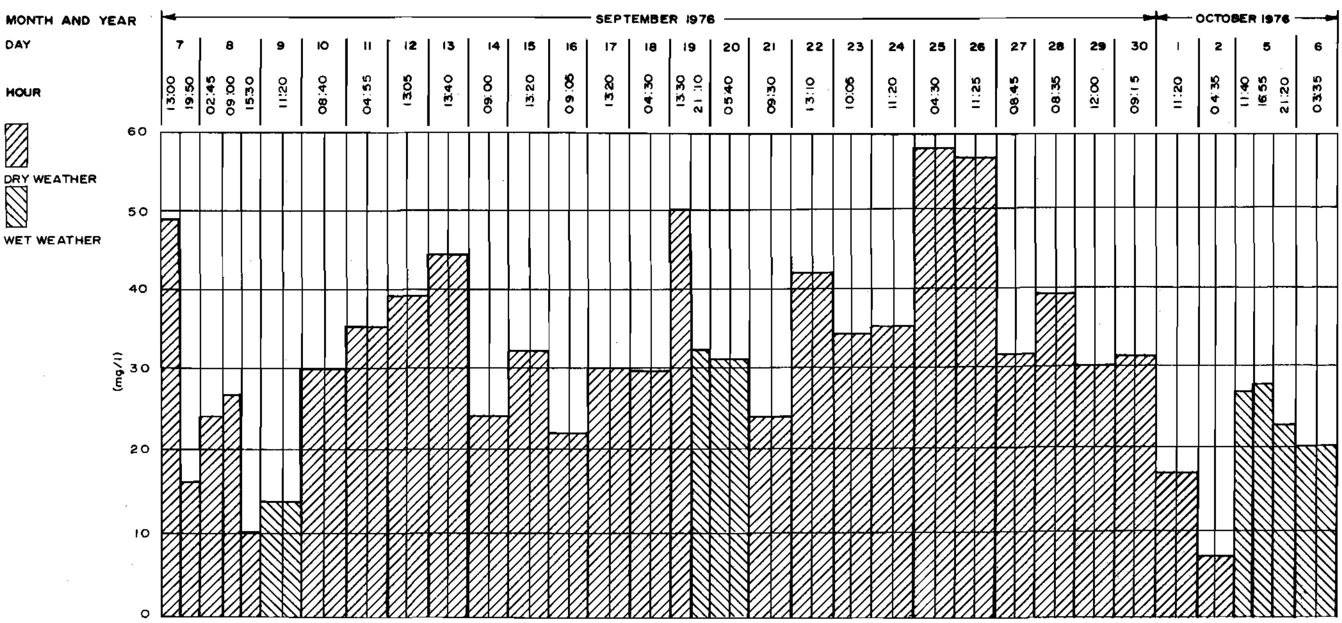


Figure 31 (continued)

NITROGEN FORMS: PK-A



NITROGEN FORMS: PK-A



Source: Wisconsin Department of Natural Resources and SEWRPC.

oxygen demand was almost doubled from dry to wet weather conditions. It is expected that the increase in biochemical oxygen demand during snowmelt events would be even more dramatic due to the fall and winter accumulation of leaves, street litter, animal droppings and vegetative ground cover.

Fecal Coliform Bacteria: About 90 percent of the dry weather samples for fecal coliform at the upstream sample station were in excess of the upper limit of the recommended level of 400 MFFCC per 100 ml. Concentrations of the downstream sample location were considerably lower, with 20 percent of the dry weather samples in excess of the standard. Both sample stations indicated a significant increase in fecal coliform bacteria following storm events, with most of the wet weather samples in excess of the recommended level.

Specific Conductance and Chloride: The monitoring data indicate that during dry weather periods, specific conductance was relatively uniform at the downstream station, averaging 390 micromhos per centimeter. Similarly, at the upstream station during dry weather periods specific conductance averaged 430 micromhos per centimeter. The sample data indicate a slight reduction of the specific conductance and chloride concentration following storm events at the upstream sample location, with no notable change at the downstream site.

Phosphorus: As already noted, the recommended phosphorus standard of 0.10 mg/l is the recognized level below which nuisance growths of algae and other aquatic plants are not expected to occur in flowing streams. About 20 percent of the dry weather total phosphorus determinations made at both the upstream and downstream sample stations exceeded this standard and 90 percent of the wet weather samples were found to be in excess of this standard. The average dry weather total phosphorus concentration at both sample stations was found to be about the same with an average concentration of 0.09 mg/l. It is assumed that during periods of the year when the instream level of phosphorus was below 0.1 mg/l, the effect of the municipal treatment plant discharges on instream phosphorus concentration is minimized by groundwater dilution, and biological processes such as plant and algae phosphorus uptake. The marked increase in phosphorus concentration during wet weather conditions indicates high concentrations of phosphorus running off the land surface during precipitation events.

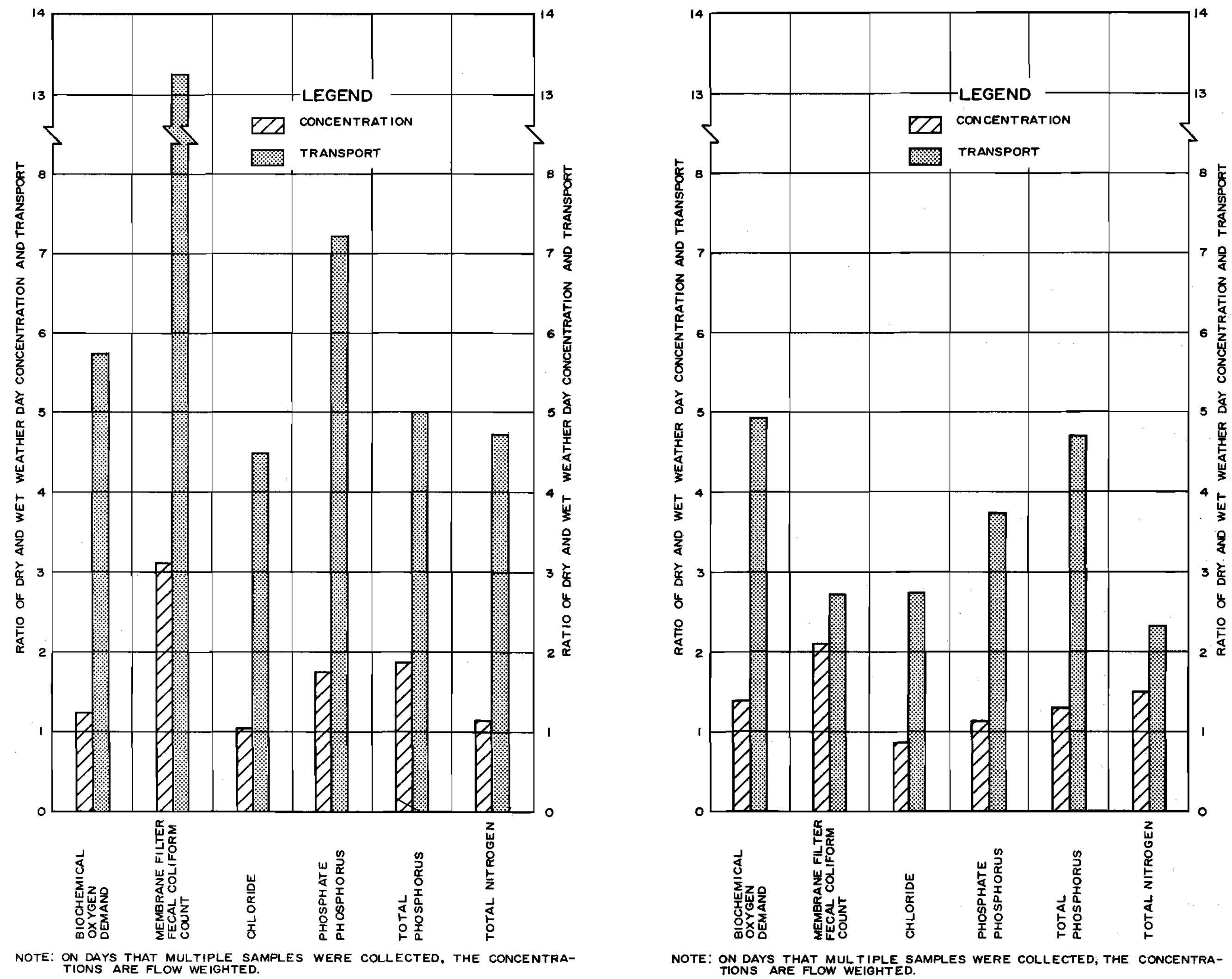
Nitrogen: The upstream sample location was found to have an average dry weather total nitrogen concentration of 3.25 mg/l, considerably higher than the downstream concentration of 1.6 mg/l. The higher dry weather concentration of total nitrogen at the upstream location may be attributable to the Village of Sturtevant sewage treatment facility. The effect of a municipal effluent discharge is not as dramatic in downstream reaches due to a greater ground and surface water dilution capacity, biological nitrogen uptake and a potential loss of nitrogen compounds to stream bottom sediments between the two stations. The upstream sample station recorded a 25 percent reduction of instream total nitrogen concentration from 3.25 mg/l to 2.48 mg/l from dry to wet weather conditions, indicating a dilution effect by surface water runoff. The opposite effect was recorded at the downstream station, with a 20 percent increase in the instream total nitrogen concentration from dry to wet weather conditions from 1.60 mg/l to 1.95 mg/l, indicating a greater concentration of nitrogen in runoff water than the baseflow concentration.

Dry and Wet Weather Concentration and Transport: The concentration of pollutants in stream waters as measured in, for example, milligrams per liter, at any place and time establishes the suitability for fish and aquatic life, recreation use, and aesthetic enjoyment. The transport of potential pollutants as measured, for example, in pounds per day at the mouth of a watershed ultimately determines the long-term quality of relatively static receiving waters such as estuaries, lakes, and reservoirs. The response or sensitivity of such surface water bodies to pollutant loads is likely to be manifested in longer time intervals such as days, weeks, months, or seasons and, therefore, the daily, weekly, monthly, and seasonal loads of pollutants are more important than are the instantaneous concentrations of pollutants in the inflowing water.

Figure 32 provides ratios between dry and wet weather conditions for the average daily concentration and transport of six parameters—biochemical oxygen demand, fecal coliform count, chloride, phosphate phosphorus, total phosphorus, and total nitrogen—for dry weather days during the period

Figure 32

RATIO OF WET TO DRY WEATHER CONCENTRATION AND TRANSPORT FOR SELECTED POLLUTANTS IN THE PIKE RIVER AT CTH G—PK-A—AND AT STH 31—PK-1: SEPTEMBER 7-OCTOBER 6, 1976



Source: Wisconsin Department of Natural Resources and SEWRPC.

from September 7, 1976 through October 6, 1976. This graphic summary illustrates the significant difference between dry and wet weather surface water quality conditions, as set forth in greater detail in Table 48, and more particularly, the marked increase in both concentration and transport that occurred during the wet weather period, with the exception of the concentration and transport of chloride.

Concentration: The instream concentration of five of the six parameters at both sample stations increased during wet weather conditions. The concentrations ranged from 0.77 times the average dry weather concentration for total nitrogen to 3.1 times the average dry weather concentration for fecal coliform bacteria. These concentration levels occurred in spite of the 4-fold increase in average streamflow on the wet weather days, of

Table 48

DRY AND WET WEATHER CONCENTRATIONS AND TRANSPORT FOR SELECTED POLLUTANTS IN THE PIKE RIVER AT CTH G—PK-A—AND AT STH 31—PK-1: SEPTEMBER 7-OCTOBER 6, 1976

Sampling Dates for Pk-A[a]	Sampling Condition	Parameter, Transport, and Concentration Biochemical Oxygen Demand Pounds per Day (mg/l)	Fecal Coliform Colonies per Day (MFFCC per 100 ml)	Chloride Pounds per Day (mg/l)	Phosphate Phosphorus Pounds per Day (mg/l)	Total Phosphorus Pounds per Day (mg/l)	Total Nitrogen Pounds per day (mg/l)
September 8, 1976	Dry	91.04 (4.7)[b]	1.13 x 10^{10} (128.2)[b]	372.87 (19.8)[b]	0.51 (0.027)[b]	1.88 (0.097)[b]	20.15 (1.07)[b]
September 9, 1976	Wet	581.76 (3.11)	2.57 x 10^{11} (330)	3,593.19 (21)	10.61 (0.062)	22.24 (0.13)	224.15 (1.31)
September 10, 1976	Dry	17.43 (0.4)	1.03 x 10^{11} (520)	871.66 (20)	1.48 (0.034)	4.36 (0.10)	96.75 (2.22)
September 11, 1976	Dry	158.23 (1.8)	5.49 x 10^{10} (330)	695.18 (19)	0.84 (0.023)	3.29 (0.09)	56.71 (1.55)
September 12, 1976	Dry	10.01 (0.6)	6.83 x 10^{9} (90)	300.24 (18)	0.46 (0.028)	2.67 (0.16)	21.68 (1.30)
September 13, 1976	Dry	36.80 (3.8)	7.49 x 10^{9} (170)	164.65 (17)	0.55 (0.57)	0.68 (0.07)	14.72 (1.52)
September 14, 1976	Dry	36.70 (2.2)	6.75 x 10^{10} (890)	283.56 (17)	0.63 (0.38)	4.00 (0.24)	21.68 (1.30)
September 15, 1976	Dry	52.73 (2.8)	6.85 x 10^{9} (80)	320.15 (17)	0.81 (0.043)	1.51 (0.08)	25.05 (1.33)
September 16, 1976	Dry	32.39 (1.4)	3.58 x 10^{10} (340)	416.46 (18)	2.20 (0.095)	3.70 (0.16)	29.62 (1.28)
September 17, 1976	Dry	119.13 (5.4)	2.00 x 10^{9} (20)	397.09 (18)	0.77 (0.035)	1.54 (0.07)	29.34 (1.33)
September 18, 1976	Dry	67.80 (3.6)	1.63 x 10^{10} (190)	320.15 (17)	1.00 (0.053)	4.52 (0.24)	33.71 (1.79)
September 19, 1976	Dry	37.29 (2.31)[b]	3.23 x 10^{10} (440.2)[b]	250.20 (15.5)[b]	0.55 (0.034)[b]	1.60 (0.099)[b]	26.80 (1.66)[b]
September 20, 1976	Wet	43.91 (1.6)	8.86 x 10^{10} (710)	466.50 (17)	2.09 (0.076)	3.57 (0.13)	45.83 (1.67)
September 21, 1976	Dry	66.18 (3.0)	4.51 x 10^{11} (4500)	330.91 (15)	1.28 (0.058)	2.21 (0.10)	33.75 (1.53)
September 22, 1976	Dry	112.99 (6.0)	4.28 x 10^{9} (50)	320.15 (17)	0.40 (0.021)	0.94 (0.05)	31.07 (1.65)
September 23, 1976	Dry	165.72 (8.8)	9.42 x 10^{9} (110)	338.98 (18)	0.62 (0.033)	1.32 (0.07)	42.94 (2.28)
September 24, 1976	Dry	127.95 (5.8)	1.00 x 10^{9} (10)	419.15 (19)	1.04 (0.047)	0.88 (0.04)	51.85 (2.35)
September 25, 1976	Dry	52.73 (2.8)	1.71 x 10^{10} (200)	376.65 (20)	0.47 (0.025)	1.51 (0.08)	43.69 (2.32)
September 26, 1976	Dry	78.67 (3.4)	2.21 x 10^{11} (2100)	439.60 (19)	1.27 (0.055)	3.24 (0.14)	54.60 (2.36)
September 27, 1976	Wet	351.68 (3.8)	5.89 x 10^{11} (1400)	1,665.85 (18)	3.24 (0.035)	7.40 (0.08)	221.19 (2.39)
September 28, 1976	Dry	19.59 (1.4)	3.12 x 10^{10} (490)	265.80 (19)	0.39 (0.028)	0.70 (0.05)	29.80 (2.13)
September 29, 1976	Dry	0.0 (1.4)	0.0 (40)	0.0 (22)	0.0 (0.020)	0.0 (0.05)	0.0 (2.73)
September 30, 1976	Dry	64.35 (2.6)	1.91 x 10^{10} (170)	470.27 (19)	0.87 (0.035)	1.49 (0.06)	43.56 (1.76)
October 1, 1976	Dry	126.77 (6.2)	4.65 x 10^{9} (50)	531.61 (26)	0.90 (0.044)	1.64 (0.08)	39.87 (1.95)
October 2, 1976	Dry	52.73 (2.8)	1.37 x 10^{10} (160)	527.30 (28)	0.56 (0.030)	1.51 (0.08)	15.44 (0.82)
October 5, 1976	Wet	486.41 (6.0)[b]	1.12 x 10^{12} (3.045.1)[b]	1,413.71 (17.4)[b]	7.23 (0.089)[b]	21.94 (0.27)[b]	166.56 (2.05)[b]
October 6, 1976	Wet	510.09 (6.0)	1.31 x 10^{12} (3,400)	1,530.26 (18)	5.87 (0.069)	10.20 (0.12)	198.08 (2.33)
Summary of Dry Weather Data	Minimum	0.0 (0.4)	0.0 (10)	0.0 (15)	0.0 (0.020)	0.0 (0.04)	0.0 (0.82)
	Maximum	165.72 (8.8)	4.51 x 10^{11} (4,500)	871.66 (28)	2.20 (0.095)	4.52 (0.24)	96.75 (2.73)
	Average	69.42 (3.3)	5.08 x 10^{10} (567.2)	382.39 (18.2)	0.80 (0.039)	2.66 (0.10)	36.34 (1.74)
Summary of Wet Weather Data	Minimum	43.91 (1.6)	8.86 x 10^{10} (330)	466.50 (17)	2.09 (0.035)	3.57 (0.08)	45.83 (1.31)
	Maximum	581 (6.0)	1.31 x 10^{12} (3,400)	3,593.19 (21)	10.61 (0.089)	22.24 (0.27)	224.15 (2.39)
	Average	394.77 (4.2)	6.73 x 10^{11} (1,777.02)	1,733.90 (18.3)	5.81 (0.066)	13.07 (0.146)	171.16 (1.95)
Ratio Between Average Daily Wet Weather and Average Daily Dry weather Transport and Concentration for Each Parameter		5.69 1.27	13.2 3.13	4.53 1.01	7.26 1.69	4.91 1.83	4.71 1.12

Table 48 (continued)

Sampling Dates for Pk-1[c]	Sampling Condition	Biochemical Oxygen Demand: Pounds per Day (mg/l)	Fecal Coliform: Colonies per Day (MFFCC per 100 ml)	Chloride: Pounds per Day (mg/l)	Phosphate Phosphorus: Pounds per Day (mg/l)	Total Phosphorus: Pounds per Day (mg/l)	Total Nitrogen: Pounds per Day (mg/l)
September 7, 1976	Dry	50.39 (2.56)[b]	1.34×10^{11} (1,498)[b]	330.47 (16.79)[b]	0.650 (0.033)[b]	1.063 (0.054)[b]	58.85 (2.99)[b]
September 8, 1976	Dry	87.17 (3.90)[b]	1.15×10^{11} (1,126)[b]	329.68 (14.75)[b]	0.782 (0.035)[b]	2.459 (0.11)[b]	44.70 (2.00)[b]
September 9, 1976	Wet	284.23 (6.0)	5.60×10^{11} (2,600)	568.45 (12)	2.368 (0.050)	5.211 (0.11)	75.32 (1.59)
September 10, 1976	Dry	22.26 (1.0)	5.87×10^{9} (58)	334.02 (15)	1.069 (0.048)	3.563 (0.16)	68.14 (3.06)
September 11, 1976	Dry	25.57 (1.4)	1.25×10^{11} (1,500)	328.76 (18)	1.151 (0.063)	2.009 (0.11)	65.20 (3.57)
September 12, 1976	Dry	14.01 (1.4)	2.64×10^{11} (5,800)	200.16 (20)	0.641 (0.064)	1.001 (0.10)	39.93 (3.99)
September 13, 1976	Dry	106.89 (4.8)	1.22×10^{12} (12,000)	423.09 (19)	1.158 (0.052)	2.672 (0.12)	100.87 (4.53)
September 14, 1976	Dry	71.26 (3.2)	1.01×10^{11} (1,000)	311.75 (14)	0.468 (0.021)	1.336 (0.06)	56.56 (2.54)
September 15, 1976	Dry	42.63 (1.8)	6.78×10^{10} (630)	378.97 (16)	0.829 (0.035)	1.658 (0.07)	77.93 (3.29)
September 16, 1976	Dry	41.70 (2.0)	6.36×10^{10} (670)	291.90 (14)	0.667 (0.032)	1.460 (0.07)	46.29 (2.22)
September 17, 1976	Dry	66.72 (3.2)	1.52×10^{11} (1,600)	333.6 (16)	0.480 (0.023)	3.128 (0.15)	64.22 (3.08)
September 18, 1976	Dry	19.60 (1.0)	1.96×10^{11} (2,200)	293.99 (15)	3.489 (0.178)	4.116 (0.21)	59.38 (3.03)
September 19, 1976	Wet	49.63 (1.73)[b]	8.42×10^{11} (6,459)[b]	469.07 (16.35)[b]	1.234 (0.043)[b]	2.788 (0.097)[b]	103.57 (3.61)[b]
September 20, 1976	Wet	111.19 (4.4)	4.14×10^{11} (3,600)	404.32 (16)	1.112 (0.044)	2.022 (0.08)	80.11 (3.17)
September 21, 1976	Dry	51.04 (3.0)	3.32×10^{10} (430)	238.19 (14)	0.800 (0.047)	1.191 (0.07)	42.70 (2.51)
September 22, 1976	Dry	142.51 (6.4)	6.38×10^{10} (630)	356.28 (16)	0.401 (0.018)	1.113 (0.05)	94.19 (4.23)
September 23, 1976	Dry	41.70 (2.0)	3.89×10^{10} (410)	354.45 (17)	0.521 (0.025)	0.834 (0.04)	71.72 (3.44)
September 24, 1976	Dry	34.09 (2.8)	2.76×10^{10} (500)	182.65 (15)	0.329 (0.027)	0.487 (0.04)	43.96 (3.61)
September 25, 1976	Dry	35.28 (1.8)	4.45×10^{10} (500)	313.58 (16)	0.921 (0.047)	1.764 (0.09)	110.93 (5.66)
September 26, 1976	Dry	47.04 (2.4)	3.03×10^{11} (3,400)	372.38 (19)	1.529 (0.078)	2.940 (0.15)	109.95 (5.61)
September 27, 1976	Dry	57.85 (3.4)	5.72×10^{11} (7,400)	340.27 (20)	2.008 (0.118)	2.382 (0.14)	54.61 (3.21)
September 28, 1976	Dry	29.19 (1.4)	5.89×10^{10} (620)	437.85 (21)	0.897 (0.043)	1.043 (0.05)	82.36 (3.95)
September 29, 1976	Dry	120.55 (6.6)	2.33×10^{10} (280)	310.50 (17)	0.475 (0.026)	0.731 (0.04)	56.25 (3.08)
September 30, 1976	Dry	170.51 (8.7)	4.99×10^{10} (560)	313.58 (16)	0.647 (0.033)	1.372 (0.07)	62.52 (3.19)
October 1, 1976	Dry	156.53 (9.2)	3.56×10^{10} (460)	272.22 (16)	0.221 (0.013)	0.510 (0.03)	30.64 (1.80)
October 2, 1976	Dry	71.46 (4.2)	7.73×10^{10} (1,000)	323.26 (19)	0.459 (0.027)	0.681 (0.04)	12.42 (0.73)
October 5, 1976	Wet	690.13 (6.48)[b]	2.50×10^{12} (5,717)[b]	1,317.43 (12.37)[b]	4.473 (0.042)[b]	11.715 (0.11)[b]	286.49 (2.69)[b]
October 6, 1976	Wet	461.87 (5.2)	1.17×10^{12} (2,900)	1,598.78 (18)	7.550 (0.085)	17.764 (0.20)	179.42 (2.02)
Summary of Dry Weather Data	Minimum	14.01 (1.0)	5.87×10^{9} (58)	182.65 (14)	0.221 (0.013)	0.487 (0.03)	12.42 (0.73)
	Maximum	170.51 (9.2)	1.22×10^{12} (12,000)	437.85 (21)	3.489 (0.178)	4.116 (0.21)	110.93 (5.66)
	Average	65.48 (3.40)	1.64×10^{11} (2,035.39)	320.50 (16.72)	0.895 (0.047)	1.718 (0.088)	63.23 (3.27)
Summary of Wet Weather Data	Minimum	49.63 (1.73)	4.14×10^{11} (2,600)	404.32 (12)	1.112 (0.042)	2.788 (0.08)	75.32 (1.59)
	Maximum	690.13 (6.48)	2.50×10^{12} (6,459)	1,598.78 (18)	7.550 (0.085)	17.764 (0.20)	286.49 (3.61)
	Average	321.08 (4.76)	1.10×10^{12} (4,255)	871.61 (14.94)	3.347 (0.053)	7.900 (0.12)	144.98 (2.53)
Ratio Between Average Wet Weather and Average Dry Weather Transport and Concentrations for Each Parameter		4.90 1.40	2.66 2.09	2.72 0.89	3.74 1.13	4.60 1.36	2.29 0.77

[a] *Insufficient data available to estimate transport on September 7 and October 3 and 4, 1976.*

[b] *For days that multiple samples were collected, the concentrations are flow weighted.*

[c] *Insufficient data available to estimate transport on October 3 and 4, 1976.*

Source: SEWRPC.

from 3.6 to 15.0 cubic feet per second (cfs). Therefore, the substantial increase in the available dilution water was more than offset by the increased quantity of substances carried into the surface waters for these five parameters by direct runoff occurring as overland flow, through the storm sewer system, or from the inflow of shallow groundwaters. Instream chloride concentrations did not show any significant change from wet weather to dry weather conditions.

Transport: The instream transport of all six parameters increased on the wet weather day to a level ranging from 2.2 times the average dry weather transport for total nitrogen at Pk-1, to 13 times the average dry weather transport for fecal coliform bacteria at Pk-A. As shown in Figure 32, the ratios of wet to dry weather transport are much greater than the ratios of wet to dry weather concentration.

Concluding Statement: The September and early October 1976 surveys at the two sample locations in the Pike River watershed indicated water quality conditions satisfying the established temperature standards in all instances, whereas dissolved oxygen standards were violated more than 40 percent of the time. About 63 percent of the dry weather fecal coliform samples were greater than 400 MFFCC/100 ml and 34 percent of the dry weather total phosphorus concentrations exceeded the established standards, whereas all of the wet weather—rainfall and snowmelt—fecal coliform and phosphorus concentrations exceeded the standards.

During a rainfall runoff event, the instream concentrations of biochemical oxygen demand, fecal coliform bacteria, phosphate, total phosphorus, and total nitrogen were found to be up to three times greater than during dry weather periods. The data suggest that violations of instream water quality standards in the Pike River watershed related to these constituents are more likely to occur during wet weather than dry weather conditions. During a rainfall runoff event, average daily transport of the above five consitutents, plus chloride, to the Pike River estuary were up to 13 times greater than during dry weather periods.

Concluding Remarks—Surface Water Quality Studies

Certain observations may be made and conclusions drawn based on the water quality data presented in the preceding sections of this chapter. Some characteristics of dry and wet weather water quality processes in the watershed may be identified and an overall assessment may be made as to the degree to which established water quality standards are satisfied within the watershed. More particularly, the following observations and conclusions are based on the historic monitoring studies in the Pike River watershed supplemented with analyses of data and information drawn from studies of other watersheds.

- Substandard water quality conditions, associated with high concentrations of pollutants, are more likely to occur during wet weather conditions than during dry weather conditions and are attributable 1) to the accumulation of pollutants on the land surface between rainfall and snowmelt events, and the subsequent transport from the land surface of pollutants to the stream system by rainfall and snowmelt runoff, and 2) to the resuspension of polluted streambed sediments by the high stream velocities which occur during runoff periods. It has been noted, however, that the increased oxygen demanding substances are initially offset by the high dissolved oxygen content of runoff waters, by increased aeration due to turbulence, and by other factors affecting the surface water system as shown by a consistant increase in dissolved oxygen concentration during and immediately following precipitation activity.

- The substantial increase in available dilution water during a rainfall or snowmelt runoff event is usually more than offset by the increased quantity of potential pollutants carried into the surface water by direct runoff to the stream system which may occur as overland flow, through storm sewer and channel systems, or from shallow subsurface groundwater inflow. One known exception is the concentration level of chloride which did not exhibit a marked increase during the rainfall events which were recorded in October.

- The ratio of wet weather to dry weather transport is significantly greater than the ratio of wet weather to dry weather concentration because of the dilution effect in the case of the latter. That is, wet weather conditions generally have a much greater impact on the mass of pollutants transported from the watershed to the harbor estuary area and to Lake Michigan than on the concentration of pollutants being transported.

- The temperature standard, which specifies that surface water temperatures be less than or equal to 89°F, appears to be met virtually all of the time in the Pike River watershed under both dry weather and wet weather conditions.

- The pH standard, which specifies that pH be within a range of 6.0 to 9.0 standard units, appears to be met virtually all of the time in the watershed during both dry and wet weather conditions. Only one dry weather sample on Waxdale Creek, recording a pH of 9.1, was found to exceed the standard range.

- The dissolved oxygen standard, which specifies a concentration greater than or equal to 5.0 milligrams per liter, appears to be met about 80 percent of the time during both dry and wet weather conditions in downstream reaches of the Pike River watershed. This suggests that the oxygen demand exerted by organic matter washed from the land surface during rainfall and snowmelt runoff events is initially offset by oxygen entrained in the storm water runoff. Upstream reaches of Pike River and Pike Creek have generally lower dissolved oxygen levels, probably due to the discharges from the Village of Sturtevant and Town of Somers wastewater treatment facilities and from bottom sediment oxygen demand. The dissolved oxygen levels in these upstream reaches are generally increased following storm events, indicating that the depressed instream oxygen concentrations caused by sewage treatment plant effluent are less than the oxygen concentrations in surface water runoff. The oxygen concentrations in runoff are maintained or enhanced by the higher stream reaeration coefficients which generally occur during high flow periods.

- The fecal coliform standard, which specifies a fecal coliform count not exceeding 400 MFFCC/100 ml, appears to be exceeded in the watershed about 56 percent of the time during dry weather conditions and virtually all of the time during wet weather conditions.

- The total phosphorus standard of 0.1 milligram per liter appears to be satisfied about 80 percent of the time during dry weather conditions but is violated almost all of the time during wet weather conditions within the watershed.

- The ammonia nitrogen standard is expressed as 0.02 mg/l of un-ionized ammonia, a level determined to be toxic to fish and aquatic life. Measured ammonia nitrogen, stream temperature, and pH are used for determining the instream concentration of un-ionized ammonia. Sample data collected in August from 1972 through 1975 on Pike River and Pike Creek indicated no violations of the ammonia nitrogen standard. The standard was violated about 10 percent of the time during low flow periods in the upstream portion of the watershed below the Sturtevant sewage treatment plant.

- Ammonia nitrogen concentrations and concentrations of other nitrogen forms may be expected to increase or decrease during wet weather conditions depending on the magnitude of the base flow nitrogen concentration which could be significantly higher or lower than the nitrogen concentration of surface runoff. The base flow concentrations are characteristically high in Pike River upstream of the confluence with Pike Creek and low in Pike Creek and the downstream reaches of the Pike River.

- Chloride concentrations in the surface waters of the Pike River watershed are generally high due to the presence of two municipal sewage treatment facilities. The chloride concentration is not significantly affected by wet weather conditions. Sample data were not recorded during periods of snowmelt, at which time it is possible that an increase in chloride loading could occur due to wash-off of accumulations of de-icing salt along roadways. It is further noted that during precipitation events, the transport loading of chloride does increase by 200-400 percent.

- The concentrations of heavy metals in the Pike River watershed were found to be generally within the limits of the recommended standards based on the limited data available. However, one sample did indicate a possible excessive instream concentration of mercury, recording a level of 2.2 ug/l compared to a recommended standard of 0.05 ug/l.

- The available sample data were not adequate to establish the presence of a PCB pollution problem because the recommended PCB standard of 0.001 mg/l is much lower than the determinant capability of the laboratory procedure used in collecting the available data—0.05 mg/l.

- The benthic community of the Pike River watershed is composed primarily of large populations of pollution-tolerant species, which are generally indicative of polluted conditions.

- Of the eight potential types of surface water pollution—toxic, organic, nutrient, pathogenic, thermal, sediment, radiological, and aesthetic—all but thermal and radiological pollution are known to exist to some degree in the Pike River watershed.

- The surface waters of the Pike River watershed generally do not meet the established water use objectives. Although the levels of some critical parameters such as pH and temperature are met most of the time, other parameters such as dissolved oxygen, phosphorus, amonia nitrogen and fecal coliform levels are in excess of recommended standards at least some of the time.

- Violations of the water quality standards associated with the warmwater fishery water use objective have been documented in the upstream reaches of the Pike River and Pike Creek. These violations are related to dissolved oxygen levels caused by oxygen demanding materials in bottom sediments as well as organic and ammonia nitrogen in sewage treatment plant discharges during periods of low flow.

- The recreational water use objective is not satisfied in the Pike River watershed primarily due to fecal coliform bacteria present in the surface waters and also due to nutrient concentrations in excess of the recommended standards, which provide the potential for aquatic weed growth.

POLLUTION SOURCES

An evaluation of water quality conditions in the Pike River watershed must include an identification, characterization and, where feasible, quantification of known pollution sources. This identification, characterization and quantification of pollution sources is intended to aid in determining the probable causes and sources of the water pollution problems discussed earlier in this chapter. The following types of pollution sources have been identified in the watershed and are discussed below: municipal and private sewage treatment facilities, sanitary sewer system overflows, industrial wastewater discharges, and urban and rural storm water runoff.

The schematic representation of the average annual volume of water passing through various paths in the hydrologic cycle of the Pike River watershed is shown in Figure 33. The hydrologic budgets were prepared using the hydrologic simulation model described in Chapter VIII of this report, supplemented with municipal, private and industrial point source discharge data collated from the Wisconsin Pollution Discharge Elimination System (WPDES). The flow associated with each of the above pollution sources reaches the surface water of the watershed by one or more of the flow paths shown in Figure 33. For example, pollutants discharged from storm sewer outfall points will be transported as wet weather flow and surface runoff to the stream system. Diffuse source pollutants will move along both the wet weather and dry weather—groundwater—routes from their point of origin to the stream system.

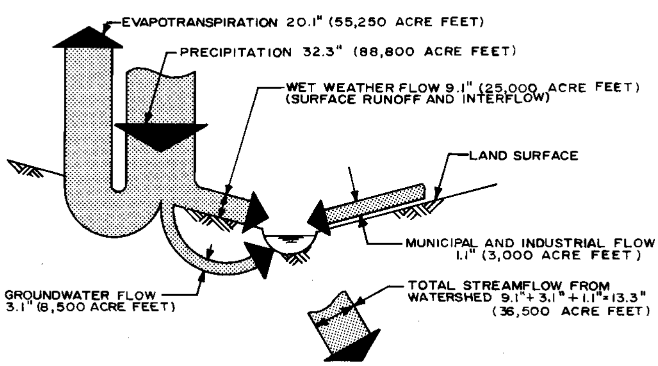
Point Source Pollution

Point source pollution is defined as pollution which is discharged to the surface waters at discrete locations. Examples of such discrete discharge points include sanitary sewerage system flow relief devices, sewage treatment plant discharges, and industrial discharges. The point sources existing within the watershed as of 1979 are located on Map 34.

Municipal Sewage Treatment Facilities: Two municipal sewage treatment facilities exist in the Pike River watershed: The Village of Sturtevant sewage treatment plant and the Town of Somers Sewer Utility District No. 1 sewage treatment plant. The Village of Sturtevant treatment plant was scheduled for abandonment, with the tributary service area to be connected to the City of

Figure 33

AVERAGE ANNUAL HYDROLOGIC BUDGET FOR THE PIKE RIVER WATERSHED: 1979 CONDITIONS



Source: SEWRPC.

Racine sewerage system in March 1980. In addition, two private wastewater treatment facilities were recently abandoned within the watershed. The Saint Bonaventure Seminary private treatment facility in the Village of Sturtevant was abandoned in December of 1979 and the seminary service area was connected to the Village of Sturtevant sanitary sewerage system. The American Motors Corporation private wastewater treatment facility in the Town of Somers was abandoned in October of 1977 and the wastewater is now discharged to a 10,000 gallon holding tank that is serviced by a private waste hauler.

The following descriptions of the municipal sewage treatment plants operating in the watershed include data and information about the location of the facilities, the manner in which they are financed and operated, the history of their construction and subsequent development, the size and characteristics of their service areas, the level of treatment and the type of treatment processes, the hydraulic capacity of the facilities, and the quality of their discharges. Recommendations in the adopted regional water quality management plan[8] concerning each plant are discussed, as are the steps that have been or will be undertaken to accomplish those recommendations. The base year for the data on the sewage treatment facilities is 1979.

Village of Sturtevant Sewage Treatment Plant: As shown on Map 34, the Village of Sturtevant sewage treatment plant is located adjacent to the Chicago, Milwaukee, St. Paul & Pacific Railroad right-of-way and Waxdale Creek in the Village of Sturtevant. Selected information for this treatment facility is set forth in Table 49. Management of the Village of Sturtevant sanitary sewer system is under the direction of the Village Board. Day to day administration of the system is provided by the water and sewer committee of the Board together with the staff of the Village Department of Public Works. Financing of the system is provided through a sewer service charge. The charge ranges from $6.15 for a 5/8-inch water meter to $12.20 for a 1-1/2-inch meter with a $0.77 per 1,000 gallon volume charge on a quarterly basis. Following connection of the Sturtevant collection system to the City of Racine wastewater treatment facility, the Village will increase the sewer service charge to a quarterly base charge of $13.40 with an additional $1.35 per 1,000 gallon volume charge.

Service Area: In 1979 the Sturtevant Facility served about 4,600 persons residing in a 0.83-square-mile service area as shown on Map 8. The entire area tributary to the Sturtevant facility is served by a separate sanitary sewer system.

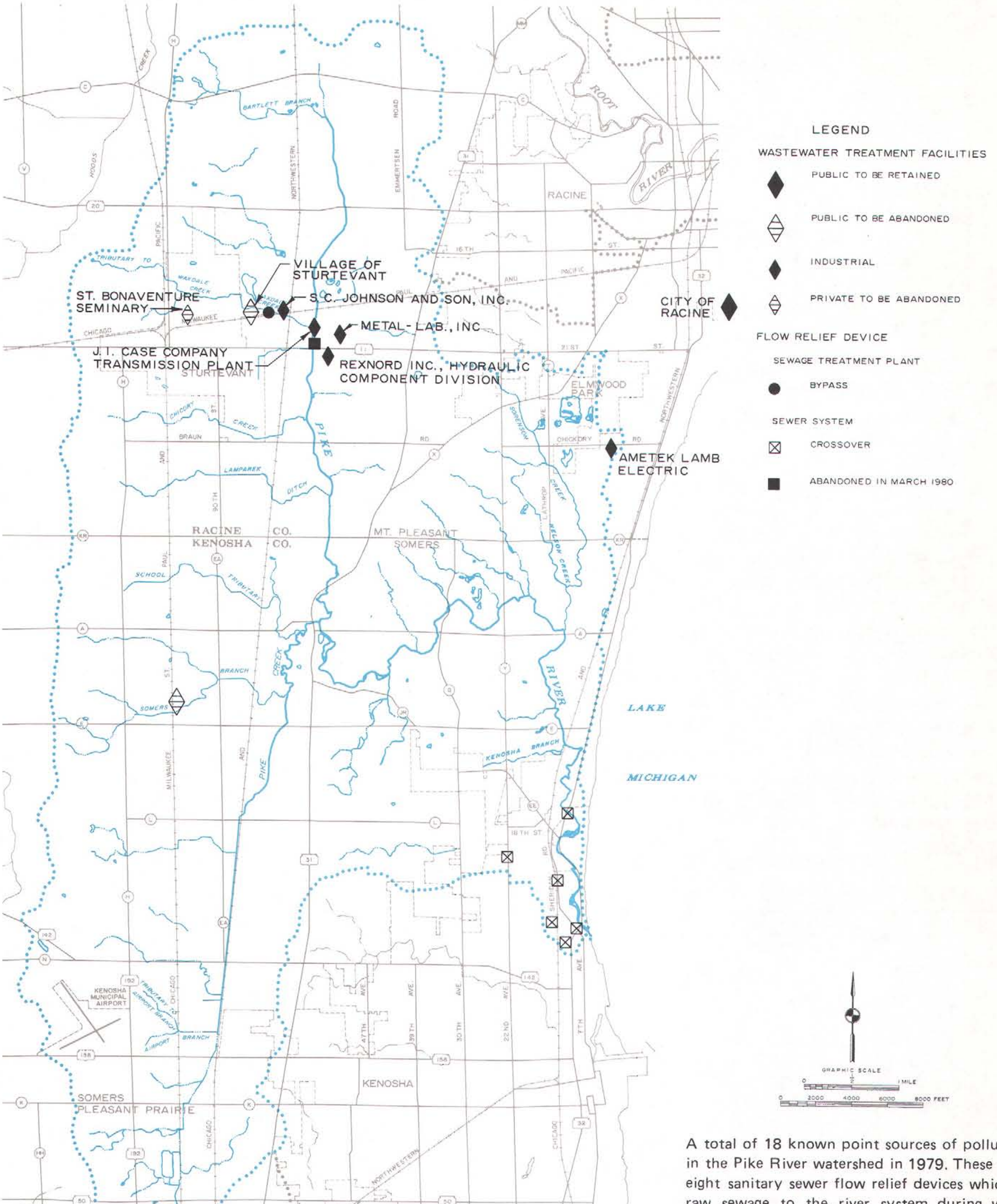
Type and Level of Treatment and Receiving Stream: The treatment plant incorporates primary and secondary waste treatment processes and advanced treatment for phosphorus removal, and provides auxiliary waste treatment for effluent disinfection. Wastewater treatment unit processes incorporated into the plant include primary sedimentation, trickling filter, final clarification, chemical treatment for phosphorus removal and chlorination. Sludge solids removed from the secondary clarifer are returned to the comminutor wet well. Sludge solids removed from the primary clarifer are wasted to an anaerobic digestion system and pumped to sludge storage lagoons prior to application as a liquid on agricultural lands. The treated effluent from the plant is discharged to Waxdale Creek in the southwest one-quarter of U. S. Public Land Survey Section 22, Township 3 North, Range 22 East.

The plant has an average hydraulic design capacity of 0.30 million gallons per day (mgd), a peak hydraulic design capacity of 0.50 mgd, and an

[8] *See SEWRPC Planning Report No. 30, A Regional Water Quality Management Plan for Southeastern Wisconsin: 2000.*

Map 34

POINT SOURCES OF POLLUTION IN THE PIKE RIVER WATERSHED: 1979



A total of 18 known point sources of pollution existed in the Pike River watershed in 1979. These consisted of eight sanitary sewer flow relief devices which discharge raw sewage to the river system during wet weather and/or mechanical failure of pumping facilities, two municipal sewage treatment plants, and eight outfalls which discharge primarily noncontact cooling waters from five industrial sources.

Source: SEWRPC.

Table 49

SELECTED CHARACTERISTICS OF PUBLIC SEWAGE TREATMENT FACILITIES IN THE PIKE RIVER WATERSHED: 1979

Name	Estimated Total Area Served (square miles)	Estimated Total Population Served	Dates of Original Construction and Major Modifications	Treatment Provided		Receiving Stream	Design Capacity				
										Average Organic	
				Type	Level		Population[a]	Average Hydraulic (mgd)	Peak Hydraulic (mgd)	Pounds BOD_5/Day	Population Equivalent[a]
Village of Sturtevant	0.83	4,600	1959 1974	Trickling Filter Phosphorus Removal Disinfection	Secondary Advanced Auxilliary	Waxdale Creek	2,500	0.30	0.50	425	2,025
Town of Somers Utility District No. 1	0.29	900	1964 1978	Activated Sludge Disinfection	Secondary Auxilliary	Somers Branch of Pike Creek	N/A	0.13	0.29	210	1,000

NOTE: N/A indicates data not available.

[a]The population design capacity for a given sewage treatment facility was obtained directly from engineering reports prepared by or for the local unit of government operating the facility and reflects assumptions made by the design engineer. The population equivalent design capacity was estimated by the Commission staff by dividing the design BOD_5 loading in pounds per day, as set forth in the engineer reports, by an estimated per capita contribution of 0.21 pound of BOD_5 per day. If the design engineer assumed a different daily per capita contribution of BOD_5 the population equivalent design capacity will differ from the population design capacity shown in the table.

Source: SEWRPC.

organic design capacity of 425 pounds of five-day biochemical oxygen demand (BOD_5) per day. During 1979, the average annual and maximum monthly hydraulic loadings to the plant—including wet weather flow that was allowed to bypass the treatment plant—were reported to be 0.73 and 1.72 mgd respectively, while the average annual and maximum monthly organic loadings were determined to be 828 and 1,052 pounds of BOD_5 per day respectively, indicating that the plant is operating substantially above its design capacity. Bypassing was reported in February, March, April, and May of 1979.

Recommendations of the Regional Water Quality Management Plan and Implementation Status: The adopted regional water quality management plan recommends the abandonment of the Village of Sturtevant wastewater treatment facility and connection of the tributary collection system to the City of Racine wastewater treatment facility. The trunk sewer that will accomplish this connection is currently under construction and is to be completed in March of 1980.[9]

[9]*On March 28, 1980, the trunk sewer to Racine was completed and the Village of Sturtevant sewer service area was connected to the Racine system, with the concomitant abandonment of the Sturtevant sewage treatment plant.*

Town of Somers Utility District No. 1 Wastewater Treatment Facility: As shown on Map 34, the Town of Somers Utility District No. 1 sewage treatment plant is located adjacent to the Somers Branch of Pike Creek and immediately east of the Chicago, Milwaukee, St. Paul & Pacific Railroad right-of-way in the Town of Somers. Selected information for this treatment facility is set forth in Table 49. Management of the Town of Somers Utility District No. 1 sanitary sewerage system is under the direction of the Town Board. Day to day administration of the system is also provided directly by the board members. Financing of the system is provided in part through a quarterly service charge of $30.00 per residential sewer connection and in part through the District tax levy.

Type and Level of Treatment and Receiving Stream: The plant incorporates primary and secondary waste treatment processes, as well as auxiliary waste treatment for effluent disinfection. The plant was expanded in 1978 providing a similar level of treatment with an additional 100,000 gallons per day capacity. Wastewater treatment unit processes incorporated into the plant include extended aeration, activated sludge, final clarification, and disinfection. Sludge solids removed from the clarifier are transported to sludge lagoons for storage prior to transfer to the City of Kenosha treatment plan for final treatment. The comprehensive plan for the Kenosha Planning District recommended that this sewage treatment facility be abandoned and its sewer service area connected to the City of Kenosha sanitary sewerage system as trunk sewer service becomes available.

The plant has an average hydraulic design capacity of 0.13 mgd, with a peak hydraulic design capacity of 0.29 mgd and an organic capacity of 210 pounds of BOD_5 per day. During 1979, the average annual and maximum monthly hydraulic loadings to the plant were reported to be 0.13 and 0.32 mgd respectively, while the average annual and maximum monthly organic loadings were determined to be 158 and 275 pounds of BOD_5 per day, indicating that the plant is currently operating over the average design capacity. There was no reported effluent bypassing activity from the Somers plant in 1979. The treated effluent from the plant is discharged to Somers Branch in the Southeast one-quarter of U. S. Public Land Survey Section 9, Township 2 North, Range 22 East.

Recommendations of the Regional Water Quality Management Plan and Implementation Status: The adopted regional water quality management plan recommends the eventual abandonment of the Town of Somers Utility District No. 1 facility and connection to the City of Kenosha wastewater collection system. Construction of the trunk sewer connection is currently underway and is being completed in segments extending north from the Kenosha wastewater treatment facility. In 1979 a connecting trunk sewer was completed by the City of Kenosha to 18th Street and 26th Avenue extended with the remainder of the sewer to continue north and follow the general drainage pattern of the Pike River and Pike Creek to the Somers Branch of Pike Creek where the connection will be completed. As of 1979 about 5.7 miles of the 11.8 mile trunk sewer were completed and in service. The regional water quality management plan recommends that the portion of the trunk sewer project to the Town of Somers Utility District No. 1 be completed by 1990 and that District's sewage plant be abandoned at that time.

Quantity and Quality of Municipal Point Source Discharges: Data presented on the quantity and quality of municipal waste discharges were obtained from the 1979 monthly reports prepared as part of the Wisconsin Pollution Discharge Elimination System permit process. That data indicate that the average annual total volume contributed by municipal sources to the surface waters of the Pike River watershed is 0.86 million gallons per day—equivalent to an estimated 0.35 inch of water annually over the land surface of the watershed. In 1975 this wastewater source contributed an estimated 70,000 pounds of suspended solids, 64,020 pounds of biochemical oxygen demand, 4,620 pounds of total phosphorus, 24,070 pounds of total nitrogen, and 13,000,000 counts of fecal coliform to the surface waters of the watershed. A comparison of the average annual transport of these substances from the watershed as presented later in this chapter indicates that the annual contribution from municipal point sources of these constituents constitutes less than 0.1, 5.0, 6.5, 4.1, and 51.3 percent respectively of the total average annual transport from the watershed.

As indicated in Figure 33, the average annual flow from the Pike River watershed, including point source discharge, is equivalent to 13.30 inches over the land surface of the watershed, with 1.15 inches being contributed by point sources. The annual contribution of the municipal discharges including the Sturtevant and Somers municipal sewage treatment plants is equivalent to 0.35 inch, or 30 percent of the total point source flow contribution and about 3 percent of the total average annual hydraulic budget.

Sanitary Sewerage System Flow Relief Points: In addition to sewage treatment plant effluent, raw sanitary sewage enters the surface water system of the Pike River watershed either directly from sanitary sewer overflows or indirectly via flow relief devices to separate storm sewer systems. This direct or indirect conveyance of sanitary sewage to the watershed's surface water system occurs through various types of flow relief devices as a result of one or more of the following conditions: inadequate sanitary sewage conveyance facilities, excessive infiltration and inflow of clear water during wet weather conditions, and mechanical and/or power failures at sanitary sewage pumping facilities.

In order to prevent damage to residential dwellings or the mechanical elements of the conveyance system due to one of the aforementioned system failures, a sanitary sewage flow relief device is provided.

Flow Relief Devices-Types and Characteristics: The four types of flow relief devices usually found in municipal sanitary sewerage systems—crossovers, bypasses, relief pumping stations, and portable pumping stations—may be defined as follows:

1. Crossover—A flow relief device by which sanitary sewers discharge a portion of their flow, by gravity, into storm sewers during periods of sanitary sewer surcharge; or by which combined sewers discharge a portion of their flow, by gravity, into storm sewers to alleviate sanitary or combined sewer surcharge.

2. Bypass—A flow relief device by which sanitary sewers entering a lift station, pumping station, or sewage treatment plant can discharge a portion or all of their flow, by gravity, into a receiving body of surface water to alleviate sewer surcharge. Also, a bypass is a flow relief device by which trunk, main and lateral sewers can discharge a portion or all of their flow by gravity into a receiving body of surface water to alleviate intercepting or main sewer surcharge.

3. Relief Pumping Station—A flow relief device by which flows from surcharged trunk or main sewers are discharged into storm sewers or directly into a receiving body of surface water through the use of permanent lift or pumping stations.

4. Portable Pumping Station—A point of flow relief device at which flows from surcharged sanitary sewers are discharged into storm sewers or directly into a receiving body of surface water through the use of portable pumping units.

Of the four types of sanitary sewerage system flow relief devices, the sanitary sewerage system bypass always discharges directly to surface waters and therefore is located near rivers and streams. Crossovers always convey flow from a sanitary sewer to a storm sewer and, therefore, need not be located near rivers and streams but may be found anywhere in the sewered portions of urban areas. Because relief and portable pumping stations may convey flow either to storm sewers or directly to surface waters, these two flow relief devices may also be found anywhere in the sewered portions of urban areas. The single most important aspect of these flow relief devices is that each provides a mechanism whereby raw sanitary sewage can be discharged directly to the surface waters of a watershed, thereby posing a surface and groundwater pollution threat in general, and a severe public health hazard in particular.

Number and Location of Flow Relief Devices in the Watershed: As discussed in Chapter IX, the Wisconsin Pollution Discharge Elimination System (WPDES) has been established by Wisconsin Statutes Chapter 147. This operational permit system provides a good source of information concerning the number, type, and location of the two types of sanitary sewer system relief points found in the Pike River watershed. In addition, information was also obtained from the Infiltration/Inflow Analysis for the City of Kenosha Service Area: 1977.

Table 50 summarizes by receiving stream and sewerage system the type and number of flow relief devices in the watershed. The spatial distribution of these devices is shown on Map 34. A total of eight flow relief devices are known to exist in the Pike River watershed—one of which bypasses a sewage treatment plant, one bypasses a sewage pump station, and six allow sanitary sewage to crossover from the sanitary sewerage system into the storm sewerage system.

Although the Pike River watershed includes portions of the urbanized areas of the Cities of Racine and Kenosha, there are no known combined sewer overflows from the sewerage systems of these communities to the surface waters of the watershed. None of the area of the watershed is served by combined sewers.

Quantity and Quality of Flow Relief Device Discharges: The average annual discharge from the six crossovers and two bypasses directly or indirectly to the Pike River watershed surface waters is estimated to be a relatively small volume, only 3 percent of the total point source flow contribution to the average annual hydrologic budget. The single sewage treatment plant bypass contribution has been considered in the previous municipal point source portion of this chapter. The average annual discharge of a typical flow relief device within the Region has been estimated to total 2 million gallons.[10] Therefore, the average annual flow contributed by the seven flow relief devices not associated with a municipal sewage treatment plant bypass in the Pike River watershed is estimated at

[10] *See Chapter III of SEWRPC Technical Report No. 21, Sources of Water Pollution in Southeastern Wisconsin: 1975.*

Table 50

KNOWN SEWAGE FLOW RELIEF DEVICES IN THE PIKE RIVER WATERSHED: 1979

Receiving Stream	Sanitary Sewer System	Sewage Treatment Plant Flow Relief Device	Sewage Flow Relief Devices in the Sewer System[a]					Total
			Crossovers	Bypasses	Relief Pumping Stations	Portable Pumping Stations	Combined Sewer Outfalls	
Pike River	City of Kenosha	--	6	--	--	--	--	6
Waxdale Creek	Village of Sturtevant	Bypass[b]	--	--	--	--	--	1
Pike River	Town of Mt. Pleasant	--	--	1[b]	--	--	--	1
Total		1 Bypass	6	1	--	--	--	8

[a] *Based on Wisconsin Pollution Discharge Elimination System Permits, 1979.*

[b] *The Village of Sturtevant sewage treatment plant bypass in the Village of Sturtevant and the Creuziger lift station bypass in the Town of Mt. Pleasant were abandoned upon completion of the Sturtevant to Racine trunk sewer in March of 1980.*

Source: Wisconsin Department of Natural Resources, Infiltration/Inflow Analysis for Kenosha Service Area, and SEWRPC.

14 million gallons, or approximately 4 percent of the total sanitary sewage generated within the watershed in 1979.

A review of the data available[11,12] on the quality of discharges from crossovers, bypasses, and relief and portable pumping stations supports an assumption that the wastewaters discharged are generally characterized by an average concentration of 30 mg/l of suspended solids, 30 mg/l of biochemical oxygen demand, 1 mg/l of total phosphorus, 3 mg/l of total nitrogen, and 100,000 fecal coliform colonies per 100 ml. These concentrations compare respectively to 155 mg/l of suspended solids, 130 mg/l of biochemical oxygen demand, 10.5 mg/l of total phosphorus, 20 mg/l of total nitrogen, and extremely high and variable levels of fecal coliform in raw sanitary sewage. Although these concentrations represent average pollutant levels for the entire period that discharge occurs through a flow relief device, much higher concentrations are likely to occur at the beginning of the discharge event because of the first flush of solids accumulated in the sanitary sewers.

Applying these concentrations to the 1975 estimated total flow relief device discharge of 15 million gallons per year results in average annual contributions of suspended solids, biochemical oxygen demand, total phosphorus, and total nitrogen to the surface waters of, respectively, 3,750, 3,750, 130, and 380 pounds and an average of 5.7×10^{13} fecal coliform counts. A comparison of these loads with the average annual transport of the same substances from the watershed—as presented later in this chapter under the subtopic of "nonpoint source pollution"—indicates that the annual contribution from crossovers and bypasses of these chemical and biological constituents constitutes less than 1 percent of the average annual transport of suspended solids, biochemical oxygen demand, total phosphorus and total nitrogen, and 2 percent of the average annual transport of fecal coliform bacteria from the watershed. Therefore, the pollution load contributed by flow relief devices is small compared to the pollution load contributed by other sources in the watershed. However, as noted in the following paragraphs, this source of pollution is a significant problem which should be eliminated.

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[11] *See SEWRPC Planning Report No. 26, A Comprehensive Plan for the Menomonee River Watershed, Volume Two, Alternative Plans and Recommended Plan, October 1976.*

[12] *See SEWRPC Technical Report No. 21, Sources of Water Pollution in Southeastern Wisconsin: 1975.*

Concluding Statement: Significance of Flow Relief Devices: While the above analyses indicate that the flow relief devices contribute a relatively small portion of the total pollution load to the surface waters of the Pike River watershed, pollutant concentrations from such flow relief devices constitute serious 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 raw human waste in the streams, particularly in an urban area, constitute a disgusting and 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 public health hazards and aesthetic nuisance conditions 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 are symptomatic of sanitary sewers being surcharged by excess sanitary sewage flows not anticipated in the design of the system; of excessive clear water entering the system during rainfall-snowmelt events as inflow through flooded manhole covers and through downspouts, footing tile drains, and sump pump discharge lines connected directly to the sanitary sewer system; and of groundwater infiltration through cracked or broken joints, pipes, and manhole walls.

The presence of extensive amounts of sewage and/or clearwater in the sanitary sewer system may cause basement flooding as sanitary sewers backup into basements and may also cause hydraulic overloads at sewage treatment plants. The latter condition necessitates the bypassing of untreated sewage and sometimes leads 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 public officials charged with the responsibility of operating sewage treatment facilities so as to provide adequate treatment while protecting costly equipment from damage.

Consequently, a reduction in the frequency of operation and, to the extent possible, the elimination of flow relief devices is desirable. Some steps toward the solution of sanitary sewerage bypass problems are: 1) eliminate excessive wet weather clearwater infiltration and inflow to the sanitary sewer system; 2) provide additional capacity at locations where the hydraulic capacity of the sanitary sewer system is not adequate to handle residual extreme wet weather flow condition problems; and 3) provide a backup power supply at sanitary sewerage pump stations to insure that, in the event of power failure for extended periods of time, it would not be necessary to bypass raw sewage to surface waters or to back raw sewage into the basements of buildings.

In summary, while flow relief devices may not contribute a significant proportion of the total pollution loading to the Pike River relative to other pollution sources, the identification and elimination of all potential sanitary sewage bypass situations in the system to the greatest extent practicable are important for the following reasons: flow relief devices are likely to constitute severe public 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 entering into the sanitary sewer system and creating potential basement flooding, attendant health hazards, and hydraulic overloads at sewage treatment facilities.

Industrial Discharges: There are five industrial plants with wastewater outfalls that discharge wastewater to the surface waters of the Pike River watershed. However, these all discharge only spent cooling waters either directly or indirectly to the surface water system. These spent cooling waters enter the Pike River and its major tributaries as direct discharge or via a storm sewer system. These discharges are of concern primarily because they may contain excessive heat, or may contain toxic substances as well as other pollutants that have a potential to cause problems in the surface waters.

Number and Location of Industrial Discharges: As described in Chapter IX, the Wisconsin Pollution Discharge Elimination System (WPDES) has been

Table 51

SELECTED INFORMATION ON KNOWN INDUSTRIAL WASTEWATER OUTFALLS IN THE PIKE RIVER WATERSHED BY RECEIVING STREAM AND CIVIL DIVISION: 1979

Name	Receiving Stream	Civil Division	Number of Cooling Water Outfalls	Reported Average Annual Hydraulic Discharge Rate (gallons/day)	Reported Wastewater Discharge Characteristics[a]			
					BOD_5 (mg/l)	Suspended Solids (mg/l)	Total Phosphorus (mg/l)	Total Nitrogen (mg/l)
Ametek-Lamb Electric	Sorenson Creek via storm sewer	Town of Mt. Pleasant	2	21,000	3.9	8.4	0.0	N/A
J. I. Case Company Transmission Plant	Pike River	Town of Mt. Pleasant	1	430,000	2.1	3.2	0.16	N/A
Rexnord, Incorporated Hydraulic Component Division	Pike River	Town of Mt. Pleasant	1	120,000	26.3	45.0	18.6	N/A
S. C. Johnson & Son, Inc.	Waxdale Creek	Town of Mt. Pleasant	3	1,365,000	- -[b]	- -[b]	- -[b]	- -[b]
Metal-Lab., Incorporated	Pike River via storm sewer	Town of Mt. Pleasant	1	288	- -[c]	- -[c]	- -[c]	- -[c]

Name	Reported Wastewater Discharge Characteristics[a]										
						Heavy Metals					
	Fecal Coliform Bacteria (number per 100 ml)	Sulfate (mg/l)	Chloride (mg/l)	Oil and Grease (mg/l)	Temperature °C	Total Chromium (mg/l)	Total Copper (mg/l)	Total Lead (mg/l)	Total Manganese (mg/l)	Total Nickel (mg/l)	Total Zinc (mg/l)
Ametek-Lamb Electric	N/A	0.0	0.0	N/A	22	0.00	0.00	0.00	0.00	0.00	0.00
J. I. Case Company Transmission Plant	N/A	45	30	16.5	20	N/A	N/A	N/A	N/A	N/A	N/A
Rexnord, Incorporated Hydraulic Component Division	N/A	136.5	21.7	27.0	18	0.01	0.09	0.01	1.07	0.01	0.17
S. C. Johnson & Son, Inc.	- -[b]	- -[b]	- -[b]	- -[b]	15	- -[b]	- -[b]	- -[b]	- -[b]	- -[b]	- -[b]
Metal-Lab., Incorporated	- -[c]	- -[c]	- -[c]	- -[c]	- -[c]	- -[c]	- -[c]	- -[c]	- -[c]	- -[c]	- -[c]

NOTE: N/A indicates data not available.

[a] *Based on 1979 industrial effluent reporting forms on file with the Wisconsin Department of Natural Resources as required under Section NR101 of the Wisconsin Administrative Code.*

[b] *Temperature is the only reported wastewater discharge characteristic as this cooling water contains no significant amount of any other pollutant parameter.*

[c] *Operations at this industry result in the discharge of a small amount of noncontact cooling water free of chemical additives.*

Source: Wisconsin Department of Natural Resources and SEWRPC.

established by the Wisconsin Department of Natural Resources in order to monitor and control point sources of pollution throughout the state. Data provided by this system were used to determine the type and location of industrial discharges in the Pike River watershed.

Table 51 summarizes by receiving stream and civil division the number of industrial wastewater outfalls in the watershed and their respective discharge characteristics and Map 34 illustrates their location in the watershed. Of the total of five industries discharging wastewaters through the eight outfalls known to exist in the watershed, Table 51 indicates that all of the outfalls discharge noncontact spent cooling waters. Five of the eight industrial wastewater outfalls discharge directly to the surface waters of the Pike River watershed.

Quantity and Quality of Industrial Discharges: Data presented on industrial discharges are 1979 data from the annual report of the Wisconsin

Pollution Discharge Elimination System. Table 51, which was prepared using that data base, indicates that the average annual total volume of discharge contributed by industrial sources to the surface waters of the Pike River watershed is 1.94 million gallons per day, equivalent to 0.79 inch of water annually over the land surfaces of the watershed.

The average annual flow from the Pike River watershed including point source discharge is equivalent to 13.3 inches over the land surface of the watershed, with 1.15 inches being contributed by point sources. The annual contribution of the five industrial plant discharges is equivalent to 0.79 inch, or 67 percent of the total point source flow contribution and 9 percent of the total average annual hydraulic budget.

The concentrations of pollutants and the quantity of discharge from industrial point sources may be expected to exhibit a wide variation from source to source and, in some cases, from time to time at a given source. For the Pike River watershed, however, all point source discharges are noncontact cooling water that normally contain and transmit insignificant amounts of pollutants to the surface waters. Therefore, the annual pollutant load contributed by the five industrial point sources in the Pike River watershed is small compared to the annual pollutant load contributed by other sources in the basin.

Nonpoint Source Pollution

Definition and Characteristics of Nonpoint Source Pollution: Nonpoint source pollution, also referred to as diffuse source pollution, consists of various discharges of pollutants to the surface waters which cannot be readily identified as point sources. Nonpoint source pollution is transported from the rural and urban land areas of a watershed to the surface waters by means of direct runoff from the land via overland routes, via storm sewers and channels, and by interflow during and shortly after rainfall or rainfall-snowmelt events. Nonpoint source pollution also includes pollutants conveyed to the surface waters via groundwater discharge—baseflow—which is a major source of streamflow between runoff events.

The distinction between point and nonpoint sources of pollution is somewhat arbitrary since a nonpoint source pollutant, such as sediment being transported in overland rainfall runoff, can be collected in open channels or in storm sewers and conveyed to points of discharge, such as a storm sewer outfall. Thus, for purposes of this report, nonpoint source pollution includes substances washed from the land surface or subsurface by rainfall and snowmelt runoff and then conveyed to the surface waters by that runoff, even though the entry into the surface waters may be through a discrete location such as a storm sewer outfall.

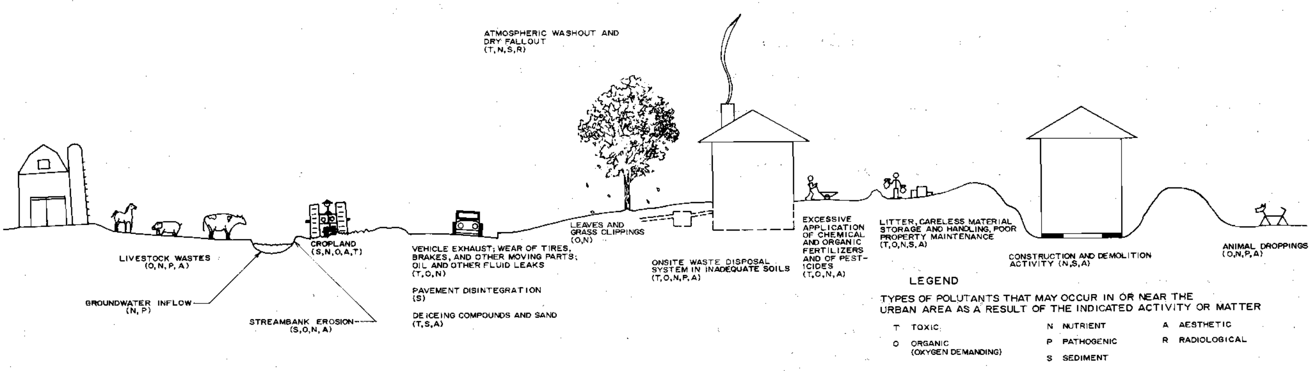
Nonpoint source pollution is similar in composition to point source pollution in that it can cause toxic, organic, nutrient, pathogenic, sediment, radiological, and aesthetic pollution problems. Nonpoint source pollution is becoming of increasing concern in water resources planning and engineering as efforts to abate point source pollution become increasingly successful. The control of nonpoint source pollution is a necessary step in the process of improving surface waters to render such waters suitable for full recreational use and a healthy fishery.

Nonpoint source pollution generally differs from point source pollution in one important aspect: nonpoint source pollution is transported to the surface water at a highly irregular rate in that large portions of the overall transport occur during rainfall or snowmelt events. In the dry period after washoff events, potential nonpoint source pollutants gradually accumulate on the land surface as a result of man's activities, becoming available for transport to the surface waters during the next runoff event (see Figure 34). The following activities of man, or effects of man's activities, result in nonpoint source pollution: 1) dry fallout and washout of atmospheric pollution; 2) vehicle exhaust and lubricating oil and fuel leakage; 3) the gradual wear and disintegration of tires, pavements, structures, and facilities; 4) improper disposal of grass clippings and leaves; 5) improperly located and maintained onsite wastewater disposal systems; 6) poor soil and water conservation practices; 7) improper management of livestock wastes; 8) excessive use of fertilizers and pesticides; 9) debris, careless material storage and handling, and poor property maintenance; 10) construction and demolition activity; 11) application of deicing salts and sand; 12) streambank erosion; and 13) domestic and wild animal litter.

With respect to spatial distribution, the potential source of nonpoint source pollution in the Pike River watershed consists of its entire 51.5-square-mile surface. The results of the examination of the available data sources and the application of several analytical techniques are presented in following

Figure 34

NONPOINT SOURCES OF WATER POLLUTION



Source: SEWRPC.

sections to illustrate some characteristics of nonpoint source pollution and to indicate its importance relative to point source pollution in the Pike River watershed. The following discussion addresses the types of nonpoint sources of water pollution in the Pike River watershed.

Residential Land Use: The concentration of people, domestic structures, and activities in residential areas and the alteration of the natural drainage and infiltration characteristics results in the production and release of nonpoint source water pollutants. Runoff from lawns, rooftops, driveways, sidewalks, and unused land is channeled through drainageways and streets and is transported directly, as overland flow, or indirectly, through storm sewerage systems, to surface waters. Pollutant sources associated with residential land uses include street debris, fertilizers, pesticides, pet wastes, garbage and litter, vegetation, degraded surface coatings such as paint particles, and detergent. Surface runoff from precipitation events and from urban activities within residential areas, such as lawn sprinkling or automobile washing, release pollutants to the environment.

Commercial Land Use: The high percentage of impervious area and attendant high runoff rates, together with the intense activity and accumulation of litter and debris, make commercial land a significant contributor of nonpoint source pollutants. Rainfall and snowmelt runoff from rooftops, parking lots, buildings, alleys, streets, loading docks and work areas, and adjacent sidewalks and open areas contribute sediment, oxygen demanding substances, dissolved substances, nutrients, toxic and hazardous substances, oil, grease, bacteria, and viruses to the streets and storm sewers which drain the commercial areas and discharge into the streams of the Pike River watershed. Another source of runoff is the washing of debris from work areas, sidewalks, and areas adjacent to storage areas as a method of debris removal performed in order to present a clean and orderly appearance to commercial customers.

Industrial Land Use: Runoff from industrial spills, production and distribution sites, loading docks and work areas, material storage sites, industrial buildings and adjacent streets, parking lots, rooftops, lawns, sidewalks, and open areas transports fuels, oil, grease, wood, metals, paper, plastic, salt, sand and gravel, organic substances, fly ash, petroleum and chemical products, corrosives, waste chemicals, brush, garbage, rubber, acids, glass, ceramics, paint particles, glue and solvents to streets, storm sewers, and large collector sewers. Large quantities of raw materials may be delivered to industrial sites to await use in the process itself or as a component of the final product. Many industrial operations do not have the indoor or covered storage capacity to house the raw materials awaiting processing, and therefore store the materials in outdoor bins or designated areas exposed to natural weathering processes, breakage, leakage, erosion, oxidation, heat, cold, and moisture which increase the degradation of the material and the potential for its removal and transport to surface waters by storm runoff or snowmelt.

Transportation Activities: Transportation-related activities contribute significant amounts of pollutants to surface waters in the Pike River watershed as goods and people are moved by rail, air, bus, truck, or car. The terminals, transportation routes, and service and maintenance areas are all sites of pollutant buildup and potential release. Motor vehicle pollutants accumulate on freeways and expressways, highways, streets, and parking lots. Motor vehicles deposit fuel, oil and grease, hydraulic fluids, coolants, exhaust emissions—particulates and gases, tire rubber, litter, heavy metals, asbestos, and nutrients on streets. Deicing salts, pavement debris, vegetation debris, animal wastes, litter, fertilizers, pesticides, chemicals, and material from adjacent land also accumulate on streets. Because the transportation-related urban surfaces are impervious and designed to drain very quickly, they play a particularly important role in the transport of pollutants.

Deicing Salt Usage: Initially, salts were used in conjunction with abrasives such as sand or ashes to facilitate travel on snowy and icy highways. In the winter of 1956-1957, the Wisconsin Highway Commission initiated a "bare pavement" winter maintenance program, which required liberal and frequent applications of "straight" salt in order to provide, wherever possible, consistently dry and therefore safer driving surfaces. Sodium chloride is the most commonly used deicing salt. The deicing salts dissolve to form solutions with lower freezing points than water. The application of deicing salts on highways during the winter may significantly affect the quality of runoff water. The salt applied to the highway must either be carried by surface runoff or must infiltrate the ground surface. Improper or excessive salt application may lead to groundwater or to surface water contamination, soil contamination, damage to plants, damage to wildlife, increased corrosion, and possible human toxicity in extreme circumstances.

Recreational Activities: Certain outdoor recreational activities, which utilize large areas of the land and water, may constitute nonpoint sources of pollution by contributing pollutants carried in storm water runoff and snowmelt to surface waters. Normally, outdoor recreational sites include large areas of land which are relatively well stabilized and act either as relatively modest sources of pollutants, or as pollutant trapping mechanisms. For example, grass buffer strips along streams serve to remove pollutants from storm water runoff and snowmelt by the sedimentation, filtration, and nutrient uptake effects of the vegetative cover. Outdoor recreational sites, however, may also include, in addition to open space with natural vegetative cover, space and impervious areas for the conduct of such recreational pursuits as tennis, swimming, and boating. Consequently, recreational areas may be sources of nonpoint pollution. The amount of pollutant contributed will depend upon such factors as the types of recreational facilities present, the location and size of vegetated buffer areas and zones, the amount of fertilizers and pesticides used, the land management methods applied, the drainage efficiency of the site, and the location of the site with respect to adjacent lakes or streams. However, well designed and managed recreational lands may serve as a means of resolution of other more severe nonpoint pollution problems.

Construction Activities: The development and redevelopment of residential, commercial, industrial, transportation, and recreational areas within the Pike River watershed can cause significant quantities of pollutants to be contributed to streams. Construction activities generally involve soil disturbance and destruction of stable vegetative cover; changes in the physical, chemical, and biological properties of the land surface; and attendant changes in the hydrologic and water quality characteristics of the site as an element of the natural system of surface and groundwater movement. The clearing and grading of construction sites subjects the soil to high erosion rates. Potential pollutants from construction activities include soil particles; pesticides; petroleum products, such as oils, grease, gasoline, and asphalt; solid waste materials, such as paper, wood, metal, rubber, garbage, and plastic; other construction chemicals such as paints, glues, solvents, sealants, acid, and concrete; and soil additives such as lime, fly ash, and salt. The transportation of pollutants from construction sites to natural waters is by direct runoff of storm water and snowmelt, leaching and groundwater infiltration, wind, soil slippage or landslide, and mechanical transfer on vehicles.

Onsite Sewage Disposal Systems: As of 1975, the sanitary and household wastewaters from approximately 4,700 persons, or about 16 percent of the total resident population of the total watershed, were treated and disposed of through the use of onsite sewage disposal systems. An onsite sewage disposal system may be a conventional septic tank system, a mound system, or holding tank. It was reported in SEWRPC Technical Report No. 21, Sources of Water Pollution in Southeastern Wisconsin: 1975, that approximately 50 percent of the septic systems in some areas of the Southeastern Wisconsin Region are connected to agricultural drainage tiles or ditches, with nearly all of the septic wastes from these systems being directly discharged to drainage channels and surface waters. Failure of an onsite sewage disposal system occurs when the soils surrounding the seepage area will no longer accept or properly stabilize the effluent, when the groundwater rises to levels which will no longer allow for uptake of liquid effluent by the soils, or when age or lack of proper maintenance cause the system to malfunction. Hence, onsite sewage disposal system failure may result from installation in soils with severe limitations for system use, improper design or installation of the system, or inadequate maintenance.

Solid Waste Disposal Sites: Solid waste disposal sites are a potential source of surface, as well as groundwater, pollution. In this respect, however, it is important to recognize the distinction between a properly designed and constructed sanitary landfill and the variety of operations that are referred to as refuse dumps—especially with respect to potential effects on water quality. A solid waste disposal site may be defined as any land area used for the deposit of solid wastes regardless of the method of operation, or whether a subsurface excavation is involved. A sanitary landfill may be defined as a solid waste disposal site which is carefully located, designed, and operated to avoid hazards to public health or safety, or contamination of groundwaters or surface waters. The proper design of sanitary landfills requires careful engineering to confine the refuse to the smallest practicable area, to reduce the refuse mass to the smallest practicable volume, to avoid surface water runoff, to avoid leachate production and percolation into the ground and surface waters, and to seal the surface with a layer of earth at the conclusion of each day's operation or at more frequent intervals as necessary.

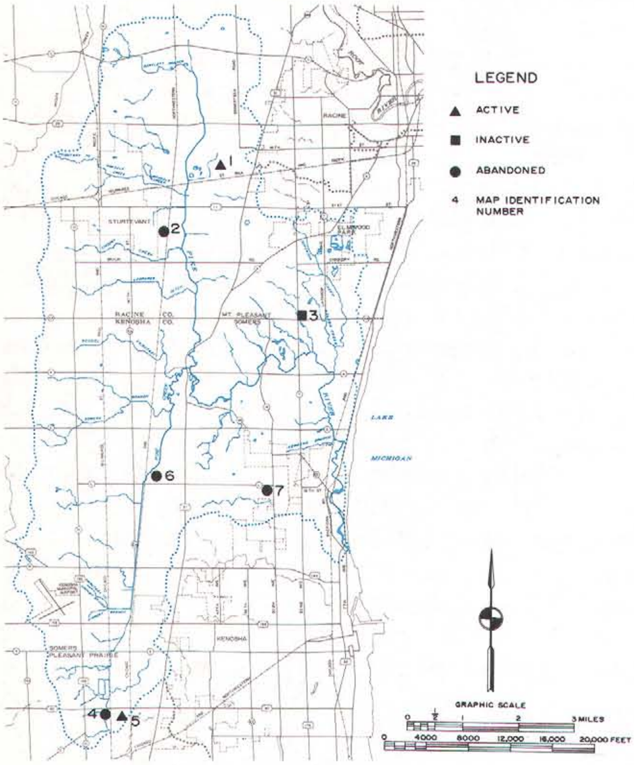
In order for a landfill to produce leachate there must be some source of water moving through the fill material. Possible sources include precipitation, the moisture content of the refuse itself, surface water infiltration, groundwater migrating into the fill from adjacent land areas, or groundwater rising from below to come in contact with the fill. In any event, leachate is not released from a landfill until a significant portion of the fill material exceeds its saturation capacity. If external sources of water are excluded from the sanitary landfill, the production of leachates in a well designed and managed sanitary landfill can be effectively minimized if not entirely eliminated. The quantity of leachate produced will depend upon the quantity of water that enters the solid waste fill site minus the quantity that is removed by evapotranspiration. Studies have estimated that for a typical landfill from 20 to 50 percent of the rainfall infiltrated into the solid waste may be expected to become leachate. Accordingly, a total annual rainfall of about 32 inches, which is typical of the Pike River watershed, could produce from 170,000 to 430,000 gallons of leachate per year per acre of landfill, if the facility is not properly located, designed, and operated.

In 1980 there were two active sanitary landfill operations located within the Pike River watershed as shown on Map 35 and in Table 52, the Oakes landfill in the Town of Mt. Pleasant in Racine County, and another landfill operated by the Wisconsin Electric Power Company in the Town of Pleasant Prairie in Kenosha County. Four other landfills located within the watershed had previously been abandoned and another remains inactive.

A review of Wisconsin Department of Natural Resources water quality monitoring and surveillance program records indicates that the Department monitors groundwater quality at the Oakes landfill site on a quarterly basis to determine whether pollutants from leachate are entering the groundwater. The pollutant indicators monitored include chemical oxygen demand, specific conductivity, and chlorides. Individual pollutants such as mercury or other heavy metals are not tested for directly, unless the pollutant indicators show a

Map 35

LANDFILL SITES IN THE PIKE RIVER WATERSHED



In 1980 there were two active sanitary landfills located within the Pike River watershed. Four other landfills located within the watershed had previously been abandoned, and one landfill remains inactive.

Source: SEWRPC.

potential for the presence of such pollutants in the groundwater. As of June 1980, the groundwater quality monitoring program had not indicated leachate movement into the groundwater, nor violations of the federal drinking water quality standards in the groundwater around the site. A routine field investigation of the site conducted by the Department staff in July of 1979 revealed that leachate had escaped from the landfill underdrain system and had entered the surface water drainage system of the area. Surface water quality sampling conducted by the landfill operator's consultant on July 24, 1979, both above and below the site confirmed this finding. The Department then required that the leachate be continuously recirculated through the landfill.

The leachate itself was also sampled and tested for possible treatment at the City of Racine wastewater treatment facility. Studies are currently being conducted by the Department to determine the best method of disposal of the leachate upon saturation of the landfill. Another potential problem being studied is the presence of silt seams in the landfill which may cause lateral migration of leachate from the site and the resulting pollution of the surface waters.

Table 52

LANDFILL SITES IN THE PIKE RIVER WATERSHED

Map Identification Number	Civil Division	Location	Operator	Wisconsin DNR License Number	Status
1	Town of Mt. Pleasant	S1/2, NE1/4 Section 23 T3N R22E	Land Reclamation (Oakes Landfill)	0572	Active
2	Town of Mt. Pleasant	SW1/4, NE1/4 Section 27, T3N R22E	Town of Mt. Pleasant	N/A	Abandoned
3	Town of Mt. Pleasant	SW1/4, SW1/4 Section 31, T3N R23E	Samuel Azarian	N/A	Inactive
4	Town of Pleasant Prairie	NE1/4, NW1/4 Section 9, T1N R22E	Harry Crow & Sons	N/A	Abandoned
5	Town of Pleasant Prairie	NW1/4, NE1/4 Section 9, T1N R22E	Wisconsin Electric Power Company	2786	Active
6	Town of Somers	SE1/4, SW1/4 Section 15, T2N R22E	Town of Somers	1070	Abandoned
7	Town of Somers	NE1/4, NW1/4 Section 24, T2N R22E	Keno Trucking	1661	Abandoned

NOTE: N/A indicates data not available.

Source: Wisconsin Department of Natural Resources and SEWRPC.

Livestock Operations: The presence of livestock and poultry manure in the environment is an inevitable result of animal husbandry and is a major potential source of water pollutants. Animal manure, composed of feces, urine, and sometimes bedding materials, contributes suspended solids, nutrients, oxygen demanding substances, bacteria, and viruses to surface waters. Most farm animals within the Pike River watershed are raised and managed in barnyards or feedlots. A feedlot is defined as a relatively small—generally less than five acres in size—confined land area, such as a fenced barnyard or a fenced portion of a pasture, for raising large numbers of livestock—generally 25 to 200 head—primarily by importing feed, as opposed to using pasture grazing. Operators usually rely on the occasional export of accumulated manure and bedding materials from the so-called feedlots which are generally denuded of vegetative cover, and are therefore subject to high rates of erosion and pollutant release. Animal waste constituents of pastureland and barnyard runoff, animal wastes deposited on pastureland and cropland and in barnyards, feedlots, and manure piles can contaminate water by surface runoff, infiltration to the groundwater, and volatilization to the atmosphere. Some livestock also wade in streams and trample stream bottoms contributing manure directly to the stream and accelerating streambank erosion. During the warmer seasons of the year the manure is often scattered on cropland and pastureland where the waste material is likely to be taken up by the vegetative growth composing the land cover. However, when the animal manure is applied to the land surface during the winter, the animal wastes are subject to excessive runoff and transport, especially during the spring snowmelt period.

Crop Production: Cropland can have an adverse effect upon water quality within the Pike River watershed, contributing sediments, nutrients, organic matter, and pesticides in runoff to streams. The extent of water pollution from cropping practices varies considerably as a result of the soils, slopes, and crops, as well as in the numerous methods of tillage, plantings, fertilization, chemical treatment, and conservation practices. The topographic, hydrographic, meteorologic, and hydrologic conditions within the watershed are also very important factors. For example, just as inadequate handling of animal wastes from a confined feeding operation will pollute the stream system, excessive fertilizer, pesticide, and herbicide usage also has the potential to damage the water resources. Crops grown in the Pike River watershed include row crops, such as corn and soybeans; small grains, such as wheat and oats; hay, such as clover, alfalfa, timothy, and canary grass; vegetables, such as potatoes, onions, peas, sweet corn, cabbage, and tomatoes; and specialty crops, such as sod. Row and vegetable crops, which have a relatively higher level of exposed soil surface, tend to contribute higher pollutant loads than crops such as hay and pastureland, which support greater levels of vegetative cover. Since the early 1930's, it has been a national objective to preserve and protect agricultural soil from wind and water erosion. Federal programs have been developed to achieve this objective, with the primary emphasis being on sound land management and cropping practices for soil conservation. An incidental benefit of these programs has been a reduction in the amount of eroded organic or inorganic material entering surface waters as sediment or attached to sediment. Some practices are effective in both regards, while others may enhance the soil conditions with little benefit to surface water quality.

Woodlands: A well-managed woodland contributes few pollutants to surface waters. Under poor management, however, woodlands may have detrimental water quality effects through the release of sediments, nutrients, organic matter, and pesticides into nearby surface waters. If trees along streams are cut, thermal pollution may occur as the direct rays of the sun strike the water. Disturbances caused by tree harvesting, livestock grazing, tree growth promotion, tree disease prevention, fire prevention, and road and trail construction are a major source of pollution from silvicultural activities. Most of these activities are seldom practiced in the Pike River watershed.

Atmospheric Sources: Streams are subjected directly to the deposition of pollutants from the atmosphere via dry fallout and precipitation washout. Man's activities and the physical environment influence air pollutant concentrations, dispersal, and fallout rates. Air pollutants in the form of smoke, dust, soot, fly ash, fumes, mist, odors, seeds, pollen, spores, and contaminated precipitation fall directly on surface waters and are direct sources of nutrients, sediments, oxygen-demanding substances, heavy metals, and chemicals. Some air pollutants present no threat to water quality, but others are significant contributors to water quality degradation. Oxides of nitrogen may react with sodium, potassium, and other heavy metals to form soluble nitrates which, when washed out of the atmosphere by rain, may contribute to the fertility of surface waters. Phosphorus adsorbed on fine clay and silt-sized particles may be transported by wind erosion and deposited in surface waters. In case ice covers a body of water, the various deposits still occur, but are stored until spring thaw. Direct contribution to surface water systems is of special concern because there is no intervening filtration by the land surface. The deposit of contaminants from the air to the water environment may be indirect with transport, transformation, and storage of contaminants on land. This may introduce a substantial time delay between when a contaminant reaches the land and the time the contaminant shows up in the water. Storage of air contaminants deposited on land also provides opportunity for the transformation of the contaminants into other chemical forms prior to their reaching the waterways. The indirect transfer of air pollutants through streets, drainageways, storm sewers, and surface runoff is considered as an element of the pollutant loadings from these sources discussed above.

Stream Processes: Instream processes also affect the pollution transport loading of a stream. The tremendous amount of energy possessed by flowing water in a stream channel is dissipated along the stream length by turbulence, streambank and bed erosion, and sediment resuspension. Sediments and associated substances delivered to a stream may be stored, at least temporarily, on the streambed, particularly where obstructions or irregularities in the channel decrease the flow velocity or act as a particle trap or filter. On an annual basis or on a long-term basis, streams may exhibit a net deposition, a net erosion, or no net change in internal sediment transport, depending on the tributary land uses, watershed hydrology, precipitation, and geology. It was reported in SEWRPC Technical Report No. 21, Sources of Water Pollution in Southeastern Wisconsin: 1975, that typically from 3 to 11 percent of the annual sediment yield in a watershed in southeastern Wisconsin may be contributed by streambank erosion.

Existing Storm Water Drainage Systems: Storm water drainage facilities are defined, for purposes of this report, as conveyances—including but not limited to subsurface pipes and conduits, ditches, channels, and appurtenant inlet, outlet, storage, and pumping facilities—located in urbanized areas and constructed or improved and operated for purposes of collecting storm water runoff from tributary drainage areas and conveying such runoff to natural water courses for disposal. In the larger and more intensively developed urban communities such as the Cities of Racine and Kenosha and the Villages of Sturtevant and Elmwood Park, these facilities consist either of complete, largely piped, storm water drainage systems which have been planned, designed, and constructed as systems in a manner similar to sanitary sewer and water utility systems, or of fragmented or partially piped systems incorporating open surface channels to as great a degree as possible.

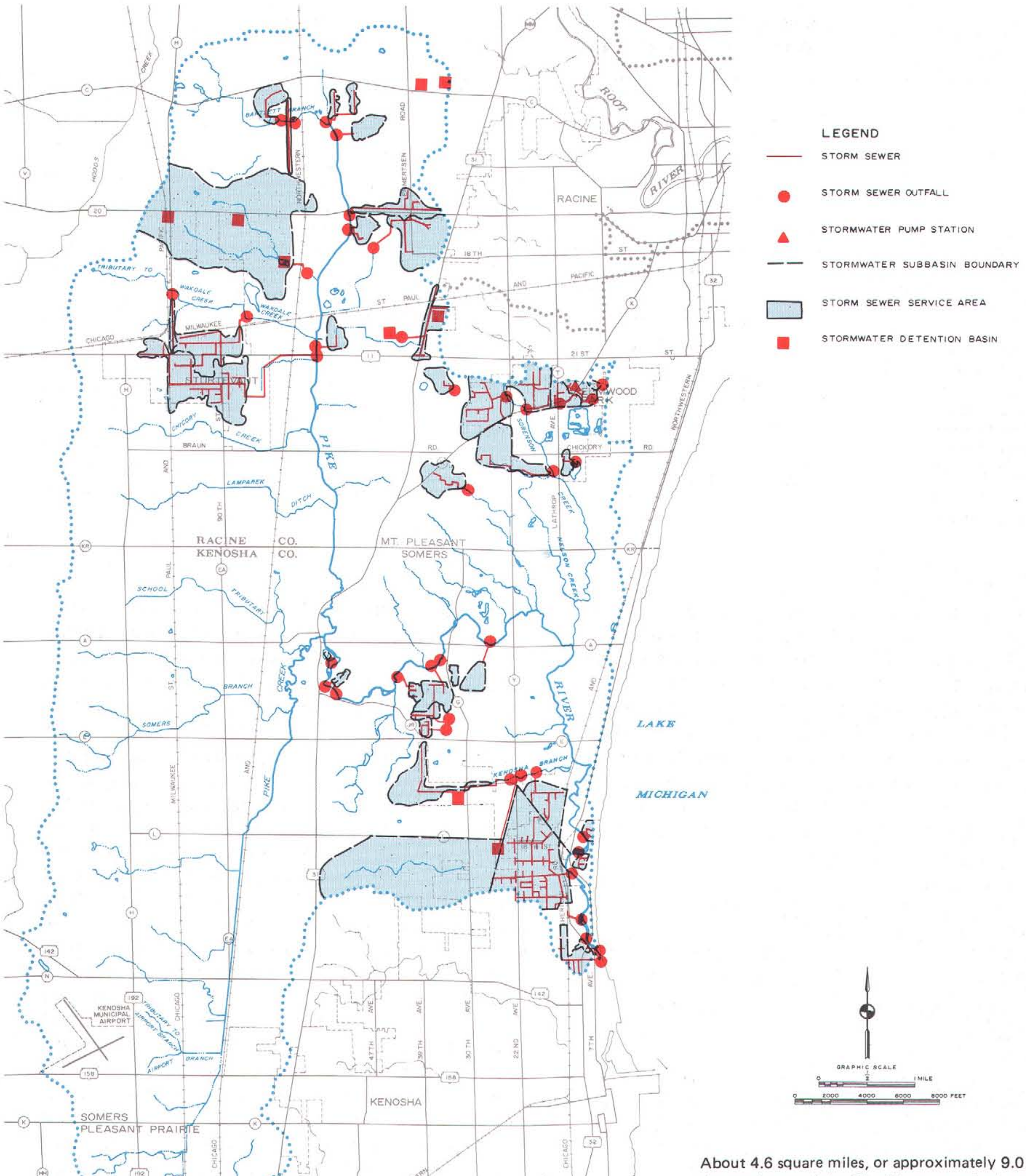
In the Pike River watershed, the storm water drainage systems provide the means by which a portion of the nonpoint source pollutants reach the surface water system. Therefore, the extent and characteristics of the existing storm water drainage system are pertinent to an understanding of the nonpoint source pollution problem. Because of the direct relationship between urban storm water drainage systems and surface water quality, the Commission's areawide water quality management planning program included an inventory of the existing urban storm water drainage systems within the Region. The results of that inventory for the Pike River watershed are presented in summary form below.[13]

Inventory Findings: The four known existing urban storm water drainage systems which serve portions of the subareas of the Pike River watershed are shown on Map 36. These include the systems operated by the Cities of Kenosha and Racine, the Villages of Sturtevant and Elmwood Park, and the Towns of Mt. Pleasant and Somers. Together these systems have a combined tributary drainage area within the watershed of about 5.6 square miles, or about 11 percent of the total area in the watershed. Included within this storm water drainage area of the watershed are a total of 41 known storm water outfalls, one storm water pumping station, and nine storm water storage facilities. The total annual average discharge from these outfalls is estimated to be 1,010 million gallons occurring

[13] *For a detailed description of the procedure used to inventory urban storm water drainage systems under the areawide water quality management planning program, see Chapter IV of SEWRPC Technical Report No. 21, Sources of Water Pollution in Southeastern Wisconsin: 1975.*

Map 36

KNOWN URBAN STORM SEWER SYSTEMS IN THE PIKE RIVER WATERSHED



Source: SEWRPC.

About 4.6 square miles, or approximately 9.0 percent of the total area of the Pike River watershed, are served by four storm sewer systems operated by the Cities of Racine and Kenosha and by the Villages of Elmwood Park and Sturtevant. The remainder of the watershed is primarily agricultural and is not served by a piped storm water drainage system, but drainage is instead carried overland and by roadside ditches and natural swales to the major stream system of the watershed.

Table 53

AREA SERVED AND SELECTED CHARACTERISTICS OF EXISTING STORM WATER DRAINAGE SYSTEMS IN THE PIKE RIVER WATERSHED

Civil Division Location of Public Storm Water Conveyance Systems	Estimated Tributary Area		Number of Storm Water Outfalls in System Discharging to Surface Waters	Number of Storm Water Retention Basins Discharging to Surface Waters	Summation of Drainage Districts		
					Total Estimated Annual Discharging Volume (million gallons)	Estimated Maximum Storm Water Discharge Rates (cubic feet per second)	
	Acres	Square Miles				2-Year Recurrence Interval Event	5-Year Recurrence Interval Event
City of Kenosha.	719	1.12	10	2	190	577	772
City of Racine.	412	0.65	3	0	110	306	406
Village of Sturtevant	457	0.71	3	0	161	191	257
Village of Elmwood Park. . .	82	0.13	3	0	14	48	64
Town of Somers.	190	0.30	9	0	47	140	190
Town of Mt. Pleasant.	1,743	2.72	13	7	488	719	960
Total	3,603	5.63	41	9	1,010	1,981	2,649

Source: SEWRPC.

in 57 events. The combined maximum discharge rate for these storm water outfalls is estimated to be 1,980 cubic feet per second (cfs) for a two-year recurrence interval rainfall event and 2,650 cfs for a five-year recurrence interval rainfall event. Pertinent characteristics of each system are summarized in Table 53. The location and configuration of the major storm water drainage conduits as well as the outlets and estimated tributary areas of the four storm water drainage systems within the Pike River watershed are shown on Map 36.

Nonpoint Source Pollutant Loads: Nonpoint source pollutant loads in the Pike River watershed were estimated by the unit load analysis method set forth in SEWRPC Technical Report No. 21, Sources of Water Pollution in Southeastern Wisconsin: 1975.[14]

Unit Load Analysis: A preliminary analysis of the relative magnitude of nonpoint source pollutant loadings from the various land use-cover combinations comprising the Pike River watershed was completed under the Regional Planning Commission's recently completed areawide water quality management planning program. That analysis was based on unit loading rates for various pollutants and land use-cover combinations. Certain assumptions were required to develop the loading rates. To the maximum extent possible, these assumptions were based upon data collected from within the Region. The unit loading rates used in the areawide water quality management plan are set forth in Table 54. The analysis provides an estimate of gross pollutant loads from nonpoint sources in the Pike River watershed, as well as a means of identifying the most important sources of each pollutant, by quantifying the drainage channel pollutant load; i.e., the overbank delivered pollutant loads to the perennial and intermittent stream of the Pike River watershed. The results of this analysis are summarized in Table 55. Estimated pollutant loads from point sources are also presented to provide a comparison of point source loads and nonpoint source loads. Annual pollutant loadings are estimated for total nitrogen, total phosphorus, biochemical oxygen demand, fecal coliform, and sediment.

The drainage channel pollutant loads can be expected to be different from the actual transport from the watershed, because material processes

[14] *See Chapter V of SEWRPC Technical Report No. 21, Sources of Water Pollution in Southeastern Wisconsin: 1975.*

Table 54

SUMMARY OF REPORTED POLLUTANT CHANNEL LOADING RATES FROM NONPOINT SOURCES USED IN THE COMMISSION AREAWIDE WATER QUALITY MANAGEMENT PLANNING PROGRAM

Category of Diffuse Pollution Sources	Rate of Pollution Loadings[a] (given in pounds/acre/year except for MFFCC, given in counts/acre/year, and onsite sewage disposal systems, given in load/capita/year)				
	Total Nitrogen	Total Phosphorus	Biochemical Oxygen Demand	Membrane Filter Fecal Coliform Count	Sediment
Urban					
Residential Land Use	4.0	0.32	24.3	1.6×10^{10}	545
	(1.9-11.5)	(0.32-7.3)	(10.2-95.9)		(356-7,360)
Commercial Land Use	9.0	0.75	97.6	3.3×10^{10}	745
	(9.0-77.4)	(0.75-4.1)	(16-168)		
Industrial Land Use	8.4	0.70	36.9	6.2×10^{10}	977
	(8.4-76.4)	(0.82-9.4)	(16-188)		
Construction Activities	60.0	45.0	120.0	Negligible	150,000
	(60-150)	(45-120)	(120-4,500)		(3,000-380,000)
Extractive Activities	60.0	45.0	120.0	Negligible	150,000
	(60-150)	(45-120)	(120-4,500)		(3,000-380,000)
Transportation					
Freeways and Highways	23.4	1.4	159.0	6.7×10^{10}	42,600
Airports	12.0	2.7	17.6	Negligible	3,200
Recreation					
Parks	2.3	0.06	1.3	3.6×10^{9}	420
	(2.3-26.1)	(0.06-1.53)			(420-750)
Golf Courses	4.4	0.20	1.3	Negligible	420
	(4.4-26.1)	(0.20-1.53)			(420-750)
Onsite Sewage Disposal Systems (pounds or MFFCC/capita/year)	5.7	1.32	81.6	1.0×10^{11}	28
Rural					
Livestock Operations (pounds/animal unit/year)	28.4	6.6	111.2	6.4×10^{11}	700
Orchards	2.3	0.14	4.6	6.6×10^{8}	251
	(0.7-9.1)	(0.01-0.80)	(3.6-6.3)		(45-389)
Pastures	4.6	0.29	9.7	Included in Livestock Load	420
	(1.0-7.6)	(0.22-0.57)	(5.4-15.4)		(12-828)
Woodlands	2.3	0.14	4.6	6.6×10^{8}	251
	(0.7-9.1)	(0.01-0.80)	(3.6-6.3)		(45-389)
Air Pollution to Surface Waters	8.9	0.5	162.0	Negligible	665
	(4.4-39.4)	(0.045-1.60)	(153-162)		(614-1,500)
Row Crops	23.1	0.64	20.7		6,900
Small Grain	4.7	0.13	9.6	Included in Livestock Load	3,200
Hay	0.9	0.09	9.6		3,200
Vegetables	23.1	0.64	30.0		10,000
Sod	0.9	0.09	2.1		700
General Agricultural Land	(0.03-23.1)	(0.09-2.59)	(Not Available)		(680-51,000)

[a] *Numbers in parentheses are the range of loadings available in the literature. If only one literature value was available, or if the loading value was computed from regional data and no additional values were available, no loading range is presented. The literature sources from which the loading rates were developed and a description of the procedures used to estimate loading rates are presented in SEWRPC Technical Report No. 21, Sources of Water Pollution in Southeastern Wisconsin: 1975.*

Source: SEWRPC.

Table 55

ESTIMATED LOADINGS FROM POLLUTION SOURCES IN THE PIKE RIVER WATERSHED: 1975

Source	Extent[a]	Parameter	Average Year Drainage Channel Loads (from SEWRPC Technical Report No. 21,[b] presented in pounds per year except for fecal coliform presented in counts x 10^8 per year, and sediment presented in tons per year) Total Estimated Loading	Percent
Urban Point Sources				
Municipal Sewage Treatment Plants . . .	2	Total Nitrogen	24,070.0	4.1
	2	Total Phosphorus	4,620.0	6.5
	2	Biochemical Oxygen Demand	64,020.0	5.0
	2	Fecal Coliform	13,000,000.0	51.3
	2	Sediment	35.0	0.0
Private Sewage Treatment Plants.	2	Total Nitrogen	0.0	0.0
	2	Total Phosphorus	0.0	0.0
	2	Biochemical Oxygen Demand	0.0	0.0
	2	Fecal Coliform	0.0	0.0
	2	Sediment	0.0	0.0
Industrial Discharges.	4	Total Nitrogen	30.0	0.0
	4	Total Phosphorus	0.0	0.0
	4	Biochemical Oxygen Demand	920.0	0.1
	4	Fecal Coliform	0.0	0.0
	4	Sediment	0.0	0.0
Sanitary Sewer Flow Relief Devices . . .	8	Total Nitrogen	380.0	0.1
	8	Total Phosphorus	130.0	0.2
	8	Biochemical Oxygen Demand	3,750.0	0.3
	8	Fecal Coliform	570,000.0	2.2
	8	Sediment	0.0	0.0
Urban Point Source Totals		Total Nitrogen	24,480.0	4.2
		Total Phosphorus	4,750.0	6.7
		Biochemical Oxygen Demand	68,690.0	5.4
		Fecal Coliform	13,570,000.0	53.5
		Sediment	35.0	0.0
Urban Nonpoint Sources				
Residential	3127	Total Nitrogen	12,510.0	2.1
	3127	Total Phosphorus	1,000.0	1.4
	3127	Biochemical Oxygen Demand	75,990.0	6.0
	3127	Fecal Coliform	500,320.0	2.0
	3127	Sediment	850.0	0.6
Commercial.	690	Total Nitrogen	6,210.0	1.1
	690	Total Phosphorus	520.0	0.7
	690	Biochemical Oxygen Demand	67,340.0	5.3
	690	Fecal Coliform	227,700.0	0.9
	690	Sediment	255.0	0.2
Industrial	752	Total Nitrogen	6,320.0	1.1
	752	Total Phosphorus	530.0	0.7
	752	Biochemical Oxygen Demand	27,750.0	2.2
	752	Fecal Coliform	466,240.0	1.8
	752	Sediment	365.0	0.3
Extractive.	92	Total Nitrogen	5,520.0	0.9
	92	Total Phosphorus	4,140.0	5.8
	92	Biochemical Oxygen Demand	11,040.0	0.9
	92	Fecal Coliform	0.0	0.0
	92	Sediment	6,900.0	5.0
Transportation	319	Total Nitrogen	4,930.0	0.8
	319	Total Phosphorus	650.0	0.9
	319	Biochemical Oxygen Demand	21,980.0	1.7
	319	Fecal Coliform	99,740.0	0.4
	319	Sediment	2,630.0	1.9
Recreation	817	Total Nitrogen	3,170.0	0.5
	817	Total Phosphorus	140.0	0.2
	817	Biochemical Oxygen Demand	1,060.0	0.1
	817	Fecal Coliform	7,200.0	0.0
	817	Sediment	170.0	0.1

Table 55 (continued)

Source	Extent[a]	Parameter	Average Year Drainage Channel Loads (from SEWRPC Technical Report No. 21,[b] presented in pounds per year except for fecal coliform presented in counts x 10^8 per year, and sediment presented in tons per year)	
			Total Estimated Loading	Percent
Construction	780	Total Nitrogen	46,800.0	8.0
	780	Total Phosphorus	35,100.0	49.2
	780	Biochemical Oxygen Demand	93,600.0	7.3
	780	Fecal Coliform	0.0	0.0
	780	Sediment	58,500.0	42.3
Septic Systems	4200	Total Nitrogen	23,940.0	4.1
	4200	Total Phosphorus	5,540.0	7.8
	4200	Biochemical Oxygen Demand	342,720.0	26.9
	4200	Fecal Coliform	4,200,000.0	16.6
	4200	Sediment	60.0	0.0
Urban Nonpoint Source Total		Total Nitrogen	109,400.0	18.8
		Total Phosphorus	47,620.0	66.8
		Biochemical Oxygen Demand	641,480.0	50.3
		Fecal Coliform	5,501,200.0	21.7
		Sediment	69,730.0	50.4
Urban Source Totals		Total Nitrogen	133,880.0	23.0
		Total Phosphorus	52,370.0	73.5
		Biochemical Oxygen Demand	710,170.0	55.7
		Fecal Coliform	19,071,200.0	75.2
		Sediment	69,765.0	50.5
Rural Nonpoint Sources				
Livestock Operations (feedlots)	980	Total Nitrogen	27,830.0	4.8
	980	Total Phosphorus	6,470.0	9.1
	980	Biochemical Oxygen Demand	108,980.0	8.5
	980	Fecal Coliform	6,272,000.0	24.7
	980	Sediment	345.0	0.2
Cropland, Pasture, and Unused Rural Land	23842	Total Nitrogen	417,720.0	71.7
	23842	Total Phosphorus	12,230.0	17.2
	23842	Biochemical Oxygen Demand	436,690.0	34.3
	23842	Fecal Coliform	0.0	0.0
	23842	Sediment	67,955.0	49.2
Silvicultural	1213	Total Nitrogen	2,790.0	0.5
	1213	Total Phosphorus	170.0	0.2
	1213	Biochemical Oxygen Demand	5,580.0	0.4
	1213	Fecal Coliform	8,005.8	0.0
	1213	Sediment	150.0	0.1
Atmospheric Contribution to Surface Water	82	Total Nitrogen	730.0	0.1
	82	Total Phosphorus	40.0	0.1
	82	Biochemical Oxygen Demand	13,280.0	1.0
	82	Fecal Coliform	0.0	0.0
	82	Sediment	25.0	0.0
Rural Nonpoint Source Totals		Total Nitrogen	449,070.0	77.0
		Total Phosphorus	18,910.0	26.5
		Biochemical Oxygen Demand	564,530.0	44.3
		Fecal Coliform	6,280,005.8	24.8
		Sediment	68,475.0	49.5
Nonpoint Source Totals		Total Nitrogen	558,470.0	95.8
		Total Phosphorus	66,530.0	93.3
		Biochemical Oxygen Demand	1,206,010.0	94.6
		Fecal Coliform	11,781,205.8	46.5
		Sediment	138,205.0	100.0
Total Sources		Total Nitrogen	582,950.0	100.0
		Total Phosphorus	71,280.0	100.0
		Biochemical Oyxgen Demand	1,274,700.0	100.0
		Fecal Coliform	25,351,205.8	100.0
		Sediment	138,240.0	100.0

[a] *Urban point sources are expressed in numbers of plants, other facilities, and points of sewage flow relief; urban nonpoint sources are expressed in number of acres except septic systems which are expressed as the number of people served; and rural nonpoint sources are expressed in acres except livestock operations which are expressed in equivalent animal units.*

[b] *See SEWRPC Technical Report No. 21, Sources of Water Pollution in Southeastern Wisconsin: 1975.*

Source: SEWRPC.

may retain or remove pollutants or change their form during transport over the land surface or within the stream system. These processes include particle deposition or entrapment on the land surface or floodplains, stream channel deposition or aggradation, biological uptake, and chemical transformation and precipitation. The drainage channel pollutant loading rates, and therefore the total drainage channel pollutant loads set forth in Table 55, are representative of the annual quantities of potential pollutants moved from small areas of the Pike River watershed into localized drainage swales and channels, but are not intended to reflect the total amount of the pollutants moving from those sources through the entire hydrologic-hydraulic system to the watershed outlet.

Based on data set forth in Table 55, urban sources of pollution are estimated to contribute 23 percent of the nitrogen, 74 percent of the phosphorus, 56 percent of the biochemical oxygen demand, 75 percent of the fecal coliform, and 51 percent of the sediment which pollutes the Pike River system. Of the urban contribution, the point sources of pollution contribute 18 percent of the nitrogen, 9 percent of the phosphorus, 10 percent of the biochemical oxygen demand, 71 percent of the fecal coliform, and 0.001 percent of the sediment. Nonpoint sources—including the estimated septic tank and construction-related contributions in the drainage area—account for the remaining 82 percent of the nitrogen, 91 percent of the phosphorus, 90 percent of the biochemical oxygen demand, 29 percent of the fecal coliform, and nearly all of the sediment contributed from urban sources.

Of the total pollutant loads, rural pollution sources contribute an estimated 77 percent of the nitrogen, 26 percent of the phosphorus, 44 percent of the biochemical oxygen demand, 25 percent of the fecal coliform, and 49 percent of the sediment from all sources within the watershed. There are no rural point sources of pollution, since none of the livestock operations in the watershed are of sufficient size to fall within the definition of a point source under the normal state or federal guidelines. Livestock feeding operations—including the disposal of manure on croplands—contribute about 6 percent of the nitrogen, 34 percent of the phosphorus, 19 percent of the biochemical oxygen demand, almost all of the fecal coliform, and 0.5 percent of the sediment attributed to rural sources. The remainder of the estimated rural pollution load, or 94 percent of the nitrogen, 66 percent of the phosphorus, 81 percent of the biochemical oxygen demand, virtually none of the fecal coliform, and virtually all of the sediment, is contributed by other rural nonpoint sources, namely storm water runoff from rural land uses and atmospheric loadings to surface waters.

Transport Load Analysis: To determine the amount of pollutants actually being transported downstream in the watershed based on measured data, a pollutant transport analysis was conducted. This analysis relied upon measured data and upon the Model Enhanced Unit Loading (MEUL) method developed under the International Joint Commission's Menomonee River Pilot Watershed Study.[15] The MEUL method may be used to estimate transport loads of total phosphorus and sediment and the method was applied for this purpose. A separate transport analysis was also conducted for total nitrogen and biochemical oxygen demand (BOD_5), as well as for total phosphorus and sediment, using measured instream conditions and application of another technique developed in the International Joint Commission's Menomonee River Pilot Watershed Study. The technique involves applying a stratified random sampling technique to distinguish between wet-weather and dry-weather estimates of instantaneous pollutant transport in order to estimate annual loads from the watershed.[16] This transport loading analysis thus provides a measure of the actual stream transport, which can be compared to the MEUL method transport load estimates. Table 56 presents the sources of data used in the transport analysis. Streamflow data were available for the Pike River about one-quarter mile downstream of Petrifying Springs Park Road, located in the northeast quarter of Section 11, Township 2 North, Range 22 East, Kenosha County, a point having a tributary drainage area of about 39 square miles. The streamflow data were available from the U. S. Geological Survey for the years 1971 to 1975 as part of its routine

[15] *International Joint Commission, Menomonee River Pilot Watershed Study, Volume 5, Simulation of Pollutant Loadings and Runoff Quality, Draft, November 1979.*

[16] *For a detailed description of the modeling technique used in the transport analysis, see Final Summary Pilot Watershed Report, International Joint Commission Menomonee River Pilot Watershed Study, December 1, 1977.*

Table 56

SOURCES OF DATA USED IN THE PIKE RIVER TRANSPORT ANALYSIS OF INSTREAM WATER QUALITY MONITORING DATA

Parameter	Sources of Data Samples		
	Annual Low Flow Data SEWRPC Technical Report No. 17 1968-1975	SEWRPC's Index Site Sampling Program 3/12/76-11/19/76	U. S. Geological Survey Continued Streamflow Monitoring Program
Flow			X
Nitrogen	X	X	
Phosphorus . .	X	X	
BOD_5.		X	
Suspended Solids			X[a]

[a] *A suspended solids analysis of the Pike River was previously conducted by the U. S. Geological Survey. See S. M. Hindall and R. F. Flint, "Sediment Yields of Wisconsin Streams," Hydrologic Investigations Atlas, HA-376, U. S. Geological Survey, Washington, 1970.*

Source: SEWRPC.

sampling program. Total phosphorus and total nitrogen concentration measurements were available from SEWRPC Technical Report No. 17, Water Quality of Lakes and Streams in Southeastern Wisconsin: 1964-1975. Total phosphorus, total nitrogen, and BOD_5 measurements were available from the Commission index site water quality sampling program. These data were available for SEWRPC sampling site Pk-1, located about two miles upstream of the U. S. Geological Survey streamflow sampling station at STH 31. A suspended solids transport analysis for the Pike River was previously conducted by the U. S. Geological Survey.[17] Inasmuch as suspended solids data were used in the U. S. Geological Survey analysis, the watershed yield was factored by 1.10 to account for the bedload component which consists of the coarser sediments transported along the stream bottom, as opposed to the finer sediments transported in suspension in the streamflow and, therefore, included in suspended solids samples. In the Pike River near Petrifying Springs Park Road, it was estimated from these instream measurements that about 349,000 pounds of nitrogen; 27,000 pounds of phosphorus; 255,000 pounds of biochemical oxygen demand; and 3,170 tons of sediment are transported annually. These values, adjusted to estimate transport loads for the full watershed, are set forth in Table 57, along with technical adjustments made subsequently by the USGS staff.

As already noted, the MEUL method provides an alternative means of estimating transport loads at the mouth of the watershed. The MEUL method uses a simulation model—the LANDRUN model developed under the International Joint Commission's Menomonee River Pilot Watershed

Table 57

COMPARISON OF ESTIMATED TRANSPORT LOADS FOR THE PIKE RIVER WATERSHED

Pollutant	Transport Load (thousands of pounds per year)		
	SEWRPC Transport Analysis[a]	Sediment Rating Curve-Flow Duration Curve Method	MEUL Method
Total Nitrogen.	461	N/A	N/A
Total Phosphorus . . .	36	N/A	37
Biochemical Oxygen Demand. . .	337	N/A	N/A
Sediment.	8,370[b]	23,746	24,400

NOTE: N/A indicates data not available.

[a] *Since the measured transport loads in the SEWRPC Transport Analysis are based on data for the Pike River at Petrifying Springs Park Road, which drains 76 percent of the watershed area, the mean values of the loads were multiplied by a factor of 1.32 to estimate transport loads from the total watershed. It should be noted that the estimates as reported in SEWRPC Technical Report No. 21 include a recognized variance in the transport load values.*

[b] *The sediment yield value used to estimate this load was published in Measurements and Prediction of Sediment Yields in Wisconsin Streams, U. S. Geological Survey Water Resources Investigations 54-75, 1976. Based upon more recent analyses (May 9, 1980), the USGS staff estimates were revised to 28,300 thousand pounds per year (14,150 tons per year) for the Pike River watershed.*

Source: SEWRPC.

[17] *S. M. Hindall, Measurement and Prediction Sediment Yields of Wisconsin Streams, U. S. Geological Survey Water Resources Investigations, 1976, pp. 54-75.*

Study program—to estimate total phosphorus and sediment loadings from various land uses. The LANDRUN model was verified and calibrated with the use of extensive field monitoring data in the Menomonee River watershed. The loading rates applied in the application of the MEUL method are adjusted for different land slope classes, hydrologic soil groups, and land management practices. Delivery ratios are applied to these loads to estimate what proportion of the load is transported downstream to the mouth of the watershed. MEUL method unit loading rates for sediment and total phosphorus for the Pike River watershed are set forth in Table 58. Table 59 indicates the delivery ratios applied to loads from the various land uses to estimate transport loads at the mouth of the Pike River watershed. Urban areas with larger amounts of impervious areas and, in some cases, engineered storm water drainage systems have higher delivery ratios than the rural areas, from which a larger proportion of the loads can be retained or removed by over-land flow and instream processes. For the Pike River watershed, application of the MEUL method resulted in estimated annual pollutant transport loads of 37,000 pounds of total phosphorus and 12,200 tons of sediment, as shown in Table 57.

Sediment Rating Curve-Flow Duration Curve Method: The sediment rating curve-flow duration curve method is another technique of measuring sediment transport loads, or yield. Three steps are involved in estimating sediment yield for a watershed by applying the sediment rating curve-flow duration curve method. The first and second steps involve construction of a suspended sediment rating curve, and development of a flow duration curve for the watershed. The third step combines the information embodied in the two curves to obtain annual sediment yield, and the application of an appropriate adjustment for bed load.

Development of a Sediment Rating Curve: A suspended sediment rating curve is a graphic representation of the relationship of the daily average discharge from a watershed, expressed in cubic feet per second (cfs) per square mile, to the daily transport of suspended sediment from the watershed, expressed in

Table 58

MEUL METHOD UNIT LOADING RATES FOR THE PIKE RIVER WATERSHED

Land Use	Unit Load (pounds per acre per year) Sediment	Total Phosphorus
Low-Density Residential	822	1.69
Medium-Density Residential	2,511	3.32
High-Density Residential	5,450	4.24
Commercial	5,210	3.03
Industrial	7,781	6.04
Construction Activity	33,125	56.73
Park and Recreation	384	0.77
Woodland	15	0.03
Row Crops	1,298	2.68
Pasture	1,083	2.20
Wetland	1,503	4.65
Feedlots	40,678	156.65

Source: International Joint Commission, Menomonee River Pilot Watershed Study, Volume 5, Simulation of Pollutant Loadings and Runoff Quality (Draft), November 1979, and SEWRPC.

Table 59

MEUL METHOD DELIVERY RATES FOR THE PIKE RIVER WATERSHED

Land Use	Delivery Ratio
Low-Density Residential	0.22
Medium-Density Residential	0.72
High-Density Residential	0.72
Commercial	0.72
Industrial	0.72
Construction Activity	0.28
Park and Recreation	0.13
Woodland	0.13
Row Crops	0.13
Pasture	0.13
Wetland	0.13
Feedlots	0.13

NOTE: These delivery ratios are applied to the total phosphorus and sediment loads generated by the application of the unit loading rates set forth in Table 58 to estimate transport loads at the mouth of the Pike River.

Source: International Joint Commission, Menomonee River Pilot Watershed Study, Volume 5, Simulation of Pollutant Loadings and Runoff Quality (Draft), November 1979, and SEWRPC.

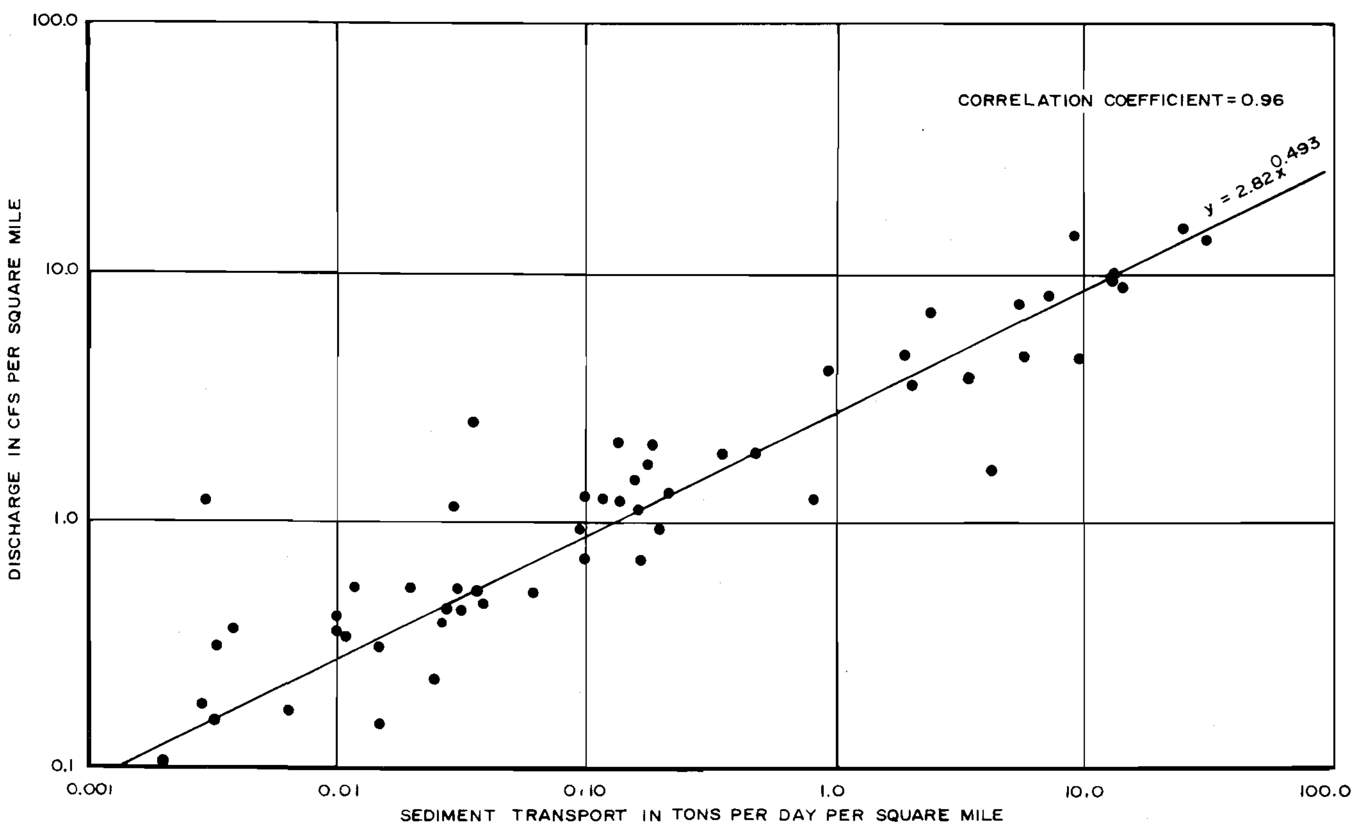
tons per day per square mile. The resulting relationship is similar to a discharge rating curve—stage as a function of discharge—in that it depicts the sediment transport capacity of an urban stream as a function of discharge.

A total of 56 pairs of suspended sediment transport-daily discharge values were used to construct the sediment ratings curve for the Pike River. The suspended sediment and streamflow data were available from the U. S. Geological Survey for the Pike River at Petrifying Springs Park Road. The sediment rating curve for the Pike River is presented in graphic form in Figure 35, as is an equation representing the transport-discharge relationship for the watershed.

The scatter of points about the lines corresponding to the best mathematical fit of the sediment-discharge data clearly indicates that the sediment rating curve is an approximation of a complex physical phenomenon. That is, the scatter indicates that sediment transport, although primarily a function of discharge, is also dependent on other factors not explicitly accounted for in the relationship. Other potentially important factors are moisture conditions and sediment accumulation prior to runoff events; the nature of the causative event, that is, rainfall or snowmelt or a combination of rainfall-snowmelt; the areal distribution of rainfall or snowmelt in the basin; basin size and slope; storm water drainage system characteristics; and the extent and nature of construction activities. Because the aggregate mathematically fitted relationship shown in Figure 35 is used only to estimate mean annual sediment yield, errors inherent in the relationship, as indicated by the scatter of data points tend to compensate and should thus provide a reasonably accurate estimate of average annual suspended sediment yield.

Figure 35

RELATIONSHIP BETWEEN SEDIMENT TRANSPORT AND DISCHARGE FOR THE PIKE RIVER WATERSHED



Source: SEWRPC.

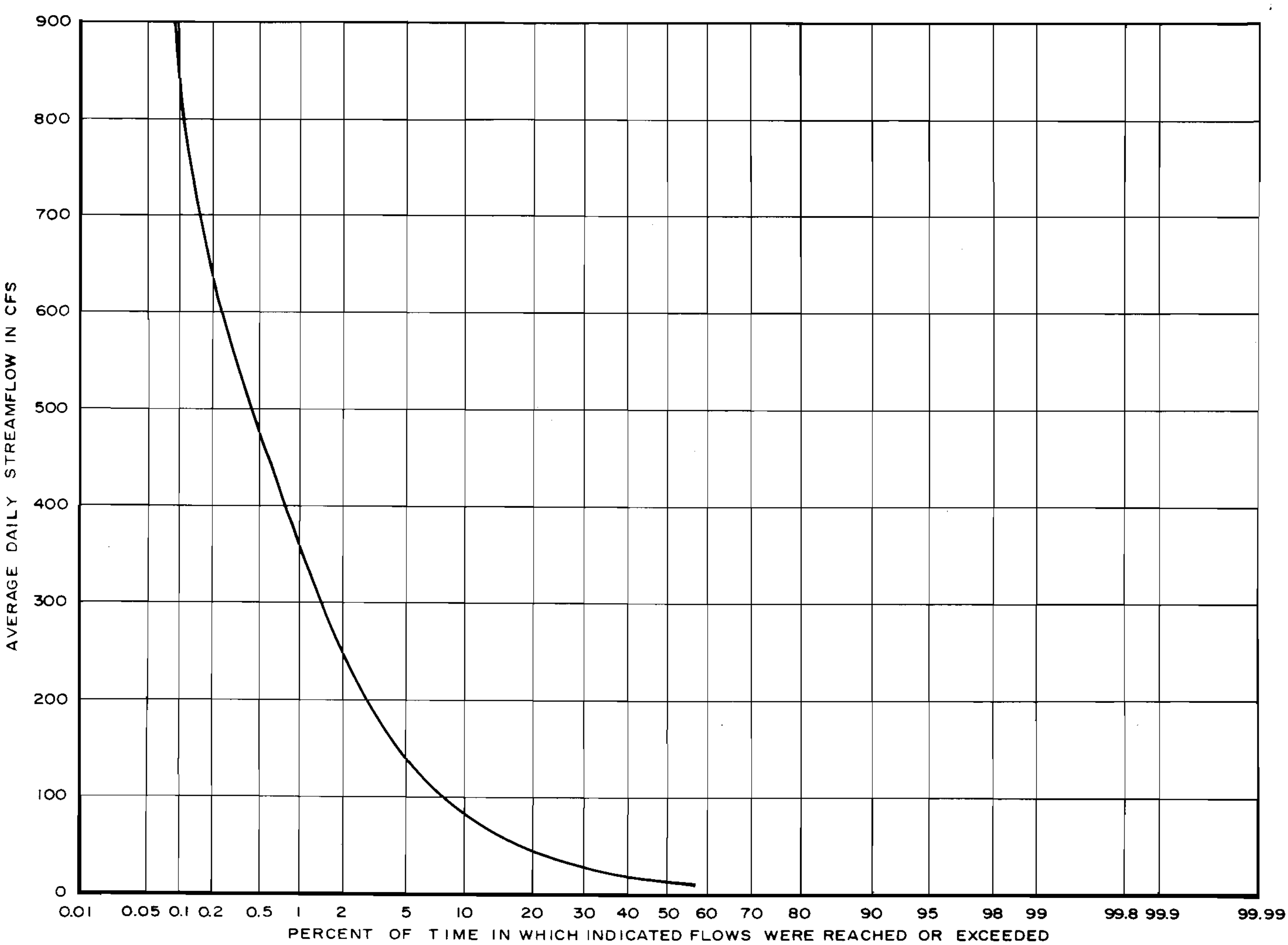
Development of Flow Duration Curve: A flow duration curve is a cumulative frequency curve indicating the percentage of time that a specified discharge may be expected to be equaled or exceeded. Measured streamflow data from the period of October 1971 through September 1978 were used to generate existing condition average daily discharges for the Pike River at Petrifying Springs Park Road. These discharges were statistically analyzed to develop the flow duration curve shown in Figure 36.

Combination of Sediment Rating and Flow Duration Relationships: As already noted, the average annual yield of suspended sediment at a point on a watershed stream system may be estimated by combining the relationship between sediment transport and discharge, as embodied in the suspended sediment rating curve, with the relationships between discharge and frequency, as embodied in the flow duration curve. The aggregate sediment rating curve shown in Figure 35 was combined with the flow duration curve shown in Figure 36 using the tabular procedure set forth in Table 60.

Daily discharge rates were divided into 18 classes, and the number of days per year in which the flow is likely to be in each class was determined. Average annual suspended sediment load was calculated by summing the products of days per year

Figure 36

FLOW DURATION CURVE FOR THE PETRIFYING SPRINGS PARK ROAD BASED ON MEASURED DATA FROM OCTOBER 1971-SEPTEMBER 1978



Source: SEWRPC.

Table 60

ESTIMATED AVERAGE ANNUAL SUSPENDED SEDIMENT YIELD FOR THE PIKE RIVER WATERSHED STUDY AT PETRIFYING SPRINGS PARK ROAD

Average Daily Discharge Range[a] (cubic feet per second)	Days Within Flow Range[a]		Sediment Transport	
	Percent of Year	Number of Days per Year	Tons per Square Mile per Day[b]	Tons per Square Mile per Year
0-10	44.00	160.6	0.002	0.32
11-20	17.00	62.1	0.018	2.92
21-30	9.00	32.8	0.05	1.64
31-40	6.00	21.9	0.10	2.19
41-50	5.00	18.3	0.17	3.11
51-60	3.00	11.0	0.25	2.75
61-70	3.00	11.0	0.35	3.85
71-80	2.00	7.3	0.47	3.43
81-90	2.00	7.3	0.60	4.38
91-100	1.00	3.6	0.76	2.74
101-200	5.00	18.3	1.91	34.95
201-300	1.00	3.6	5.37	19.33
301-400	1.00	3.6	10.62	38.23
401-500	0.4	1.5	17.69	26.54
501-600	0.3	1.1	26.58	29.24
601-700	0.09	0.3	37.29	1.12
701-800	0.04	0.1	49.85	4.99
More than 800	0.17	0.6	56.82	34.09
Annual Total	100.00	365.0	- -	215.82

[a]*From flow-duration relationship.*

[b]*From sediment rating relationship as a function of discharge.*

Source: U. S. Geological Survey and SEWRPC.

that each flow class occurred and the corresponding sediment transport rate as determined from Figure 35.

As shown in Table 60, the suspended sediment load per square mile of the Pike River watershed is estimated at 216 tons per year. Increasing this value 10 percent to account for the bed load, the total average sediment yield per unit area of the watershed is estimated at 237 tons per square mile per year. Applying this unit sediment yield to the 39-square-mile portion of the watershed upstream of Petrifying Springs Park Road, which consititutes 76 percent of the total watershed area, produces a total average annual sediment yield from that portion of the watershed of about 9,243 tons. Applying the unit sediment load of 237 tons per square mile per year to the entire Pike River watershed produces a total average annual sediment yield of about 11,873 tons.

The sediment yield data set forth in Table 60 also illustrate the importance of storm water runoff flows in generating sediment yields. Over 87 percent of the annual sediment yield is generated during streamflows exceeding 100 cubic feet per second, which occur only about 8 percent of the time.

Table 61 compares the sediment yields estimated by the application of the sediment rating curve-flow duration curve method for the Milwaukee River, Menomonee River, Kinnickinnic River, Root River, Fox River, and Pike River watersheds. The

Table 61

COMPARISON OF ESTIMATED SEDIMENT YIELDS IN SELECTED WATERSHEDS OF SOUTHEASTERN WISCONSIN

Watershed	Drainage Area of Sediment Sample Site (square miles)	Sediment Yield (tons per square mile per year)
Kinnickinnic River . . .	20	450.0
Pike River	39	237.0
Menomonee River. . . .	123	97.5
Root River.	187	96.3
Milwaukee River	686	61.1
Fox River	868	20.2

Source: SEWRPC.

comparison indicates that smaller watersheds tend to have higher sediment yields on a unit-area basis than larger watersheds have. The reported average suspended sediment yield for the seven-county Southeastern Wisconsin Region, excluding bedload, was about 50 tons per square mile per year.[18]

Comparison of Transport Loads: A comparison of estimated transport loads is set forth in Table 57. The total phosphorus transport load estimated by the Model Enhanced Unit Loading (MEUL) method is very similar to the phosphrous load estimated by the SEWRPC transport analysis. The sediment transport loads estimated by the MEUL method, by the Sediment Rating Flow Duration Curve method, and by a recently updated application of one method used by the U. S. Geological Survey are also quite similar. Table 57 therefore indicates that the three methods of estimating pollutant transport loads give results which are consistent.

Comparison of Transport Loads to Unit Load Analysis: These two different methods were utilized in order to provide a comparability check on the estimates of the major pollutant sources in the watershed. The unit loading analysis set forth in SEWRPC Technical Report No. 21 provides drainage channel pollutant loads, i.e., the overbank delivered pollutant loads to the perennial and intermittent stream and drainage system of the Pike River watershed. The MEUL method provides watershed transport loads, i.e., the loads transported to the downstream end of a watershed or subwatershed. Estimates of both channel and transport loads are useful to an understanding of the pollution sources and conditions in a watershed, and a comparison of these two different loading estimates provides an insight into the factors affecting nonpoint source pollutant load contributions to the streams and the transport of these pollutants through the stream system. The drainage channel pollutant loads are an important measure of relative pollutant loading conditions and the more localized importance of pollutant sources throughout an entire watershed. Transport loading estimates are important when considering information relative to the total pollutant loading to a downstream point such as the mouth of the Pike River at Lake Michigan.

Since the MEUL method develops watershed transport load estimates for nonpoint source pollutants on the basis of the land uses in a watershed, the comparison was made at a level of the resulting urban and rural nonpoint source proportions of the total estimated loads. Table 62 summarizes the results of the application of the MEUL method loading rates and delivery ratios to the Pike River watershed and compares resultant transport loads to the watershed drainage channel pollutant loads generated by the application of the SEWRPC Technical Report No. 21 loading rates. Point source load estimates from SEWRPC Technical Report No. 21 are used with the MEUL method nonpoint source load estimates to estimate total pollutant transport from the watershed. This assumes that the point source loads exhibit essentially complete transport to the mouth of the river.

Review of the results of these two different analytical methods indicates that there is a reasonable relationship between the loading estimates. Comparisons were made for total urban nonpoint and total rural nonpoint watershed loads. The comparison of loads for each individual detailed land use category was not deemed appropriate since the two methods of estimating loads were developed independently, at a systems level of accuracy, and on the basis of research study reports from different time periods, thus reflecting changes in the state-of-the-art of pollutant load estimating.

[18] *S. M. Hindall and R. F. Flint, "Sediment Yields of Wisconsin Streams," Hydrologic Investigations Atlas HA-367, U. S. Geological Survey, Washington, D. C., 1970.*

Table 62

SUMMARY COMPARISON OF ESTIMATED CHANNEL AND TRANSPORT LOADINGS FROM POLLUTANT SOURCES IN THE PIKE RIVER WATERSHED: 1975

Source	Parameter	Estimated Pollutant Loads Presented in Pounds per Year, Except for Fecal Coliform Presented in Counts x 10^8 per Year, and Sediment Presented in Tons per Year			
		SEWRPC Technical Report No. 21 Drainage Channel Loads[a]		MEUL Method Transport Load[b]	
		Total Estimated Loading	Percent of Total	Total Estimated Loading	Percent of Total
Urban Point	Phosphorus	4,750	7	4,750	13
	Sediment	35	<1	35	<1
Urban Nonpoint	Phosphorus	47,620	67	23,720	64
	Sediment	69,730	50	10,140	83
Urban Source Totals	Phosphorus	52,370	74	28,470	77
	Sediment	69,765	50	10,175	83
Rural Nonpoint	Phosphorus	18,910	26	8,690	23
	Sediment	68,475	50	2,030	17
Total Nonpoint Sources	Phosphorus	66,530	93	32,410	87
	Sediment	138,205	100	12,170	100
Total Sources	Phosphorus	71,280	100	37,160	100
	Sediment	138,240	100	12,205	100

[a]*See SEWRPC Technical Report No. 21, Sources of Water Pollution in Southeastern Wisconsin: 1975. These drainage channel pollutant loads represent pollutant contributions from very small drainage areas. Only a portion of these loads would be delivered to the major stream channel and to the mouth of the Pike River.*

[b]*The point source loads under the MEUL method are those presented in SEWRPC Technical Report No. 21. Since the MEUL method does not include a component for point source loads, these were added to obtain a total loading comparison. The MEUL method loads represent the portion of the total watershed load transported to the mouth of the Pike River.*

Source: SEWRPC.

Accordingly, it was concluded that comparisons of load proportions at the most detailed level of land use categories were not warranted.

As could be expected, the MEUL method results in total phosphorus and sediment transport load quantities from nonpoint sources which are generally lower than the quantities estimated from drainage channel pollutant loads in SEWRPC Technical Report No. 21. The transport loads of phosphorus and sediment from nonpoint sources, as estimated by the MEUL method, represent 49 percent and 9 percent of the drainage channel pollutant loads of phosphorus and sediment, respectively, as estimated in SEWRPC Technical Report No. 21. The transport loads are expected to be lower than the drainage channel pollutant loads because only a portion of the total amount of pollutants contained in storm water runoff—i.e. drainage channel pollutant loads—is transported to the mouth of the river—i.e., transport loads. This expected relationship between drainage channel pollutant loads and transport loads is demonstrated by the review of both the total urban and the total rural nonpoint source loads. The percent of the total phosphorus load contributed by the total of all urban nonpoint sources—much of which is dissolved phosphorus—is nearly identical for drainage channel and transport pollutant loads (67 percent versus 64 percent). The MEUL method analysis indicates that the transport of sediment from all urban nonpoint sources constitutes about

80 percent of the total sediment transport load, while Technical Report No. 21 indicates that about 50 percent of the total sediment drainage channel load is contributed by urban nonpoint sources. This difference in percentage of total sediment loads can be attributed, in part, to a significantly greater transport of particulate materials from impervious storm sewered urban surfaces than from the pervious rural surfaces, as demonstrated by the MEUL method analysis.

With regard to rural nonpoint sources, the proportion of the total phosphorus load contributed by runoff from cropland and other rural land is similar for channel loads and transport loads. However, the proportion of the total sediment load contributed by rural nonpoint sources is lower for the transport load than it is for the drainage channel pollutant load. The MEUL method analysis results demonstrate the effective pollutant removal properties in rural areas, especially for sediment loads from cropland and other rural land. Nevertheless, phosphorus sediment loads from rural nonpoint sources constitute a significant portion—about one-fifth—of the total transport load of these pollutants in the Pike River watershed.

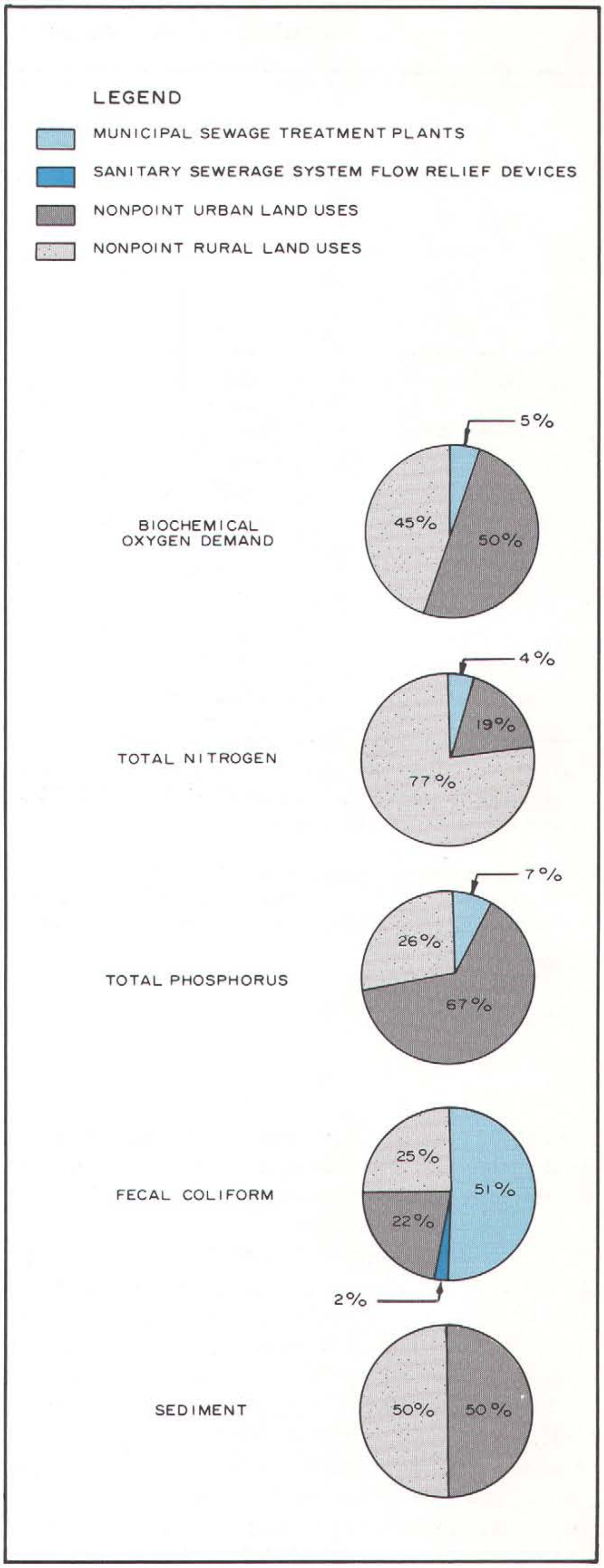
Pollution Sources: Overview

Figure 37 provides a graphic summary of average annual loads of selected pollutants to the stream network of the Pike River watershed, from point and nonpoint sources. The following observations may be made and conclusions may be drawn based on the identification, characterization, and quantification of pollution sources:

- There were, in 1975, two municipal sewage treatment plants in the Pike River watershed which contributed 3 percent of the total average annual flow from the watershed and 30 percent of the total point source flow. The average annual contribution of biochemical oxygen demand, total nitrogen, total phosphorus, and sediment from municipal point sources is small, ranging from less than 1 percent to 7 percent of the total annual transport of such materials from the watershed. Fecal coliform loads, however, have historically been significant, about 50 percent of the total, due chiefly to bypasses and overloaded conditions from the former Village of Sturtevant sewage treatment plant. The two municipal point sources are located in the upper portions of the watershed, with one discharging to Waxdale Creek at Sturtevant and one discharging to the Somers Branch of Pike Creek.

Figure 37

SUMMARY OF AVERAGE ANNUAL POLLUTANT YIELDS FROM SOURCES IN THE PIKE RIVER WATERSHED



Source: SEWRPC.

- Sanitary sewage enters the surface water system of the watershed through two types of flow relief devices, consisting of six crossovers and two bypasses. These flow relief devices are concentrated in the lower watershed in the City of Kenosha except for one bypass located at the Sturtevant sewage treatment plant on the upper portion of the Pike River, and one pumping station bypass[19] in the Town of Mt. Pleasant also located in the upper portion of the watershed. A bypass located at the Town of Somers Sewer Utility District No. 1 sewage treatment plant on Somers Branch of Pike Creek was sealed off in 1978 when an addition to the plant was put into operation. When compared to other pollution sources in the watershed, these flow relief devices do not have a severe impact on instream water quality conditions as they contribute a maximum of 3 percent of any of the total channel loads of pollutants studied. However, all of these flow relief devices should be abated as a source of pollution because they constitute public health hazards in the immediate vicinity of the discharge point; they cause objectional aesthetic conditions; and they are symptomatic of excessive clear water entering the sanitary sewer system and, therefore, may indicate potential basement flooding and hydraulic overloads of the sanitary sewerage system. These devices should be eliminated, except where they must be maintained to protect sewage treatment units against extreme events which are beyond planned design conditions.

- Five industrial establishments which discharge wastewaters through eight outfalls are known to exist in the watershed and constitute an important component of the hydraulic budget of the basin, accounting for 9 percent of the total average annual flow from the basin and about 67 percent of the total point source flow. These eight industrial outfalls all normally discharge spent cooling waters which are reported to contain no or very low concentrations of pollutants. While these industrial outfalls should not have adverse effects on stream water quality, it should be noted that there may be water quality problems occasionally associated with spills of substances which may, as a result of accidental or intentional discharge with the spent cooling waters, contribute pollutants to the surface waters of the watershed. The industrial discharges are all located in the upper portions of the watershed, with three outfalls discharging to the Pike River near Sturtevant, two outfalls to Sorenson Creek, and three outfalls to Waxdale Creek. The average annual contribution of biochemical oxygen demand, total phosphorus, total nitrogen, fecal coliforms, and sediment from these sources is, as already indicated, very small, contributing less than 1 percent to the total annual transport of these materials from the watershed.

- Nonpoint source pollution includes materials washed from the atmosphere, land surface, or subsurface by rainfall, by snowmelt, or by seepage waters, and conveyed to surface waters. The majority of potential pollutants accumulated on or near the land surface may be traced to a variety of man's activities or to the effects of man's activities. Nonpoint sources account for a major portion of the total annual pollutant load imposed on the surface waters of the Pike River watershed: 95 percent of the biochemical oxygen demand, 96 percent of the total nitrogen, 93 percent of the total phosphorus, 46 percent of the fecal coliform, and nearly 100 percent of sediment.

- Of the total nonpoint source pollutant load to the watershed, urban and rural sources are estimated to contribute approximately equal amounts of biochemical oxygen demand, fecal coliform counts, and sediment. Rural sources are located primarily in the upper watershed and contribute about 80 percent of the nonpoint nitrogen loading and 30 percent of the nonpoint phosphorus loading. The remaining nonpoint source load, from urban sources, is contributed primarily in the lower reaches of the watershed.

- During dry weather conditions, the recommended temperature and pH standards are met virtually all of the time. Violations of the ammonia nitrogen standard occur infrequently—only about 10 percent of the time—in the upstream portion of the watershed in the Pike River main stem below the

[19] *This bypass was eliminated on March 28, 1980.*

Village of Sturtevant sewage treatment plant. The phosphorus, dissolved oxygen, and fecal coliform standards are violated from 20 to 60 percent of the time during dry weather conditions, indicating point sources and inplace pollutants to be major sources of these conditions during periods of low flow when streamflow capacity for dilution of pollutants is limited.

- During wet weather conditions, the established temperature, pH, dissolved oxygen, and ammonia nitrogen standards are met nearly all of the time. However, the recommended phosphorus and fecal coliform standards are violated more than 50 percent of the time during wet weather indicating that major contributions of these pollutants are related to nonpoint sources.

- Pollutant sources identified in the Pike River watershed can be categorized into point sources, urban nonpoint sources, and rural nonpoint sources. Known point sources of pollution include eight sanitary sewage flow relief devices, two municipal sewage treatment plants, and five industrial sources which have eight outfalls. Nonpoint sources of pollution include materials washed from the atmosphere, and the land surface or subsurface, by rainfall, by snowmelt, or by seepage waters. In urban areas, these pollutants are conveyed to the surface waters directly or, as in many cases in the Pike River watershed, via one of the four storm sewer systems located in the watershed. As of 1975, urban land uses comprised about 28 percent of the Pike River watershed,with the approximately 6.3 square miles of residential land use being about one-half of the total urban land. Other significant factors in the urban nonpoint effect on water quality conditions in the watershed were the approximately 1.2 square miles of commercial land use and 0.7 square mile of industrial land use, and the septic tanks which served about 4,200 persons. The approximately 1.2 square miles of land under construction is also a potential source of nonpoint source pollutants. Rural lands comprised about 72 percent of the watershed, with pollutant loadings from the 32.4 square miles of cropland and the estimated 980 livestock equivalents being the most significant rural pollutant sources.

SUMMARY

The activities of man and the occurrences of nature affect and are affected by the quality of surface water. In a watershed, such as the Pike River watershed, the effects of human activities on water quality tend to overshadow the natural influences. A comprehensive watershed planning program must assess water quality conditions and, if pollution problems exist, or are likely to develop, must address the abatement of such problems in the plan preparation phase of the work. This chapter determines the extent to which surface waters in the Pike River watershed have been and are polluted, and identifies the sources of that pollution.

The term "water quality" encompasses the physical, chemical, and biological characteristics of water. Water is deemed to be polluted when foreign substances caused by, or related to, human activities are in such form and concentration as to render the water unsuitable for desired beneficial uses. Water pollution may be classified as one or more of the following eight types, depending on the nature of the substance causing the pollution: toxic pollution, organic pollution, nutrient pollution, pathogenic or disease-carrying pollution, thermal pollution, sediment pollution, radiological pollution, and aesthetic pollution. Water pollution is relative in the sense that determination of whether or not a particular water resource is polluted is a function of the intended use of that water resource; that is, water may be polluted with respect to some uses and not polluted with respect to others.

Many parameters or indicators are available for measuring and describing water quality. The parameters used in analyzing water quality conditions in the Pike River watershed include temperature, dissolved solids, suspended solids, specific conductance, turbidity, hydrogen ion concentration (pH), chloride, dissolved oxygen, biochemical oxygen demand, total and fecal coliform bacteria counts, phosphorus and nitrogen forms, aquatic flora and fauna, heavy metals, pesticides, and polychlorinated biphenyls (PCB's).

Water quality standards supporting water use objectives for the watershed surface water system provide a scale against which historic and existing water quality can be judged. For purposes of the comparative water quality analysis set forth in this chapter, the water quality standards corresponding to the "warmwater fishery and aquatic life, recreational use and minimum standards" objectives

established under the areawide water quality management planning program, in conformance with the national water quality objectives cited in Public Law 92-500, have been used.

A distinction must be drawn between instream water quality during dry weather conditions and during wet weather conditions. Dry weather instream quality reflects the quality of groundwater discharged to the stream plus the continuous or intermittent discharge of various point sources, such as industrial cooling or process waters and leakage or other continuous discharges from municipal wastewater treatment facilities. While instream water quality during wet weather conditions includes the above discharges, the dominant influence—particularly during major rainfall or snowmelt events—is the load from soluble and insoluble substances washed into the streams by stormwater runoff. This runoff moves from the land surface to the stream waters by overland routes, such as drainage ditches and streets and highway ditches and gutters, or by the underground storm sewer system. Wet weather conditions—defined as being days on which 0.10 inch or more of precipitation occurs—may be expected to occur on an average of 18 percent of the days in a given year in the Pike River watershed.

A variety of data sources, based primarily on field studies and dating back to 1955, were used to assess the historic and existing water quality in surface water in the Pike River watershed. Most of the historic water quality monitoring information available for the watershed represents dry weather conditions with some information available on wet weather conditions and relatively little information on either dry or wet weather condition concentrations of such more exotic pollutants as heavy metals, pesticides, and polychlorinated biphenyls (PCB's).

The past studies have shown that high concentrations of pollutants are more likely to occur during wet weather conditions in the Pike River watershed than during dry weather conditions. The ratio of measured wet weather to measured dry weather pollutant concentrations ranges from 0.8 to 3.13. The ratio of wet weather to dry weather pollutant transport values ranges from 2.3 to 13 and is significantly greater than the ratio of wet weather to dry weather concentrations. That is, as may be expected, wet weather conditions generally have a greater impact on pollutant transport from the watershed than on pollutant concentrations, since wet weather causes significant dilution in the stream systems in addition to causing the increased pollutant loading.

During dry weather conditions, the recommended temperature and pH standards appear to be satisfied in the Pike River system virtually all of the time. Infrequent violations—about 10 percent of the time—of the ammonia nitrogen standard are noted in the upstream portion of the watershed below the Village of Sturtevant sewage treatment plant. In contrast, the phosphorus, dissolved oxygen, and fecal coliform standards are violated from 20 to 60 percent of the time during dry weather conditions.

During wet weather conditions, the established temperature, pH, and ammonia nitrogen standards appear to be satisfied nearly all of the time; dissolved oxygen standards were met nearly all of the time in the upstream reaches and about 80 percent of the time in the downstream reaches; and the recommended phosphorus and fecal coliform standards appear to be violated most of the time.

An adequate assessment of the magnitude and extent of toxic and hazardous substance contamination of the Pike River watershed cannot be made from the limited data available.

The benthic community in the watershed is composed of large populations of pollutant tolerant species and only limited populations of intolerant species, a situation indicative of polluted to semipolluted conditions.

Of the eight potential types of surface water pollution, all but thermal and radiologic pollution are known to exist to at least some degree in the Pike River watershed. The quality of the surface waters of the Pike River watershed generally does not support warmwater fishery and aquatic life objectives, nor does it generally support recreational use objectives.

Commission inventories indicate that as of 1975 the major sources of water pollution in the Pike River watershed included two municipal sewage treatment plants; eight sanitary sewage flow relief devices; private onsite sewage disposal systems serving about 4,200 residents; residential, commercial, and industrial land runoff; sediments from construction erosion; agricultural cropland runoff; and livestock wastes. Other land uses and the five industrial establishments, which discharged spent cooling waters through a total of six outfalls were found to contribute relatively minor amounts of pollutants to the Pike River and its tributaries.

Point source pollutant loads in the Pike River watershed were estimated by utilizing measured data obtained under the Wisconsin Pollution Discharge Elimination System. Pollutant loads from all other sources were estimated based on information presented in SEWRPC Technical Report No. 21, Sources of Water Pollution in Southeastern Wisconsin: 1975. Based on these analyses, urban sources of pollution are estimated to contribute 23 percent of the nitrogen, 74 percent of the phosphorus, 56 percent of the biochemical oxygen demand, 75 percent of the fecal coliform, and 51 percent of the sediment which occur as water pollutants to the Pike River. Of this urban total, nonpoint sources account for 82 percent of the nitrogen, 91 percent of the phosphorus, 90 percent of the biochemical oxygen demand, 29 percent of the fecal coliform, and nearly all of the sediments contributed by urban sources. Point sources were estimated to contribute the balance of the urban total load: 18 percent of the nitrogen, 9 percent of the phosphorus, 10 percent of the biochemical oxygen demand, 71 percent of the fecal coliform, and less than 1 percent of the sediment. Of the total pollutant loads, rural pollutant sources—all nonpoint in nature—contribute an estimated 77 percent of the nitrogen, 26 percent of the phosphorus, 44 percent of the biochemical oxygen demand, 25 percent of the fecal coliform, and 49 percent of the sediment from all sources.

As an alternative to the unit load analysis, which estimates drainage channel pollutant loads from very small drainage areas, methods can be used to estimate transport loads at the mouth of the watershed. These methods indicate the proportions of the drainage channel pollutant loads which are actually delivered to the mouth of the watershed. The transport loads from nonpoint sources as estimated by the Commission represent 79 percent of the nitrogen, 50 percent of the phosphorus, 26 percent of the biochemical oxygen demand, and 9 percent of the sediment, when compared to the drainage channel pollutant loads estimated by the unit load analysis.

Chapter VIII

WATER RESOURCE SIMULATION MODEL

INTRODUCTION

A quantitative analysis of watershed hydrology, hydraulics, and water quality under existing and alternative future conditions is a fundamental requirement of any comprehensive watershed planning effort. Of particular interest to the watershed planning process are: 1) those aspects of the hydrology and hydraulics of the watershed which affect peak flood discharges and stages and, therefore, floodland management planning; and 2) those aspects which affect water quality conditions, such as periods of critically low streamflows or of washoff from the land surface, and therefore water quality management planning.

Discharge, stage, and water quality at any point and time within the surface water system[1] of a watershed are a function of three factors. The first is the meteorological events which determine the amount of runoff and, therefore, not only the amount of water that the stream system must carry in times of high flow, but also base flow levels and the amounts of water available for various instream uses including the maintenance of a fishery, recreation, and waste assimilation. The second factor is the nature and use of the land, with emphasis on those features that affect the quantity and temporal distribution of runoff and the quality of that runoff. The third factor is those stream characteristics that determine the manner in which runoff from the land moves through the stream system. These characteristics significantly influence flood discharges and stages, and the rate at which pollutants are either assimilated within or transported from the watershed.

Recently developed water resources engineering techniques make it possible to calculate existing and future hydrologic, hydraulic, and water quality conditions in a watershed as influenced by the above three factors. These techniques involve the formulation and application of mathematical models that simulate[2] the behavior of the surface water system. These models, which are usually programmed for digital computer application, permit the necessary quantitative analysis of hydrology, hydraulics, and water quality under existing and alternative future conditions as required in the comprehensive watershed planning effort.

The purpose of this chapter is to describe the Water Resource Simulation Model—actually a combined hydrologic, hydraulic, water quality, and flood economics model—used in the Pike River watershed planning program. More specifically, this chapter discusses model selection, the submodels contained within the model, input data requirements and data base development, and model calibration.[3] Not all of the voluminous quantity of input and output data resulting from the modeling effort is included in this report. However, data not included are available in Commission files.

[1] *A system is defined as 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.*

[2] *Simulation is defined as reproduction of the important behavioral aspects of the system. It should be emphasized that simulation, as used in comprehensive watershed planning, does not normally achieve, or need to achieve, exact duplication of all aspects of system behavior.*

[3] *For further background information on water resources modeling, including discussions of the need for, and nature of, modeling, discrete event versus continuous process models, and the use of algorithms, see Chapter VIII of SEWRPC Planning Report No. 26, A Comprehensive Plan for the Menomonee River Watershed, Volume One, Inventory Findings and Forecasts, October 1976.*

It is important to emphasize that the model used in the Pike River watershed planning program, or more specifically the mathematical computations and logic decisions executed during the operation of that model, are no more and no less sophisticated or valid than the operations which could, with sufficient personnel and time, be accomplished manually. The only advantage of digital computer simulation over manual computations is the rapidity of the computer computations. The application of mathematical simulation models to water resources planning and engineering was dependent on the development of a computational device—the digital computer—capable of rapidly making, without error, voluminous repetitive calculations and logic operations and was not dependent on an increased understanding of hydrologic, hydraulic, and water quality processes. In fact, most of the hydrologic, hydraulic, and water quality phenomena included in the most sophisticated water resource simulation models were known and formulated many years prior to the advent of simulation, some as early as the eighteenth century. Because of the staff and time requirements and associated monetary costs, it would have been impractical to manually execute the computations necessitated in even a single application of the model used in the Pike River watershed study.

MODEL USED IN THE PIKE RIVER WATERSHED PLANNING PROGRAM

Model Selection Criteria

Prior to the selection by the Commission in 1974 of a hydrologic-hydraulic-water quality-flood economics model for use in the Menomonee River watershed planning program, that proposed planning program as well as the water resource problems of that watershed were examined in order to determine the applicability of simulation modeling. Based on that examination, it was determined that the "ideal" model should:

1. Be able to simulate the hydrology, hydraulics, and water quality conditions of streams and watercourses in both rural and urban areas.

2. Be able to compute 100-year recurrence interval flood discharges and stages with sufficient accuracy for use in delineating floodland regulatory districts and areas.

3. Be able to calculate a wide range of flood discharges and stages for federal flood insurance study purposes.

4. Be able to accurately incorporate the effects of hydraulic structures such as bridges, culverts, and dams and of localized floodland encroachments on upstream and downstream flood discharges and stages.

5. Be able to compute average annual flood damages and costs and benefits of alternative floodland management measures.

6. Be able to accurately incorporate the hydrologic and hydraulic effects of land use changes—particularly the effects of the conversion of land from rural to urban uses—not only within the floodlands but within the entire tributary watershed.

7. Be able to accurately incorporate the hydrologic and hydraulic effects of alternative structural flood control works, such as channelization, dikes and floodwalls, and storage impoundments.

8. Permit assessment of the impact on surface water quality of discharges from point sources of pollution such as municipal and industrial discharges.

9. Permit assessment of the impact on surface water quality of diffuse, or nonpoint, sources of pollution, such as organic materials and plant nutrients washed from the land surface or leached out of soil profiles.

In addition to the application of these nine criteria which pertain directly to the needs of the Menomonee River watershed planning program—and which are also applicable to the Pike River watershed planning program—the model selection process involved two determinations related to the overall work program of the Commission. First, because the installation of a new model, or a portion of a new model, requires considerable staff time and expense, maximum use should be made of existing in-house models. Second, the model selected for use in the Commission watershed planning programs should have the potential to substantially fill the water resource simulation modeling needs of other ongoing or scheduled Commission water resources planning programs. During the time period in which the model was being selected and implemented on the Commission's computer system for the Menomonee River watershed study—approximately June 1974 to April 1975—the Commission was either participating in or planning to undertake the following major water resource-related studies: The International Joint Commission Menomonee River pilot watershed study,[4] the Kinnickinnic River watershed planning program,[5] and the areawide water quality planning and management program.[6] Since it was anticipated that the model or portions of it would be extensively used in these and other Commission water resources planning programs over a period of several years, it was deemed desirable to select a flexible model and one for which some formal model maintenance, refinement, and extension services were available.

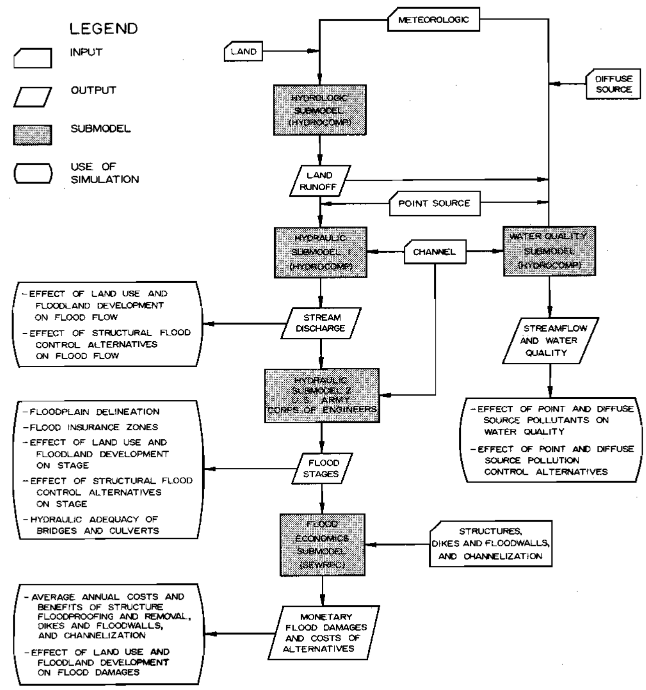
Model Selection

No single digital computer model existed that had the capability of meeting all of the selection criteria. Therefore, the modeling requirements were satisfied by using a combination of several different existing digital computer programs—a model "package"—that could be used in sequence to satisfy the modeling needs of the Commission water resource-related planning programs. Figure 38, which graphically illustrates the overall structure of the selected model, identifies five submodels, or computer programs, within the model that perform the calculations; shows the relationships between these submodels; indicates the input and output of each submodel; and indicates the uses of the simulation model results. The set of submodels contains both continuous process and discrete event submodels selected so as to maximize the favorable features of each of the two basic model types.

The Hydrologic Submodel, Hydraulic Submodel 1, and the Water Quality Submodel are three computer programs contained within a program package called "Hydrocomp Simulation Programming."[7] This computer program, which is available on a proprietary basis through the consulting firm Hydrocomp, Inc., has been under development since the early 1960's, when pioneer work in hydrologic-hydraulic modeling was initiated at Stanford University.[8] In 1972, the Hydrocomp firm added water quality simulation capability to the model. The Hydrocomp programming—that is, the Hydrologic Submodel, Hydraulic Submodel 1, and the Water Quality Submodel—are continuous process submodels that were installed on the SEWRPC computer system in late 1974 and early 1975.

Figure 38

HYDROLOGIC-HYDRAULIC-WATER QUALITY-FLOOD ECONOMICS MODEL USED IN THE PIKE RIVER WATERSHED PLANNING PROGRAM



Source: SEWRPC.

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[4] *Wisconsin Department of Natural Resources, University of Wisconsin System—Water Resources Center, and Southeastern Wisconsin Regional Planning Commission, Menomonee River Pilot Watershed Study Work Plan, September 1974.*

[5] *Southeastern Wisconsin Regional Planning Commission, Kinnickinnic River Watershed Planning Program Prospectus, November 1974.*

[6] *Southeastern Wisconsin Regional Planning Commission, Study Design for the Areawide Water Quality Planning and Management Program for Southeastern Wisconsin, 1975-1977, revised August 1975.*

[7] *Hydrocomp, Inc., Hydrocomp Simulation Programming Operations Manual, Fourth Edition, January 1976; and Hydrocomp, Inc., Hydrocomp Water Quality Operations Manual, April 1977.*

[8] *N. H. Crawford and R. K. Linsley, Digital Simulation in Hydrology: Stanford Watershed Model IV, Technical Report No. 39, Department of Civil Engineering, Stanford University, July 1966.*

The submodel identified as Hydraulic Submodel 2 is the U. S. Army Corps of Engineers Program called "Water Surface Profiles."[9] This discrete event, steady state model was provided to the Commission without cost by the Hydrologic Engineering Center of the Corps of Engineers and is continuously maintained by the Center at no cost to the Commission. This large computer program has been used extensively by the Commission in its floodland management planning and plan implementation activities since mid-1972,[10] and has been operable on the Commission computer system since February 1974. The Flood Economics Submodel is an extension of a computer program originally prepared by the Commission staff in November 1973 for the purpose of conducting an economic analysis of floodland management alternatives along the North Branch of the Root River in the City of West Allis.

Each of the five submodels is described briefly below. These separate discussions emphasize the function of each submodel within the overall modeling scheme, the types of algorithms that are contained within each submodel, data needs, and the kinds of output that are provided.

Hydrologic Submodel: The principal function of the Hydrologic Submodel is to determine the volume and temporal distribution of flow from the land to the stream system. As used here, the concept of runoff from the land is broadly interpreted to include surface runoff, interflow, and groundwater flow to the streams. The amount and rate of runoff from the land to the watershed stream system are largely a function of two factors. The first is the meteorological events which determine the quantity of water available on or beneath the land surface and the second key factor is the nature and use of the land.

The basic conceptual unit on which the Hydrologic Submodel operates is called the hydrologic land segment. A hydrologic land segment type is defined as a unique combination of meteorological characteristics such as precipitation and temperature, land characteristics such as the proportion of land surface covered by impervious surfaces, soil type, and slope. A strict interpretation of this definition results in a virtually infinite number of unique hydrologic land segment types within even a small watershed because of the large number of possible combinations of meteorological characteristics, land characteristics, and soils which exhibit a continuous, as opposed to discrete, spatial variation throughout the watershed. To apply the concept, the study area is divided into hydrologic land segments. A hydrologic land segment is defined as a surface drainage unit which exhibits a runoff pattern characteristic of a unique hydrologic land segment type. Thus the practical, operational definition of a hydrologic land segment is a surface drainage unit consisting of a subbasin, or a combination of subbasins, that are represented by a particular hydrologic land segment type. The hydrologic land segments were defined so as to provide a travel time of approximately one hour for flow through the segment, and so that simulated output data could be obtained at sites where historic water quality sampling data are already available or at points located upstream or downstream of known sources of pollution. As described later in this chapter, 12 hydrologic land segment types and 46 hydrologic land segments were identified within the Pike River watershed for the modeling of existing conditions.

The hydrologic processes explicitly simulated within the Hydrologic Submodel are shown in Figure 39. The submodel, operating on a time interval of one hour or less, continuously and sequentially maintains a water balance within and between various hydrologic processes. The water balance accounting procedure is based on the interdependence between the various hydrologic processes shown schematically in Figure 40. The Hydrologic Submodel maintains a running account of the quantity of water that enters, leaves, and remains within each phase of the hydrologic cycle during each successive time interval.

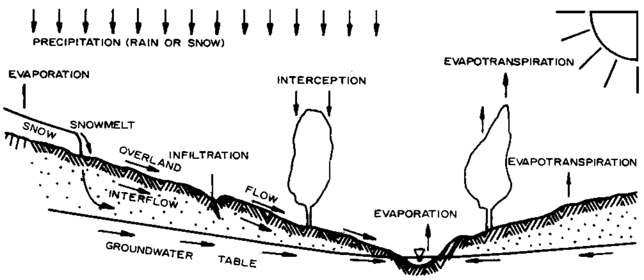
As already noted, the volume and rate of runoff from the land is determined by meteorological phenomena and the nature and use of the land. Therefore, meteorological data and land data constitute the two principal types of input data for each land segment type in the Hydrologic Submodel. Table 63 identifies eight categories of historic meteorological data sets, seven of which are input directly or indirectly to the Hydrologic

[9] *U. S. Army Corps of Engineers, Hydrologic Engineering Center, Computer Program 723-X6-L202A, HEC-2, Water Surface Profiles Users Manual, Davis, California, November 1976.*

[10] *From late 1970 to mid-1972, the Commission used the U. S. Army Corps of Engineers program "Backwater-Any Cross-Section," the predecessor of the current program.*

Figure 39

PROCESSES SIMULATED IN THE HYDROLOGIC SUBMODEL



Source: Hydrocomp, Inc. and SEWRPC.

Submodel for each land segment type, and notes the use of each data set. The procedures used to acquire or develop the eight different types of meteorological data sets used in simulating the hydrologic response of the Pike River watershed land surface are described later in this chapter.

Table 64 identified the 16 land and 12 snow parameters that are input to the Hydrologic Submodel for each hydrologic land segment type and indicates the primary source of numerical values for each parameter. The numerical values assigned to each of these land parameters for a given land segment have the effect of adapting the Hydrologic Submodel to the land segment type. The procedures used to assign values to the land parameters for each hydrologic land segment type are described later in this chapter.

Hydraulic Submodel 1: The primary function of Hydraulic Submodel 1 is to accept as input the runoff from the land surface in combination with point and groundwater discharges as produced by the Hydrologic Submodel, to aggregate it, and to route[11] it through the stream system, thereby producing a continuous series of discharge values at predetermined locations along the rivers and streams of the watershed. Computations proceed at a time interval of an hour or fraction thereof.

[11] *Routing refers to the process in which a streamflow hydrograph for a point at the entrance to a river reach or an impoundment, such as a lake or reservoir, is significantly attenuated—that is, the peak flow is reduced and the base lengthened—through the reach or impoundment as a result of either temporary channel-floodplain storage or temporary impoundment storage.*

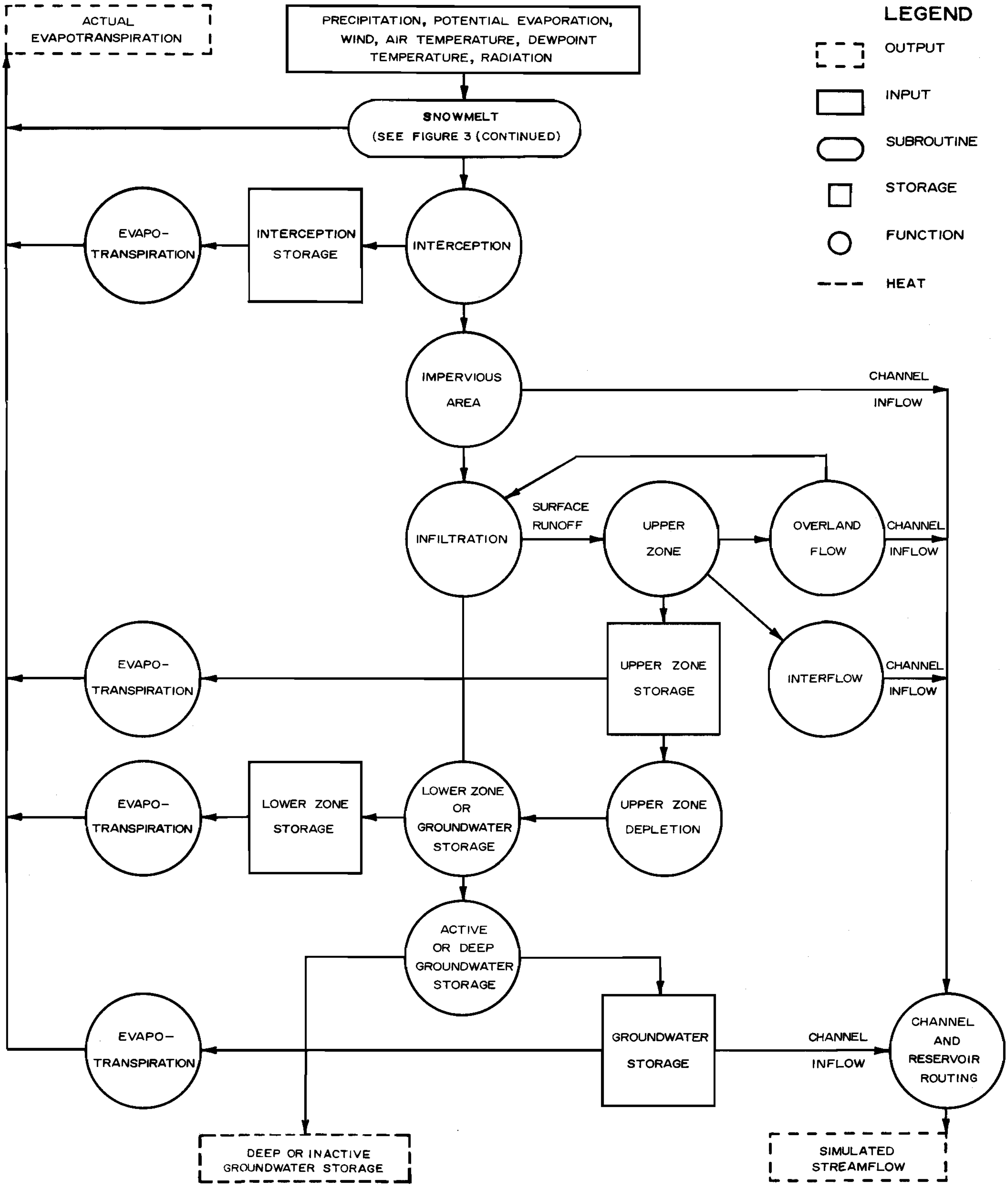
Statistical analyses performed on the resulting continuous series of discharges yield the various recurrence interval flood discharges that are then input to Hydraulic Submodel 2 for calculation of stage. Stages are also computed by Hydraulic Submodel 1, but because of the highly simplified manner in which channel-floodplain geometry is represented in the model, these stages are not, in the opinion of the Commission staff, accurate enough for certain watershed planning purposes, including mapping of floodland regulatory zones, testing of the hydraulic adequacy of bridges and culverts, and determination of flood damages. The discharges produced by Hydraulic Submodel 1 are, however, judged adequate for all watershed planning applications.

Hydraulic Submodel 1 was also used as a discrete event simulation model, which involved utilizing, as input to the model, data characterizing discrete rainfall events which produce the various recurrence interval floods, operating the model at a 15-minute computational time interval, and generating as output the corresponding instantaneous peak discharges from the resulting hydrographs. This version of Hydraulic Submodel 1 was necessary for use on the headwater reaches of the Pike River and Pike Creek, and their tributaries because of the tendency for these small drainage basins to experience a rapid rise and fall of floodwaters, thus creating the possibility of the instantaneous peak discharge not being correctly simulated because the model would be otherwise operated at too large a computational time interval—such as one-hour interval or greater. More specifically, selected total rainfall amounts for specified duration rainfall events—as shown in Figure C-2 of Appendix C—were distributed over their respective durations at 15 minute time intervals and thus applied to generate the simulated instantaneous peak flood discharge for the specified recurrence interval event.[12] Hydraulic Submodel 1 was thus operated at a 15-minute computational time interval for each duration rainfall event, which produced several hydrographs and corresponding instantaneous peak discharges for the various duration rainfall events. The largest instantaneous peak discharge obtained from the various duration rainfall events for the particular recurrence interval flood was chosen for use in Hydraulic Submodel 2.

[12] *Michael L. Terstriep, and John B. Stall "The Illinois Drainage Area Simulator, ILLUDAS," Illinois State Water Survey, Bulletin 58, Urbana, 1974.*

Figure 40

INTERDEPENDENCE BETWEEN PROCESSES IN THE HYDROLOGIC SUBMODEL



Source: Hydrocomp, Inc. and SEWRPC.

Table 63

METEOROLOGICAL DATA SETS AND THEIR USE IN THE HYDROLOGIC AND WATER QUALITY SUBMODELS

Data Set	Units	Frequency		Origin of Data		Use in Hydrologic Submodel	Use in Water Quality Submodel	Use in Synthesizing Other Meteorological Input Data for the Submodels
		Desirable	Allowable	Historic	Computed			
Precipitation	10^{-2} inches	Hourly or more frequent	Daily	X	—	Rain or snowfall applied to the land Data from hourly stations used to disaggregate data from daily stations	—	—
Radiation	Langleys/Day[a]	Daily	Semimonthly	—	X	Snowmelt	Water temperature-heat flux to water by short wave solar radiation	Compute potential evaporation
Potential Evaporation	10^{-3} inches	Daily	Semimonthly	—	X	Evaporation from lakes, reservoirs, wetlands, depression storage, and interception storage Evapotranspiration from upper zone storage, lower zone storage, and groundwater storage Evaporation from snow	—	—
Temperature	^{o}F	Daily (maximum and minimum)	—	X	—	Snowmelt Density of new snow Occurrence of precipitation as snow	Water temperature-heat flux to water surface by long wave solar radiation Water temperature-heat flux from water by conduction-convection	Average daily temperature used to compute evaporation
Wind Movement	Miles/Day	Daily	—	X	—	Snowmelt by condensation-convection Evaporation from snow	Water temperature-heat loss from water surface by evaporation Lake reaeration	Compute evaporation
Dewpoint-Temperature[b]	^{o}F	Daily	Semimonthly	X	—	Snowmelt by condensation-convection Evaporation from snow	Water temperature-heat loss from water surface by evaporation	Compute evaporation
Cloud Cover	Decimal fraction	Daily	Semimonthly	X	—	—	Water temperature-heat flux to water surface by long wave solar radiation	—
Sunshine	Percent possible	Daily	—	X	—	Used indirectly	Used indirectly	Compute solar radiation which was in turn used to compute evaporation

[a] *Solar energy flux, that is, the rate at which solar energy is delivered to a surface—such as the earth's surface—is expressed in terms of energy per unit area per unit time. The langley expresses energy per unit area and is equivalent to 1.0 calories/cm^2 or 3.97 x 10^{-3} BTU/cm^2. Therefore, a langley/day, which expresses solar energy flux in terms of energy per unit area per unit time, is equivalent to 1.0 calories/cm^2/day or 3.97 x 10^{-3} BTU/cm^2/day. The solar energy flux above the earth's atmosphere and normal to the radiation path is about 2,880 langleys/day.*

[b] *Dewpoint temperature is the temperature at which air becomes saturated when cooled under conditions of constant pressure and constant water vapor content.*

Source: Hydrocomp, Inc., and SEWRPC.

Table 64

PARAMETERS REQUIRED FOR EACH HYDROLOGIC LAND SEGMENT TYPE SIMULATED WITH THE HYDROLOGIC SUBMODEL

Parameter Number	Parameter Symbol	Definition or Meaning	Unit	Primary Source of Numerical Values[a]
1	K1	Ratio of average annual segment precipitation to average annual precipitation at measuring station	None	Isohyetal map of annual precipitation
2	A	Impervious area factor related to directly connected impervious area in segment as a percent of total area	None	Aerial photographs
3	EPXM	Maximum interception storage	Inches	Extent and type of vegetation as determined from aerial photographs and field examination
4	UZSN	Nominal transient groundwater storage in the upper soil zones	Inches	A function of LZSN and therefore determined primarily by calibration
5	LZSN	Nominal transient groundwater storage in the lower soil zones	Inches	Related to annual precipitation but determined primarily by calibration
6	K3	Evaporation loss index: percent of segment area covered by deep-rooted vegetation	None	Extent and type of vegetation as determined from aerial photographs and field examination
7	K24L	Decimal fraction of the groundwater recharge that percolates to deep or inactive groundwater storage	None	- -b
8	K24EL	Decimal fraction of land segment with shallow groundwater subject to direct evapotranspiration	None	Soils and topographic data
9	INFILTRATION	Nominal infiltration rate	None	Calibration
10	INTERFLOW	Index of interflow	None	Calibration
11	L	Average length of overland flow	Feet	Topographic maps
12	SS	Average slope of overland flow	None	Topographic maps
13	NN	Manning roughness coefficient for overland flow	None	Field reconnaissance
14	IRC	Interflow recession rate	None	Hydrograph analysis
15	KK24	Groundwater recession rate	None	Hydrograph analysis
16	KV	Variable to permit the KK24 to vary with the groundwater slope	None	- -b
17	RADCON	Adjust theoretical snowmelt equations to field conditions	None	- -b
18	CONDS-CONV	Adjust theoretical snowmelt equations to field conditions	None	- -b
19	SCF	Adjust snowfall measurements to account for typical catch deficiency	None	- -c
20	ELDIF	Elevation of segment above mean elevation of temperature station	10^3 feet	Topographic maps
21	IDNS	Density of new snow at 0°F	None	- -b
22	F	Decimal fraction of land segment with forest cover	None	Aerial photographs
23	DGM	Groundmelt rate attributable to conduction of heat from underlying soil to snow	Inches/day	- -b
24	WC	Maximum water content of the snowpack, expressed as a fraction of the water equivalent of the pack; that is, the maximum amount of liquid water that can be accumulated in the snowpack	None	- -c
25	MPACK	Water equivalent of snowpack when segment is completely covered by snow	Inches	- -b
26	EVAPSNOW	Adjust theoretical snow evaporation equations to field conditions	None	- -b
27	MELEV	Mean elevation of segment	Feet Sea Level Datum	Topographic map
28	TSNOW	Air temperature below which precipitation occurs as snow	°F	- -b

[a] *Regardless of the primary source of parameter values, all land parameters were subject to adjustment during the calibration process.*

[b] *Initial values were assigned based on experience with the Hydrologic Submodel on watersheds having similar geographic or climatological characteristics. See Chapter VIII of SEWRPC Planning Report No. 26, A Comprehensive Plan for the Menomonee River Watershed, Volumn 1, Inventory Findings and Forecasts, October 1976.*

[c] *Initial values were assigned based on information and data reported in hydrology textbooks. See R. K. Linsley, M. A. Kohler, and J. L. H. Paulhus, Hydrology for Engineers, Second Edition, McGraw-Hill, N.Y. 1975.*

Source: Hydrocomp, Inc., and SEWRPC.

In addition to maintaining a continuous accounting of inflow to the stream system, Hydraulic Submodel 1 performs two types of routing calculations—one for channel reaches and another for impoundments, that is, lakes and reservoirs. These two routing procedures are similar in concept in that both employ the conservation of mass principle and basic hydraulic laws. The procedures differ significantly, however, with respect to input data needs and the detailed manner in which the computations are executed. For the purpose of applying these two routing techniques, the channel system is divided into reaches and impoundment sites.

Reach routing is accomplished on a continuous basis using the kinematic wave technique. Application of this technique requires that the following information be provided for each reach: length; upstream and downstream channel invert elevation; a channel-floodplain cross-section consistent with a prismatic representation of the reach; Manning roughness coefficients for the channel and the floodplains, and size and other characteristics of the tributary drainage area. Table 65 identifies the 15 channel parameters that are input to Hydraulic Submodel 1 for each reach and indicates the primary source of numerical values for each. Numerical values assigned to each of these channel parameters for a given reach have the effect of adapting Hydraulic Submodel 1 to the reach. The principal means of establishing the channel parameters is direct observation or measurement of the watershed stream system. Additional information on the procedures used to assign values to the channel parameters for each channel reach is presented later in this chapter.

As simulated by the kinematic wave routing algorithm, a volume of flow enters the reach during a given time increment with the flow entering from the reach immediately upstream or coming directly from the land contiguous to the reach. The incremental volume of flow is added to that already in the reach at the beginning of the time interval, and the Manning equation is then used to estimate the discharge rate within the reach during the time increment and, thereby, the volume of flow that would discharge from the reach during the time increment. The volume of water in the reach at the end of the time increment is then calculated as the initial volume plus the inflow volume minus the outflow volume. The above computational process is then repeated for the next time increment and, as in the case for the first time increment, the average flow rate from the reach is obtained. The channel routing computations proceed in a similar manner for subsequent time increments in the reach in question and for all other reaches, thus effectively simulating the passage of flood waves through the channel system.

Impoundment routing through lakes or reservoirs is accomplished on a continuous basis using the technique known as reservoir routing. Use of this analytic procedure requires that a stage-discharge-cumulative storage table be prepared for each reservoir with the values selected so as to encompass the entire range of physically possible reservoir water surface elevations. As simulated by the reservoir routing algorithm, a volume of flow enters the impoundment during a particular time increment with the origin of the flow being discharge from a reach or impoundment immediately upstream and from land contiguous to the impoundment. The incremental volume of flow is added to that already in the impoundment at the beginning of the time interval, and the stage-discharge-cumulative volume relationship is then used to estimate the rate of discharge from the impoundment during the time increment. The volume of water stored in the impoundment at the end of the time increment is calculated as the initial volume plus the inflow volume minus the outflow volume. This computational process is then repeated for subsequent time increments with the result of each such computation being the stage of, and the discharge rate from, the impoundment at the end of each time increment. Any number of stage-discharge-storage relationships may be utilized for a given existing or potential lake or reservoir site, thus facilitating the simulation of a variety of potential outlet works and operating procedures.

Hydraulic Submodel 2: The primary function of Hydraulic Submodel 2 is to determine the flood stages attendant to the flood flows of specified recurrence intervals produced by Hydraulic Submodel 1. Given a starting discharge and stage, this "backwater" computer program employs the conservation principles of mass and energy to calculate river stages at successive, preselected upstream locations.

A computational procedure known as the "standard step method" is used in floodland reaches between hydraulic structures such as bridges, culverts, and dams. Given a discharge and stage at a starting floodland cross-section, a trial stage is

Table 65

CHANNEL PARAMETERS REQUIRED FOR EACH REACH SIMULATED WITH HYDRAULIC SUBMODEL 1

DISCHARGE-RELATED PARAMETERS

Parameter Number	Parameter Symbol	Definition or Meaning	Unit	Primary Source of Numerical Values
1	REACH	Reach identification number	None	Assigned so as to increase in the downstream direction
2	LIKE	Permits repeating W1, W2, H, S-FP, N-CH, and N-FP of a preceding reach by entering the number of that reach	None	--
3	TYPE[a]	Indicates the type of channel or the presence of an impoundment. RECT indicates a rectangular channel, CIRC indicates a circular conduit, and DAM indicates the presence of a dam and an impoundment	None	Observed condition of existing stream system or hypothetical future condition of stream system
4	TRIB	Identification number of the reach that the reach in question is tributary to	None	Stream system configuration and assigned identification numbers
5	SEGMT	Index number of land segment type tributary to reach	None	Map of watershed subbasins and stream system
6	TRIB-AREA	Watershed area directly tributary to reach	Square Miles	

CROSS SECTION-RELATED PARAMETERS

Parameter Number	Parameter Symbol	Definition or Meaning	Unit	Primary Source of Numerical Values
7	LENGTH	Length of reach	Miles	Map of watershed subbasins and stream system
8	EL-UP	Channel bottom elevation at upstream end of reach	Feet	Channel bottom profile
9	EL-DOWN	Channel bottom elevation at downstream end of reach	Feet	
10	W1	Channel bottom width	Feet	Generalized, representative reach floodland cross section constructed from detailed cross sections prepared for Hydraulic Submodel 2
11	W2	Channel bank-to-bank width	Feet	
12	H	Channel depth	Feet	
13	S-FP	Lateral slope of the floodplains	None	

ROUGHNESS COEFFICIENTS

Parameter Number	Parameter Symbol	Definition or Meaning	Unit	Primary Source of Numerical Values
14	N-CH	Manning roughness coefficient for the channel	None	Coefficients established for Hydraulic Submodel 2 revised as needed during calibration
15	N-FP	Manning roughness coefficient for both floodplains	None	

[a] *If TYPE is CIRC, then W1 is replaced with DIA—circular conduit diameter in inches—and W2 is replaced by NN-CH—Manning roughness coefficient for the conduit—and the following channel parameters are not needed: H, S-FP, N-CH, N-FP.*
If TYPE is DAM, then the channel parameters are replaced with a set of parameters describing the dam and its impoundment.

Source: Hydrocomp, Inc. and SEWRPC.

selected for the next upstream cross-section. The Manning equation for open channel flow is used to calculate the mechanical energy loss between the two cross-sections, and then a check is made to determine if the conservation of energy principle is satisfied. If not, another upstream stage is selected and tested, and the process repeated until the unique upstream stage is found at which the conservation of energy principle is satisfied. The above iterative computational process is then repeated for successive upstream floodland reaches. The end result is a calculated flood stage at each of the cross-section locations.

Hydraulic Submodel 2 also determines the hydraulic effect of a bridge or culvert and the associated approach roadways by computing the upstream stage as a function of the downstream stage, flood discharge, and the physical characteristics of the hydraulic structure. Starting downstream of the structure, the mechanical energy loss due to the expansion of the flow leaving the structure is computed, then the energy losses directly attributable to flow through or over the structure are calculated, and finally the energy loss due to contraction of the flow approaching and entering the structure is computed. Flow through or over a bridge or culvert may consist of various combinations of open channel flow, pressure flow, and weir flow depending on the position of the upstream stage relative to the low chord of the waterway opening and the profile of the roadway surface.

Input data for that portion of Hydraulic Submodel 2 that performs backwater computations through floodland reaches between hydraulic structures include flood discharges, channel-floodplain cross-sections including distances between such sections, and Manning roughness coefficients for the channel and each floodplain. Data requirements for that portion of Hydraulic Submodel 2 that calculates the hydraulic effect of bridges, culverts, and other hydraulic structures include channel bottom elevations, waterway opening measurements, pier position and shape, profiles along the approach roads and across the structure from one side of the floodland to the other, and dam crest shape and elevation.

The backwater computations assume proper waterway opening design and maintenance so that the full waterway opening of each bridge or culvert, as it existed at the time of the hydraulic structure inventory, is available for the conveyance of flood flow. In recognition of the fact that waterway openings can be temporarily blocked as a result of ice and buoyant debris being carried on floodwaters, floodplain regulations applicable to areas adjacent to or on the fringes of flood-prone areas normally require protection to an elevation equal to the 100-year recurrence interval flood stage plus a freeboard of two feet. A similar freeboard is normally used in the design of structural flood control works intended to convey 100-year flood flows such as dikes and floodwalls or major channel modifications.

Flood Economics Submodel: The Flood Economics Submodel fulfills two principal functions in the total simulation modeling. The first function is to calculate flood stage-damage relationships for urban riverine areas under a variety of developmental conditions which are then used in the submodel to estimate average annual monetary damages. The second key function of the Flood Economics Submodel is to calculate the cost of alternative flood control and floodland management measures, including the cost of floodproofing and of removal of flood-prone structures, the cost of alternative configurations of earthen dikes and concrete floodwalls, and the cost of major channel modifications. Capital costs as well as operation and maintenance costs are calculated by the submodel and the total costs are summarized on both a present worth and an average annual basis.

With the exception of certain minor refinements designed to make the Flood Economics Submodel more suitable for use in this study, the submodel is fully described in SEWRPC Planning Report No. 26, A Comprehensive Plan for the Menomonee River Watershed, Volume One, Inventory Findings and Forecasts.

Water Quality Submodel: The principal function of the Water Quality Submodel as used in the Pike River watershed planning program is to simulate the time-varying concentraton, or levels, of the following nine water quality indicators at selected points throughout the surface water system of the watershed: temperature, dissolved oxygen, fecal coliform, phosphate phosphorus, total dissolved solids, carbonaceous biochemical oxygen demand, ammonia nitrogen, nitrate nitrogen, and nitrite nitrogen. These indicators were selected because they are directly related to the water quality standards that support the adopted water use objectives set forth in Chapter X of this report.

The concentration of a particular water quality constituent in the surface waters of the watershed at a particular point and time is a function of three factors. The first is the temporal and spacial distribution of runoff—surface or overland runoff, interflow and baseflow—which determines the amount of water available to transport a potential pollutant to and through the surface water system. The second factor is the nature and use of the land, with emphasis on those features that affect the quantity and quality of point and nonpoint sources of pollutants. For example, a portion of a watershed that supports agricultural activity is a nutrient source for the surface waters. The third factor is the characteristics of the stream system which determine the rate and manner in which a potential pollutant is either assimilated in or transported from the watershed.

Simulation of the above three factors that influence instream water quality requires a large and diverse data base. As shown in Figure 38, operation of the Water Quality Submodel requires the input of six data sets—meteorological, land, channel, riverine-area structure, diffuse or nonpoint source, and point source—as well as output from the Hydrologic Submodel. Table 63 identifies the six categories of historic meteorological sets that are input directly or indirectly to the Water Quality Submodel and notes the use of each data set. The channel data required for the hydraulic portion of the Water Quality Submodel are similar to the data required for Hydraulic Submodel 1, (see Table 65). In addition, a considerable amount of nonhydraulic channel data must be provided. These data consist primarily of water quality parameters and coefficients such as the maximum benthic algae concentration and the deoxygenation coefficient for each reach.

The basic conceptual unit upon which the Water Quality Submodel operates is called the water quality land segment type. A water quality land segment type is defined as an area of land which exhibits a unique combination of meteorological characteristics such as precipitation and temperature, land characteristics such as the proportion of land surface covered by impervious surfaces, soil type slope, vegetative cover, and land management practices such as contour plowing on agricultural land and street sweeping in urban areas. A strict interpretation of this definition results in a virtually infinite number of unique water quality land segment types even within a small watershed because of the large number of possible combinations of the above-mentioned characteristics within a watershed that exhibit continuous, as opposed to discrete, spatial variations throughout the watershed. To apply the concept, the study area is divided into water quality land segments. A water quality land segment is defined as a surface drainage unit which exhibits the pollutant runoff characteristic of a unique water quality land segment type. Thus, the practical, operational definition of a water quality land segment is a surface drainage unit consisting of a subbasin, or a combination of subbasins, which can be considered to be represented by a particular water quality land segment type.

Water quality land segment types and water quality land segments are refinements of hydrologic land segment types and hydrologic land segments in that they incorporate the pollutant runoff characteristics of the land. For a given hydrologic land segment, the different types of land management practices that affect pollutant runoff will produce different water quality response although the same hydrologic response. Thus, several water quality land segments may have to be identified within a single hydrologic land segment.

A set of nonpoint pollution source data is required for each constituent that is to be modeled on each hydrologic-water quality land segment type. Each set of data contains monthly land loading rates of the pervious and impervious portions, expressed as a weight per unit area, and a loading limit for the pervious and impervious areas, expressed in weight per unit area of land surface. The nonpoint source data set for each land segment also contains the concentration of the constituent in the groundwater flow from the segment to the stream system. Each point source of pollution similarly requires a data set consisting of identification of the river reach to which the source discharges, a series of monthly volumetric flow rates, and a series of corresponding concentrations for each of the constituents to be modeled. The final category of input to the Water Quality Submodel is output from the Hydrologic Submodel which consists of hourly runoff volumes from the pervious and impervious portion of each hydrologic land segment as well as daily groundwater discharges to the stream system.

For the purpose of describing the operation of the Water Quality Submodel, the simulation process may be viewed as being composed of a land phase and a channel phase, each of which is simulated on an hourly basis. In the land phase, the quantity of a given constituent that is available for washoff from the land at the beginning of a runoff event is equal to the amount of material remaining on the land surface after the last runoff event plus the net amount of material that has accumulated on the land surface since the last runoff event. The hourly quantity of washoff from the land to the stream system during a runoff event is proportional to the amount of material on the land surface at the beginning of the interval and is also dependent on the hourly runoff rate. The above process is not used to simulate the temperature and dissolved oxygen of land runoff. The model assumes that the temperature of the runoff is equal to atmospheric temperature and that the runoff is fully saturated with dissolved oxygen. Pervious surface runoff and impervious surface runoff during and immediately after rainfall or rainfall-snowmelt events are the two mechanisms for transporting accumulated nonpoint source constituents from the land surface to the stream system. Groundwater flow is the mechanism for continuously transporting potential pollutants to the stream system from the subsurface of the watershed.

Operating on a reach-by-reach basis, the channel phase of the Water Quality Submodel uses kinematic routing to determine the inflow to, outflow from, and net accumulation of flow within each reach on an hourly basis. This is followed by a summation over the hourly interval of all mass inflows and outflows of each water quality constituent for the end of the period. The above channel phase computations are then repeated within the reach for subsequent time intervals and also are repeated for all other reaches. Water quality processes explicitly simulated within the Water Quality Submodel are shown in Figure 41.

DATA BASE DEVELOPMENT

The largest single work element in the preparation and application of the hydrologic-hydraulic-water quality-flood economics model is data base development. This consists of the acquisition, verification, and coding of data needed to operate, calibrate, test, and apply the model. The model data base for the Pike River watershed is a file of information that quantitatively depicts the characteristics or condition of the surface water system of the watershed.

As shown schematically in Figure 38, application of the model requires the development of an input data base composed of the following six distinct categories of information: meteorological data, land data, channel data, riverine-area structure data, nonpoint source data, and point source data. Each of the six data categories provides input to at least one of the five submodels. Of the six input data sets, the meteorological data set is the largest because it consists of 40 years of daily or hourly information for each of the eight historic meteorological data types. The meteorological data set is also the most critical in that experience with the model indicates that simulated discharges, stages, and water quality levels are very sensitive to how well the meteorological data set—particularly precipitation—represents historical meteorological conditions.

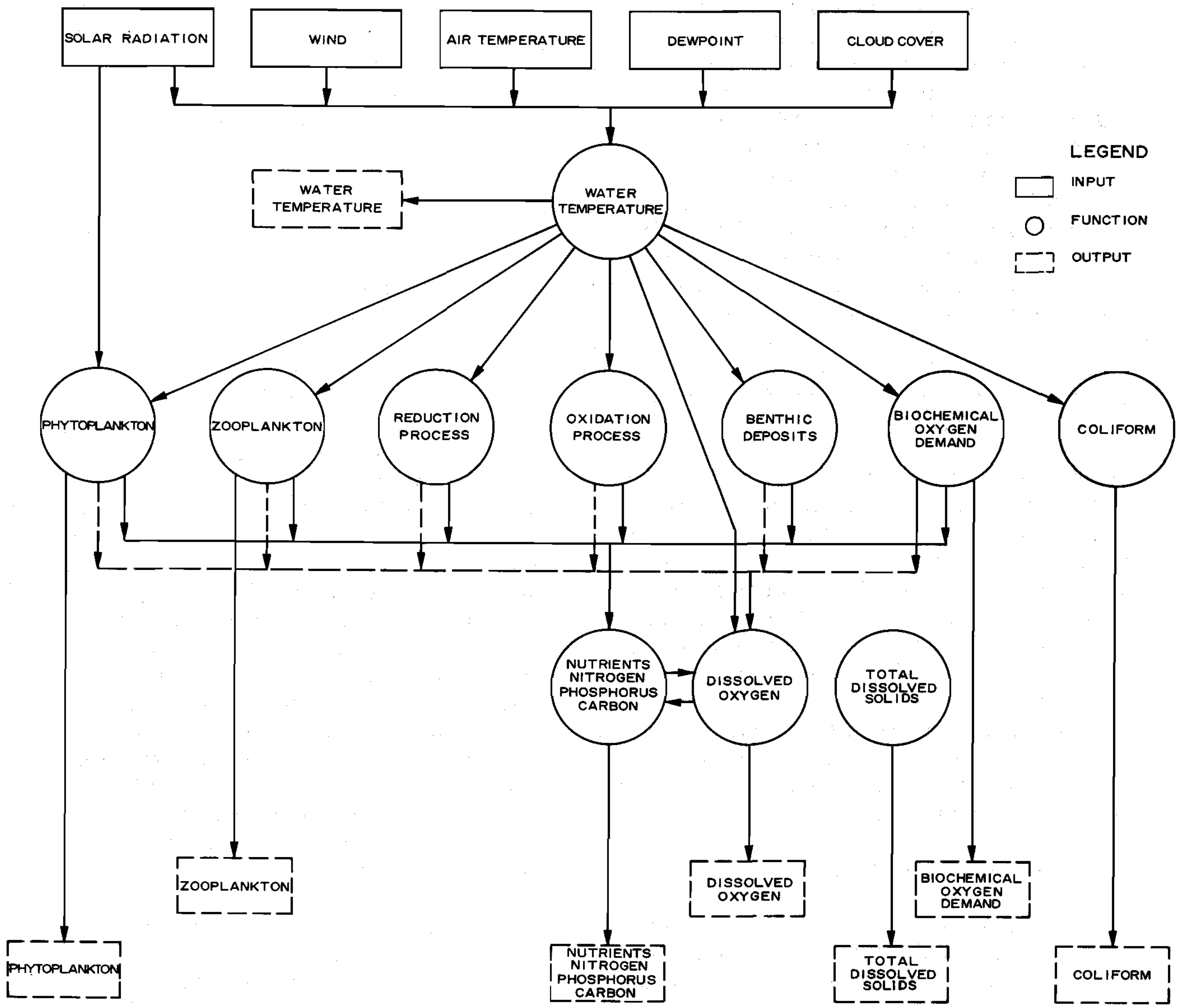
With respect to their origin, the data in the data base are largely historic in that they are based on existing records of past observations and measurements. For example, the bulk of the meteorological data in the data base are historic in that they are assembled from National Weather Service (NWS) records. Some of the data in the data base are original in that they were obtained by field measurements made during the watershed planning program. Most of the channel data, for example, were obtained from field surveys conducted during the course of the study. A small fraction of the data in the data base are synthetic in that they were calculated from other readily available historic data. Calculated data sets were used when historic data were not available and it would have been impossible or impractical to obtain original data. The solar radiation data used, for example, are synthetic in that they were computed from historic percent sunshine measurements because of the absence of long-term historic radiation observations in or near the watershed coupled with the impracticality of developing long-term original solar radiation data.

A distinction should be drawn between model input data and model calibration data. The six categories of data identified above constitute the input data for the model and constitute the data base needed to operate the various submodels in the model. Calibration data, which are discussed in a subsequent section of this chapter, are not required to operate the model, but are vital to the calibration of the model. The principal types of calibration data are streamflow, flood stage, and water quality.

Each of the six types of input data, as well as the validation data, is described separately in the following sections. The origin of each data set is described as are the procedures used to verify and code the information. In the case of some of

Figure 41

INTERDEPENDENCE OF PROCESSES IN THE WATER QUALITY SUBMODEL



Source: Hydrocomp, Inc. and SEWRPC.

the data types, the means of acquisition have been described in earlier chapters of this report or in another report, and, with the exception of a brief reference, will not be repeated in this chapter.

Meteorologic Data

As shown in Table 63, the following seven of the eight types of meteorological data are required as direct input to the Hydrologic and/or Water Quality Submodels: hourly precipitation, daily maximum-minimum temperature, daily wind movement, daily solar radiation, daily dewpoint temperature, daily potential evaporation, and daily cloud cover. Map 11 in Chapter III shows five National Weather Service meteorologic observation stations located in or near the watershed and the Thiessen polygon network which was constructed for the purpose of delineating the geographic area to be represented by each station. Almost the entire watershed lies within the Kenosha and Racine polygons and, therefore, the daily precipitation and maximum-minimum temperature data for these two stations were selected as being the most representative of the watershed. Hourly precipitation data for the Milwaukee station was used to disaggregate daily precipitation totals for the Kenosha and Racine stations.

The other required meteorological data sets—daily wind movement, daily solar radiation, daily dew-point temperature, daily potential evaporation, and daily cloud cover—were available or could be developed only for the Milwaukee station but were applied to the entire watershed. Therefore, the meteorological data base for the watershed is drawn entirely from historic data from three stations—Milwaukee, Kenosha, and Racine.

The process used to develop the meteorological data sets for the model is schematically depicted in Figure 42. Most of the meteorologic data base development was completed under the Commission's Menomonee River Watershed planning program.[13] The principal work element under the Pike River watershed planning program was a 32-month extension of the termination date of the meteorologic data base from April 30, 1977 to December 31, 1979.

Selected information about the six meteorological data sets used for the Hydrologic Submodel and Hydraulic Submodel is presented in Table 66. Meteorological data sets were developed for the 40-year period from 1940 through 1979. January 1, 1940, was selected as the starting date for the data sets since it marks the beginning of hourly observations at the Milwaukee station.

Land Data

As shown in Figure 38, land data are important in that they are needed to operate the Hydrologic Submodel, the output of which influences the four other submodels. Table 64 identifies the 28 land-related parameters that are required for each land segment type that is to be simulated. As defined earlier in this chapter, a land segment is a surface drainage unit consisting of a subbasin or a combination of contiguous subbasins that is represented by a particular meteorological station and contains a unique combination of three key land characteristics—soil type, slope, and land use-cover. Four land characteristics—meteorology, soil type, slope, and land use-cover—are the major determinants of the magnitude and timing of surface runoff, interflow, and groundwater flow from the land to the watershed stream system and therefore are the basis for hydrologic land segment identification and delineation. There are other land characteristics that may influence the hydrologic response of the land surface; for example, depth to bedrock, type of vegetation, and density of the storm water drainage system. However, the above four characteristics were selected for use as both the most basic and the most representative.

Identification of Hydrologic Land Segment Types: The process used to identify hydrologic land segment types in the watershed began with the subdivision of the watershed into subbasins using the procedure described in Chapter V. As shown on Map 30 in Chapter V, a total of 46 subbasins were delineated ranging in size from 0.06 to 2.18 square miles. These subbasins provided the basic "building blocks" for the identification of hydrologic land segment types and subsequently, for hydrologic-water quality land segment types in the watershed.

Influence of Meteorological Stations: As noted earlier in this chapter, and as shown on Map 11 in Chapter III of this report, a Thiessen polygon network was constructed for the watershed and surrounding areas in order to facilitate subdivision of the watershed into areas closest to the Kenosha and Racine meteorological stations. The polygon boundaries were approximated by subbasin boundaries and then each subbasin was assigned to either the Kenosha or Racine meteorological stations. Thus, each subbasin was associated with the closest meteorological station and therefore with the station most likely to be representative of the meteorological processes affecting the subbasin.

Hydrologic Soil Group: The soils of the Region have been classified into four hydrologic soil groups, designated A, B, C, and D, based upon those properties affecting runoff. In terms of runoff characteristics, these four soil groups range from Group A soils, which exhibit very little runoff because of high infiltration capacity, high permeability, and good drainage, to Group D soils, which generate large amounts of runoff because of low infiltration capacity, low permeability, and

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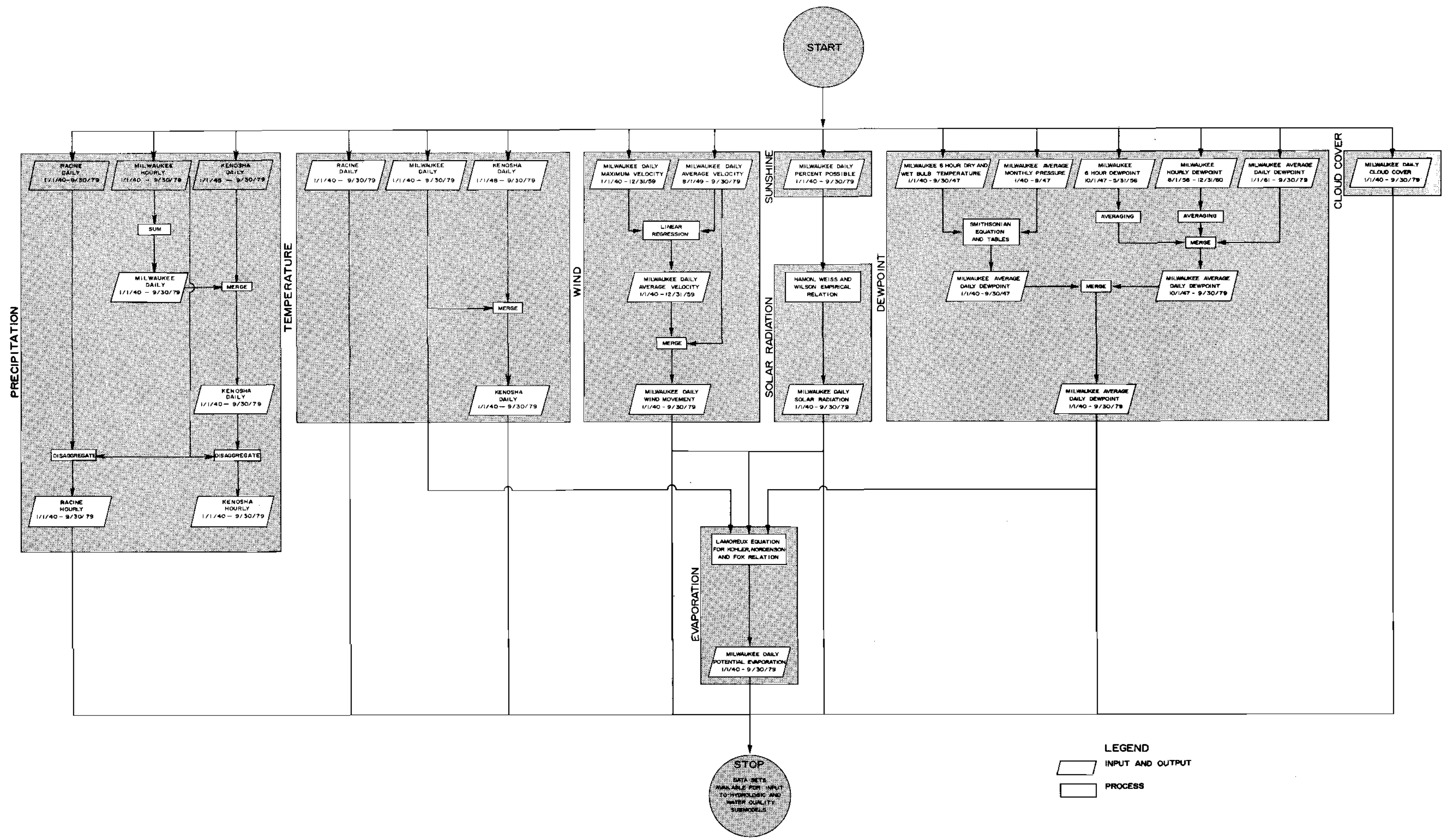
[13] *For a discussion of acquisition of the meteorologic data, double mass curve analysis, conduct of contingency checks, merging and disaggregation procedures, and use of empirical equations see Chapter VIII of SEWRPC Planning Report No. 26, A Comprehensive Plan for the Menomonee River Watershed, Volume One, Inventory Findings and Forecasts, October 1976.*

Figure 42

PROCESS USED TO DEVELOP METEOROLOGICAL DATA SETS FOR THE MODEL



Source: SEWRPC.

Table 66

SELECTED INFORMATION ON DATA SETS USED FOR THE HYDROLOGIC SUBMODEL AND HYDRAULIC SUBMODEL 1

Data Category	Data Type	Interval	Index Number of Data Set	Geographic Reference of Data: Name	National Weather Service Identification Number	U. S. Geological Survey Identification Number	Period of Data Set: From Month	From Day	From Year	To Month	To Day	To Year	Duration of Data Set (years)
Meteorological	Precipitation	Hourly[a]	10	Kenosha	474174	--	1	1	1940	12	31	1979	40
			14	Racine	476922	--	1	1	1940	12	31	1979	40
	Solar Radiation	Daily	41	Milwaukee	14839	--	1	1	1940	12	31	1979	40
	Potential Evaporation	Daily	43	Milwaukee	14839	--	1	1	1940	12	31	1979	40
	Wind Movement	Daily	47	Milwaukee	14839	--	1	1	1940	12	31	1979	40
	Dewpoint Temperature	Daily	49	Milwaukee	14839	--	1	1	1940	12	31	1979	40
	Maximum-Minimum Temperature	Daily	60	Kenosha	474174	--	1	1	1940	12	31	1979	40
			64	Racine	476922	--	1	1	1940	12	31	1979	40
Land	Land Parameters	--	36	--	--	--	--	--	--	--	--	--	--
	Land Surface Runoff	Hourly[b]	160	Segment 1	--	--	1	1	1940	12	31	1979	40
			161	Segment 2	--	--	1	1	1940	12	31	1979	40
			162	Segment 3	--	--	1	1	1940	12	31	1979	40
			163	Segment 4	--	--	1	1	1940	12	31	1979	40
			164	Segment 5	--	--	1	1	1940	12	31	1979	40
			165	Segment 6	--	--	1	1	1940	12	31	1979	40
			166	Segment 7	--	--	1	1	1940	12	31	1979	40
			167	Segment 8	--	--	1	1	1940	12	31	1979	40
			168	Segment 9	--	--	1	1	1940	12	31	1979	40
			169	Segment 10	--	--	1	1	1940	12	31	1979	40
			170	Segment 11	--	--	1	1	1940	12	31	1979	40
			176	Segment 17	--	--	1	1	1940	12	31	1979	40
Channel	Channel Parameters	--	38	--	--	--	--	--	--	--	--	--	--
Point Source	Industrial Discharge	Daily	143	Reach 5	--	--	1	1	1940	12	31	1979	40
			144	Reach 8	--	--	1	1	1940	12	31	1979	40
			145	Reach 9	--	--	1	1	1940	12	31	1979	40
			146	Reach 39	--	--	1	1	1940	12	31	1979	40
	Wastewater Treatment Facility Discharge	Daily	147	Reach 26	--	--	1	1	1940	12	31	1979	40
Calibration and Testing	Streamflow	Daily	141	Pike River	--	4087257	10	1	1971	9	30	1979	8
		Hourly	142	Pike River	--	4087257	10	1	1971	9	30	1979	8
	Annual Peak Discharge	--	--	Pike Creek	--	4087250	1	1	1960	12	31	1979	20

[a] *Hourly precipitation for Kenosha and Racine was produced by distributing the recorded daily precipitation at these two stations on an hourly basis according to the distribution of recorded hourly precipitation at the Milwaukee Station.*

[b] *Land surface runoff was simulated at an hourly interval for calibration purposes and long-term streamflow simulation of most of the watershed. However, nine small subwatersheds required short-term streamflow simulation at an interval of 15 minutes to properly simulate the effects of urbanization and existing storm water management facilities.*

Source: SEWRPC.

poor drainage. The Pike River watershed was determined to be primarily covered with Hydrologic Group C soils.

Slope: A watershed slope analysis was conducted by determining the ground slope at the center of each U. S. Public Land Survey quarter section. Topographic information required to estimate the ground slope was taken from 1" = 2000' scale, 10' contour interval, U. S. Geological Survey quadrangle maps since they provided good uniform coverage for the entire watershed. Although more accurate slope values could have been obtained from either large-scale topographic maps or from Commission soils maps, these sources of information were not used because the resulting accuracy would have exceeded that required by the model. The slope analysis indicated that while some relatively small areas of steep slope, ranging up to 7 percent, were scattered throughout the watershed, flat slopes of less than 4 percent predominated. Based on the flatness of the slopes throughout the watershed and previous slope sensitivity studies,[14] it was deemed not necessary to categorize subbasins as to slopes other than mild.

Land Use and Cover: The combination of land use and cover is the characteristic which most often reflects man's influence on the hydrologic proesses in that land use-cover, particularly in the Pike River watershed, is largely the result of man's activities. Land cover differs from land use in that it describes the types of surface—for example, paved, grassed, and wooded—whereas land use describes the purpose served by the land—for example, residential, commercial, and recreational. Consider two four-acre areas with identical population densities that may be assumed to represent medium-density residential land use. One area consists of a high-rise apartment building on 0.5 acre with recreation and open space on the remaining 3.5 acres. The other four-acre tract has single-family residences distributed over the entire area. From a hydrologic viewpoint, these two areas with identical land use but different land cover have different amounts of directly connected impervious surface and different amounts of area available for infiltration and, as a result, are likely to exhibit significantly different runoff volumes and peak flows. The combination of land use and cover is quantified and represented in the model for hydrologic modeling purposes through use of percent imperviousness.

Table 67 lists the four imperviousness categories defined for the purpose of identifying hydrologic land segments in the Pike River watershed. These four imperviousness categories encompass the full spectrum of existing and probable future conditions in the watershed. The four imperviousness categories were selected by first determining the relative area of each of eight land use-cover classifications within each of the watershed subbasins using 1975 1" = 400' scale Commission aerial photographs and corresponding land use data. A weighted average percent impervious value was calculated for each subbasin based on the relative areas of each land use-cover type using a percent imperviousness assigned to each of the eight land use-cover classifications. A frequency distribution of the subbasin percent imperviousness values and information from previous watershed studies were then used to select the four representative percent imperviousness categories.

Resulting Hydrologic Land Segment Types and Hydrologic Land Segments: Application of the above process yielded a total of 12 different hydrologic land segment types in the Pike River watershed. The 12 hydrologic land segment types used to represent the land surface of the Pike River watershed for hydrologic-hydraulic simulation are defined in Table 68 in terms of their hydrologic soil grouping, slope, imperviousness, and proximity to a meteorological station.

It should be noted that the land segment types reflecting imperviousness as a feature of different urban and rural land cover types, coupled with urban drainage efficiency as characterized in the hydrologic submodel, serve to distinguish between the effects on storm water runoff of lands having various types and densities of urban development. The imperviousness of different urban and rural land cover types is incorporated into the hydrologic submodel by expressing the percent for each particular land segment type. The drainage efficiency of a particular hydrologic land segment type can be represented in the hydrologic submodel by specifying the length of overland flow. In an urban area provided with an engineered storm sewer system, the length of overland flow is the average distance which storm water runoff must travel before reaching a street gutter, storm sewer inlet, or drainage channel. This length is much shorter in urban than in rural areas, and serves to increase the peak rate of runoff.

Thus the simulation model has the capability of differentiating between the rate of runoff from various densities of urban use, as well as between the rate of runoff from urban as opposed to rural land. This capability is particularly important in the preparation of a watershed plan which is to serve as a basis for integrating land use and flood control planning and development. The integrated plans can identify those areas of the watershed which are in urban use and those which are recommended to be converted from rural to urban use over the plan design period; and can calculate peak flood flows to be used in delineating flood hazard areas and in determining the hydraulic capacity of flood control works, recognizing the increases in flood flows that will accompany the planned land use conversion. Future conversions of land from rural to urban use in locations and at densities

[14] *See Chapter VIII of SEWRPC Planning Report No. 26, A Comprehensive Plan for the Menomonee River Watershed, Volume One, Inventory Findings and Forecasts, October 1976.*

Table 67

IMPERVIOUSNESS CATEGORIES IN THE PIKE RIVER WATERSHED AS DEFINED FOR THE HYDROLOGIC SUBMODEL

Identification Number	Description	Range of Percent Imperviousness	Typical Corresponding Land-Use Cover Combinations
1	Rural	0-8	Agricultural Lands, Woodlands, Wetlands, and Unused Lands
2	Low Imperviousness	9-20	Low-Density Residential with Supporting Urban Uses and Associated Land Cover
3	Low to Medium Imperviousness	21-33	Low- to Medium-Density Residential with Supporting Urban Uses and Associated Land Cover
4	Medium Imperviousness	34-45	Medium-Density Residential with Supporting Urban Uses and Associated Land Cover

Source: SEWRPC.

Table 68

HYDROLOGIC LAND SEGMENT TYPES REPRESENTATIVE OF THE PIKE RIVER WATERSHED

Identification Number of Hydrologic Land Segment Type	Most Influential Meteorological Station		Impervious Category				Subbasins In Watershed Represented by Land Segment Type	
	Kenosha	Racine	Rural	Low	Low to Medium	Medium	Number	Percent of Total
1	X	- -	X	- -	- -	- -	1	2.0
2	X	- -	- -	X	- -	- -	3	6.2
3	X	- -	- -	- -	- -	X	2	4.2
4	X	- -	X	- -	- -	- -	6	12.5
5	X	- -	- -	X	- -	- -	2	12.5
6	- -	X	X	- -	- -	- -	10	20.9
7	- -	X	- -	X	- -	- -	3	6.2
8	- -	X	- -	- -	X	- -	3	6.2
9	- -	X	X	- -	- -	- -	5	10.4
10	- -	X	X	- -	- -	- -	9	18.8
11	- -	X	- -	X	- -	- -	2	4.2
12	- -	X	- -	- -	X	- -	2	4.2
Total	- -	- -	- -	- -	- -	- -	48	100.0

Source: SEWRPC.

different, and in amounts greater than, those envisioned in the land use plan can be required to provide sufficient storage in the drainage system to maintain the post development peak rate of runoff at the predevelopment level.

The spatial distribution of the 12 hydrologic land segment types in the watershed under 1975 conditions are depicted on Map 37. The map also shows the actual 46 hydrologic land segments; that is, surficial drainage units as input to the model. Each hydrologic land segment consists of a subbasin or combination of contiguous subbasins that is within the influence of a given meteorological station and contains a unique combination of soil type, slope, and percent imperviousness, that is an area considered to be represented by a particular hydrologic land segment type.

Assignment of Parameters to Hydrologic Land Segment Types: Subsequent to identification of the hydrologic land segment types and delineation of the hydrologic land segments present in the watershed, numerical values were selected for each of the 28 land-related parameters required for each of the land segment types. Table 64 indicates that the numerical values were established in a number of ways including direct measurement of watershed characteristics, experience gained through previous application of the Hydrologic Submodel to watersheds having geographic and climatologic characteristics similar to the Pike River watershed, information taken from hydrology references, and calibration—under the Pike River Watershed planning program—of the Hydrologic Submodel and Hydraulic Submodel 1 against historic streamflow records. The calibration process, which is the principal means of assigning numerical values to four parameters,[15] is discussed later in this chapter.

Channel Data

Channel conditions including slope and cross-section are important determinants of the hydraulic behavior of a stream system. As indicated in Figure 38, channel data are needed to operate Hydraulic Submodel 1, Hydraulic Submodel 2, and the Water Quality Submodel. The channel data required for hydraulic Submodel 2 will be discussed first since the amount and detail of data required by Hydraulic Submodel 2 exceeds that needed for Hydraulic Submodel 1 and since the data needed for Hydraulic Submodel 1 is based on data assembled for Hydraulic Submodel 2.

Channel Data for Hydraulic Submodel 2: The following four types of channel data are required as input to Hydraulic Submodel 2: discharge; channel-floodplain cross-sections, including the distance between cross-sections; Manning roughness coefficients for the channel and each floodplain; and hydraulic structure—bridge, culvert, and dam—data. Hydraulic structure data include channel bottom elevations, waterway opening measurements, pier position and shape, profiles along the approach roads and across the structure from one side of the floodlands to the other, and dam crest shape and elevation.

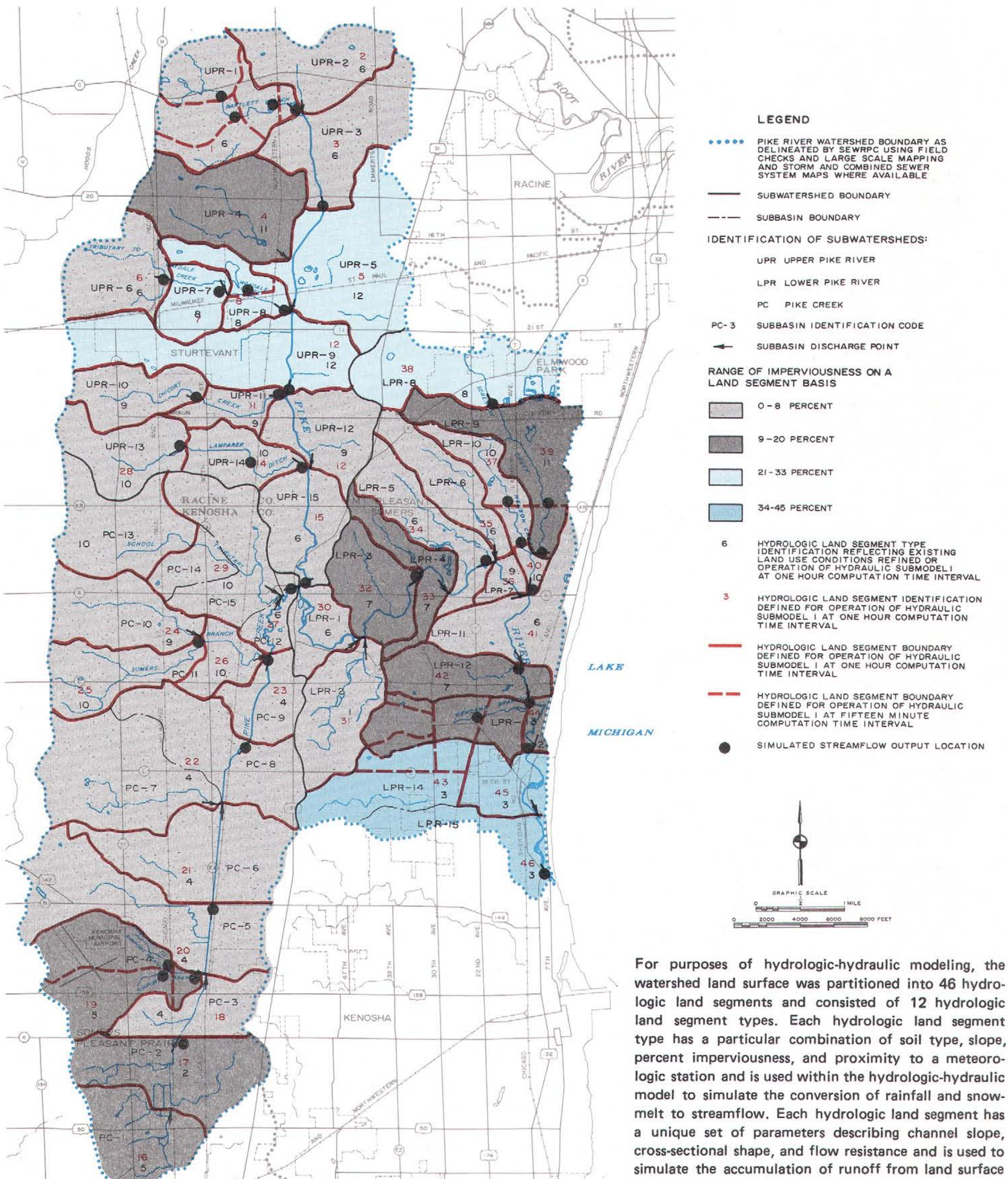
The required discharges were obtained using two modeling procedures. For points in the watershed with accumulated drainage areas of approximately 12 square miles or greater, the required discharges were obtained as a result of operating Hydraulic Submodel 1 at a one-hour computational time interval over the 40-year simulation period for which recorded meteorological data were available—January 1, 1940 through September 30, 1979—and performing discharge frequency analyses on the 40 simulated annual instantaneous peak discharges using the log Pearson Type III technique.[16] The frequency analyses yield flood discharges of a known recurrence interval at various points throughout the watershed stream system. For points in the watershed with accumulated drainage areas of less than approximately 12 square miles, a discrete event modeling procedure was used to obtain the required discharges as was described in the section on Hydraulic Submodel 1 presented earlier in this chapter. These procedures were used to obtain 10-year, 50-year, and 100-year recurrence interval discharges which were input to the Hydraulic Submodel 2, which in turn was used to compute the corresponding flood stage profiles. The procedures used to obtain the other three types of data required by Hydraulic Submodel 2 are described in detail in Chapter V. As indicated there, the necessary information, including floodland cross-sections with an average

[15] *LZSN, UZSN, INFILTRATION, and INTERFLOW.*

[16] *"Guidelines for Determining Flood Flow Frequency," Bulletin No. 17, United States Water Resources Council, Washington, D. C., March 1976.*

Map 37

REPRESENTATION OF THE PIKE RIVER WATERSHED FOR HYDROLOGIC-HYDRAULIC SIMULATION



Source: SEWRPC.

For purposes of hydrologic-hydraulic modeling, the watershed land surface was partitioned into 46 hydrologic land segments and consisted of 12 hydrologic land segment types. Each hydrologic land segment type has a particular combination of soil type, slope, percent imperviousness, and proximity to a meteorologic station and is used within the hydrologic-hydraulic model to simulate the conversion of rainfall and snowmelt to streamflow. Each hydrologic land segment has a unique set of parameters describing channel slope, cross-sectional shape, and flow resistance and is used to simulate the accumulation of runoff from land surface in the stream system and the transport of that flow through the watershed.

spacing of about 500 feet and physical descriptions of 81 hydraulically significant structures, was obtained for about 42 miles of watershed stream selected for simulation.

Channel Data for Hydraulic Submodel 1: The following three categories of channel data are required as input to Hydraulic Submodel 1 for each river reach that is to be simulated: discharge; channel-floodplain cross sections, including the length and upstream and downstream elevations of the reach represented by each cross-section; and Manning roughness coefficients for the channel and the floodplains. Table 65 lists the 15 channel parameters that are input to the submodel for each reach and indicates the primary source of numerical values for each. If lakes or reservoirs are present in the system and are to be modeled, a stage-discharge-cumulative storage table must be provided along with the surface area of the impoundment and other impoundment characteristics.

The types of data required for Hydraulic Submodel 1 are generally quite similar to those required for Hydraulic Submodel 2 in that both require discharges, floodland cross-sections, and Manning roughness coefficients. Submodel input data requirements differ, however, in several significant ways. First, Hydraulic Submodel 2 uses closely spaced floodland cross-sections—an average spacing of 500 feet was used in the watershed modeling—consistent with its primary function of using given discharges to accurately compute flood stages. Hydraulic Submodel 1 uses generalized floodland cross-sections, with each cross-section representing an average reach length of about 1.2 miles to be consistent with its primary function of calculating discharges. Second, the floodland cross-sections prepared for Hydraulic Submodel 1 are general representations of the channel-floodplain topography, whereas the cross sections developed for Hydraulic Submodel 2 are more precise representations. In Hydraulic Submodel 2, the cross-section shape is defined by up to 100 coordinates, in Hydraulic Submodel 1, the cross-section is defined by only a channel bottom width, a bank-to-bank width, a channel depth, and a single lateral slope representative of the floodplains on both sides of the channel. Third, Hydraulic Submodel 2 accepts more than one Manning roughness coefficient for each floodplain. Under Hydraulic Submodel 1, however, only one coefficient is permitted to represent both floodplains. Fourth, Hydraulic Submodel 2 includes algorithms for calculating the hydraulic effect of a bridge or culvert and associated approach roadways under a variety of upstream and downstream conditions, whereas bridge and culvert computations are not included in Hydraulic Submodel 1 except where they are modeled as impounding structures.

The process used to establish numerical values for the channel parameters was initiated by subdividing the approximately 42 miles of stream system selected for simulation into reaches and assigning tributary areas to the reaches, thus creating hydrologic land segments. The first step in this process is to insure that there is exactly one channel reach associated with each hydrologic land segment. This is a requirement of the model in that the channel reach provides the mechanism whereby runoff from the land surface is intercepted, aggregated with flows from upstream reaches, and then routed downstream through the stream system. The second step in reach identification is determination of the minimum allowable reach length based on the relationship between the computational time interval, as used in the Hydrologic Submodel and Hydraulic Submodel 1, and the reach flow through time. It is necessary for the computational interval to be approximately equal to or less than twice the reach flow through time in order for the model to properly perform hydrograph routing. Applying this criterion, it was determined that for a one-hour computational time interval used in modeling, the minimum reach length should be about one mile. The third and final criterion used to identify reaches is that each reach be relatively homogeneous with respect to floodland cross-sectional shape, channel slope, and channel-floodplain roughness coefficients. Reaches were thus terminated at points of confluence in the stream system, at locations where the tributary area exhibited abrupt changes in land use, and at locations where discharges were to be computed. The net effect of the above factors was the partitioning of the approximately 42 miles of stream system into 46 reaches, or hydrologic land segments, as shown on Map 37, having an average reach length of about 1.31 miles, which was appropriate for operation of Hydraulic Submodel 1 at a one-hour computational time interval. For operation of the model at a 15 minute computational time interval for small drainage areas as described in the section on Hydraulic Submodel 1 presented earlier in this chapter, it was necessary to further partition certain portions of the watershed into shorter reaches, as shown on Map 37, appropriate for the shorter computational time interval.

After subdivision of the stream system into reaches, channel cross-sections representative of each reach were quantified. Seven cross-section related parameters were assigned on a reach-by-reach basis. Cross-sections were selected from the set of detailed cross-sections prepared for Hydraulic Submodel 2, the selected cross-sections were composited, and one generalized representative cross-section was constructed for each reach. That cross-section was then used to determine numerical values for channel parameters 10 through 13 in Table 65. A procedure similar to the above was used to assign a channel Manning roughness coefficient and a floodplain Manning roughness coefficient to each reach. Coefficients established for Hydraulic Submodel 2 were examined in order to select representative channel and floodplain coefficients for each of the reaches. This completed the assignment of the 15 channel parameters listed in Table 65 and required for operation of Hydraulic Submodel 1. A channel data set was prepared for each stream system configuration—for example, existing condition and proposed channel improvements—that was to be simulated.

Channel Data for Water Quality Submodel: Hydraulic channel data required for the Water Quality Submodel are almost identical to the data described above for Hydraulic Submodel 1, the major difference being that Hydraulic Submodel 1 allows only one land segment type to be associated with each channel reach whereas the Water Quality Submodel accepts up to three land segment types per reach.

Nonhydraulic channel data must also be provided for each water quality channel reach. These data consist of water quality parameters and coefficients such as the biochemical oxygen demand reaction rate coefficient, maximum benthic algae concentration, total coliform die-away coefficient, and the benthal release rates for nutrients. The principal source of numerical values for these parameters and coefficients is the literature on previous successful experiences with the Water Quality Submodel.

Riverine Area Structure and Related Data

Physical and economic data for riverine area structures—residential and commercial buildings—are needed as input to the Flood Economics Submodel along with flood event information and dike-floodwall and channelization data. Numerical values for up to 68 structure, flood event, dike-floodwall, channelization, and related parameters are required for each flood-prone reach for which flood damage, floodproofing and removal costs, dike-floodwall costs, and channelization costs are to be calculated. This section describes the process used to subdivide flood-prone areas into reaches and subreaches and to obtain or assign numerical values to the parameters.

Preparation of submodel input data was initiated with the assignment of basic cost and economic data applicable to all reaches. Flood damage reaches—reaches for which flood economics calculations were executed using the submodel—were then established based partly on historic flood information collected under the watershed study and described in Chapter VI of this volume, and partly on the results of the hydrologic-hydraulic simulation as described in this chapter. In addition to delineating flood damage reaches so as to encompass areas of existing or potential flood problems, reach boundaries were made coincident with civil division boundaries so as to facilitate the summarization of flood damages and the costs of structure floodproofing or removal, dikes and floodwalls, and channelization by civil division. This approach provides each community with a monetary quantification of both the seriousness of its flood problem and of alternative solutions to that flood problem. The reaches were also selected to encompass areas in which each structure category—for example, single-family residential—exhibited similar market values. Each reach was extended out from the river beyond the 100-year recurrence interval flood hazard line so as to encompass both the primary flooding zone—the floodland area adjacent to the channel and subject to overland flooding during a 100-year flood—and the secondary flooding zone—the area contiguous with the primary zone in which basement flooding may occur as a result of sanitary and storm sewer backups.

The next step in submodel data preparation consisted of partitioning the reaches into subreaches, the principal consideration being that the length of each subreach along the river be selected so that each would have approximately uniform flood stages from the upstream end to the downstream end. The implication of this criterion is that steeper streams will have shorter subreaches than streams with flatter slopes. Subreach boundaries were made coincident with hydraulic restrictions such as bridges and culverts as determined under Hydraulic Submodel 2, because these locations represented abrupt changes in the flood stage profile. Flood-prone riverine areas for which floodproofing and/or removal measures or dike-floodwall protection measures could be applied were included in separate subreaches so as to permit a direct comparison of the costs of structural measures to the benefits—reduced flood damages—that would result from those measures. The resulting subreaches were delineated on the available 1" = 200' scale, 2 foot contour interval topographic maps, and the necessary subreach identification parameters were assigned.

Output from Hydraulic Submodel 2, consisting of flood stage profiles for a range of recurrence intervals, provided the flood event input data required for each subreach. Structural, physical, and economic information was obtained from large-scale topographic maps, aerial photographs, field surveys, civil division assessors, and personal interviews. For those subreaches where dike-floodwall or channelization alternatives were considered, the plan of the potential dike-floodwall or channelization systems—as delineated on a topographic map or aerial photograph—was used in combination with additional information obtained from river bed profiles to establish the input parameters, thus completing the assignment of numerical values for all parameters.

Point Source Data

Figure 38 illustrates how point source data are input to the Hydraulic Submodel 1 and to the Water Quality Submodel. Point source input data for Hydraulic Submodel 1 consisted of monthly discharge values for five industrial point sources in the watershed as shown on Map 34 and in Table 51 in Chapter VII of this report. Point source input data for the Water Quality Submodel consisted of monthly discharge values plus monthly water quality values for seven point sources in the watershed as shown on Map 38 and in Table 69.

Nonpoint Source Data

Figure 38 illustrates how nonpoint source data are input to the Water Quality Submodel, along with meteorologic, point source, and channel data and output from the hydrologic submodel. The choice of initial numerical values for some nonpoint source pollution parameters, such as land surface loading rates, was based largely on values reported in the literature for urban and rural areas similar to the Pike River watershed[17] and previous experience under the Water Quality Submodel in the Menomonee River watershed and areawide water quality management planning programs. Some of these values were subsequently adjusted during the calibration process to improve the correlation between observed and simulated water quality. A set of land surface loading rates was established for each of the 40 hydrologic water quality land segments in the watershed as shown in Table 70. Map 39 indicates how the Pike River watershed was subdivided into three subwatersheds for water quality simulation.

Calibration Data

The six categories of data discussed above—meteorological, land, channel, riverine area structure, point pollution source, and nonpoint pollution source—constitute the total input data for operation of the model that are required to operate the five submodels. Of equal importance are calibration data which, although not needed to operate the model, are necessary for the calibration of the model. These data, which are derived strictly from field measurements, include recorded actual streamflow, river stage, and water quality data. Since calibration data represent the actual historic response of the watershed to a variety of hydro-meteorological events and conditions, such data may be compared to the simulated response of the watershed and the model thereby calibrated.

Streamflow Data: The principal source of historic streamflow information in the watershed is the streamflow measurements made by the U. S. Geological Survey (USGS) from October 1, 1971 to September 30, 1979 at the continuous recording gage on the Pike River near Racine at the University of Wisconsin-Parkside. A discussion of this stream gaging station is presented in Chapter V. This streamflow information was supplemented with streamflow information obtained at a crest-stage partial-record station also maintained by the U. S. Geological Survey. This station is located on Pike Creek at STH 43 and has provided the annual maximum discharge beginning in 1960.

Flood Stage Data: Information on historic high water levels was provided by public officials, consulting engineers, private citizens, and the staff of the Regional Planning Commission. This information was plotted on profiles of the stream system and used to check the validity of simulated flood stage profiles. Additional information on the source and characteristics of historic flood stage information is presented in Chapter VI.

Water Quality Data: The principal source of stream water quality data is the stream water index site sampling program conducted by the Commission

[17] *See Chapter IV of SEWRPC Technical Report No. 18, State of the Art of Water Pollution Control in Southeastern Wisconsin, Volume Three, Urban Storm Water Runoff, July 1977; Hydrocomp, Inc., Hydrocomp Water Quality Operations Manual, Fourth Edition, April 1977; and U. S. Army Corps of Engineers-Seattle District, Environmental Management of the Metropolitan Area Cedar-Green River Basins, Washington, Part II: "Urban Drainage," December 1974, p. 86.*

Table 69

SELECTED INFORMATION ON POINT SOURCES REPRESENTED IN THE WATER QUALITY SUBMODEL: 1975

Reach	Quantity	Subbasin	Name	Average Annual Parameter Values												
				Flow (cfs)	Temperature (°C)	Five-Day Biochemical Oxygen Demand (mg/l)	Dissolved Oxygen (mg/l)	Ammonia Nitrogen (mg/l)	Nitrate Nitrogen (mg/l)	Nitrite Nitrogen (mg/l)	Organic Nitrogen (mg/l)	Phosphate Phosphorus (mg/l)	Chloride (mg/l)	Total Dissolved Solids (mg/l)	Fecal Coliform (MFFCC per 100 ml)
5	1	UPR-5	J. I. Case Company-Transmission Plant	0.080	16.5	4.0	8.88	0.00	0.00	0.00	0.00	0.00	0.0	300	0.0
7	1	UPR-7	St. Bonaventure Seminary Wastewater Treatment Plant	0.013	13.6	4.6	5.30	5.00	4.00	0.40	0.00	5.00	0.0	700	200
8	2	UPR-8	S. C. Johnson & Son, Inc.	2.74	16.9	0.0	8.73	0.00	0.00	0.00	0.00	0.00	0.0	300	0.0
		UPR-8	Village of Sturtevant Wastewater Treatment Plant	0.822	13.6	33.0	5.30	5.00	4.00	0.40	0.00	1.61	104	700	179,000
9	1	UPR-9	Rexnord, Inc.-Hydraulic Components Division	0.201	15.7	0.0	8.95	0.00	0.00	0.00	0.00	0.00	0.0	300	0.0
18	1	PC-2	American Motors-Transport Department	0.002	17.9	30.0	6.59	0.00	0.00	0.00	0.00	0.00	0.0	300	0.0
29	1	PC-11	Town of Somers Utility District No. 1 Wastewater Treatment Plant	0.095	13.6	59.0	5.30	5.00	4.00	0.40	0.00	5.00	104	700	200

Source: Wisconsin Pollution Discharge Elimination System and SEWRPC.

in cooperation with the Wisconsin Department of Natural Resources and the U. S. Geological Survey under the areawide water quality management planning program, as described in Chapter VII. Under this program, stream water quality determinations were made at approximately one-day intervals from September 7, 1976 to October 5, 1976 at two locations: the STH 31 bridge of the Pike River and the CTH A bridge of the Pike River. In addition, on those days in which runoff occurred as the result of rainfall events, several water quality samples were taken for the purpose of defining the instream pollutographs. Each of these water quality determinations was based on measurements of physical, chemical, and biological quality indicators as well as streamflow measurements.

MODEL CALIBRATION

Need for Model Calibration

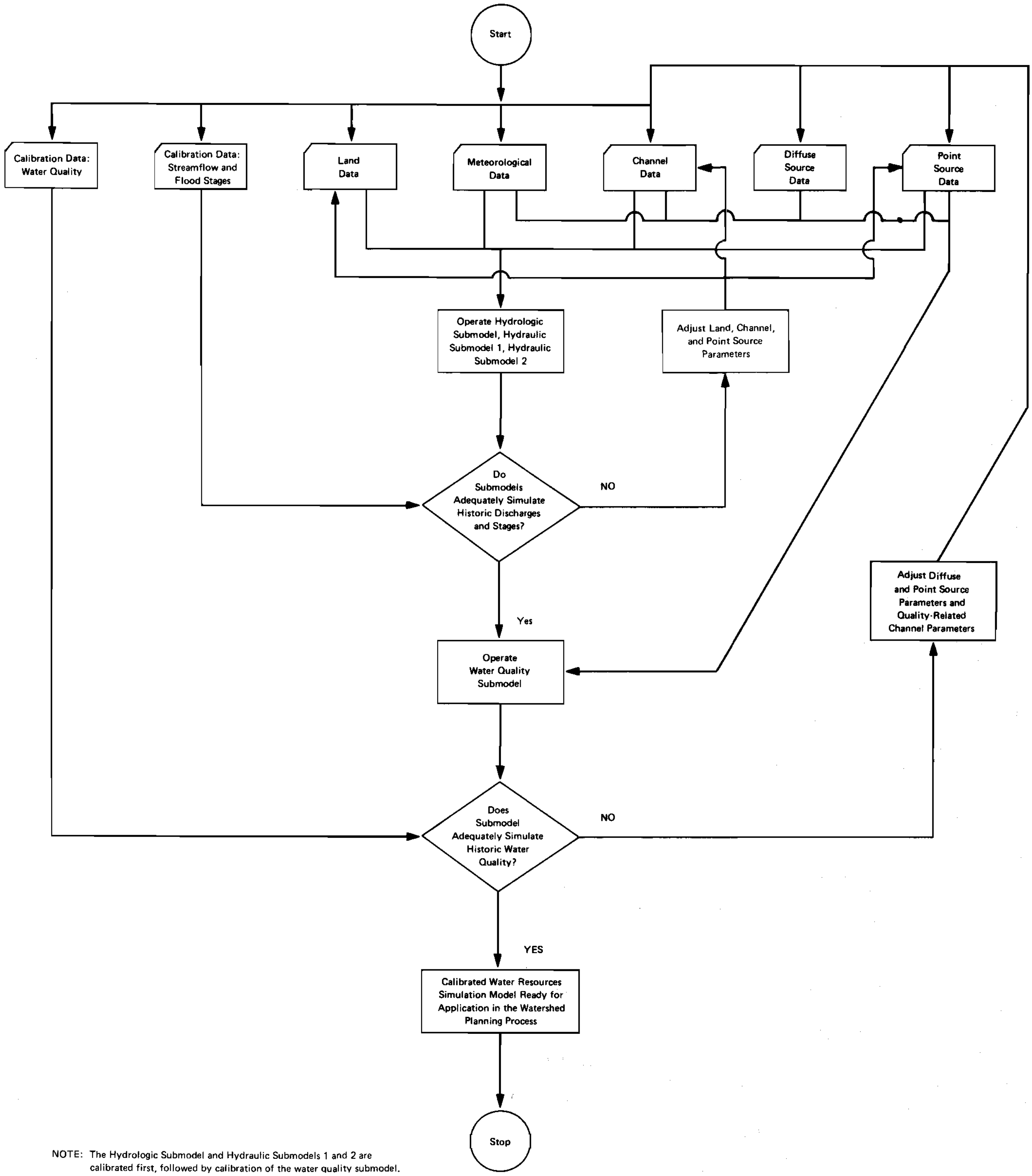
Many of the algorithms contained in the model are mathematical approximations of complex natural phenomena. Therefore, before the model could be reliably used to simulate streamflow behavior and water quality conditions under alternative hypothetical watershed development conditions, it was necessary to calibrate the model—that is, to compare simulation model results with actual historic data and, if a significant difference was found, to make parameter adjustments so as to adjust the model to the specific natural and man-made features of the watershed. While the model is general in that it is applicable to a wide range of geographic and climatic conditions, its successful application to any given water resource system—such as the Pike River watershed—very much depends on the calibration process in which pertinent data on the natural resource and man-made features of the watershed are used to adapt the model to the local conditions. A schematic representation of the calibration process as used for the hydrologic-hydraulic-water quality modeling in the Pike River watershed planning program is shown in Figure 43. Once the watershed simulation model is calibrated for a particular water resource system, the basic premise of subsequent simulation is that the model will respond accurately to a variety of model inputs representing hypothetical watershed conditions, such as land use changes and channel modifications, and thereby provide a powerful analytic tool in the watershed planning process.

In a strict sense, no data are available for the systematic, watershedwide calibration of the Flood Economics Submodel. This is not a serious limitation of that submodel, however, since the relationships used in this submodel are based on recognized stage-damage relationships for various structure types. Furthermore, an analysis conducted under the Menomonee River watershed planning program of scattered and diverse information on the number of structures affected and monetary losses incurred verified the accuracy of the results obtained through application of the Flood Economics Submodel.[18]

[18] *See SEWRPC Staff memorandum to the Menomonee River Watershed Committee entitled, "Flood Damage Computation Procedures in the Menomonee River Watershed," February 18, 1976.*

Figure 43

CALIBRATION PROCESS USED FOR HYDROLOGIC-HYDRAULIC-WATER QUALITY MODELING

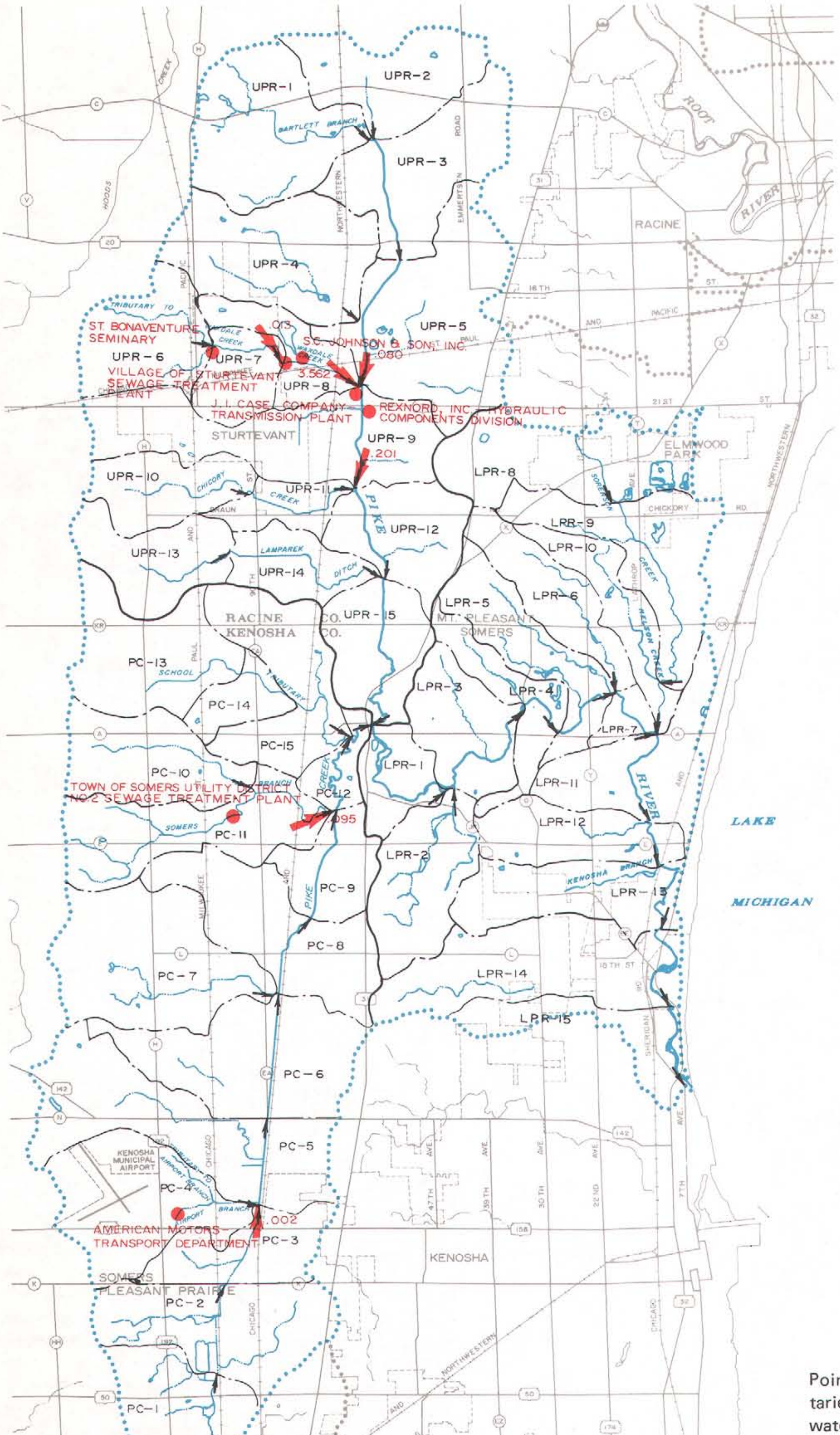


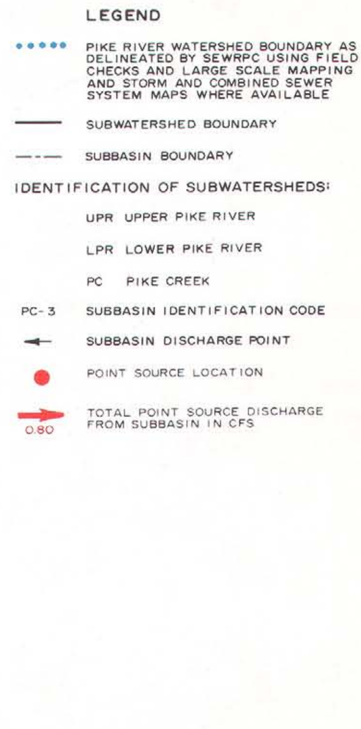
NOTE: The Hydrologic Submodel and Hydraulic Submodels 1 and 2 are calibrated first, followed by calibration of the water quality submodel.

Source: SEWRPC.

Map 38

POINT SOURCES INCLUDED IN THE WATER QUALITY SUBMODEL FOR THE PIKE RIVER WATERSHED

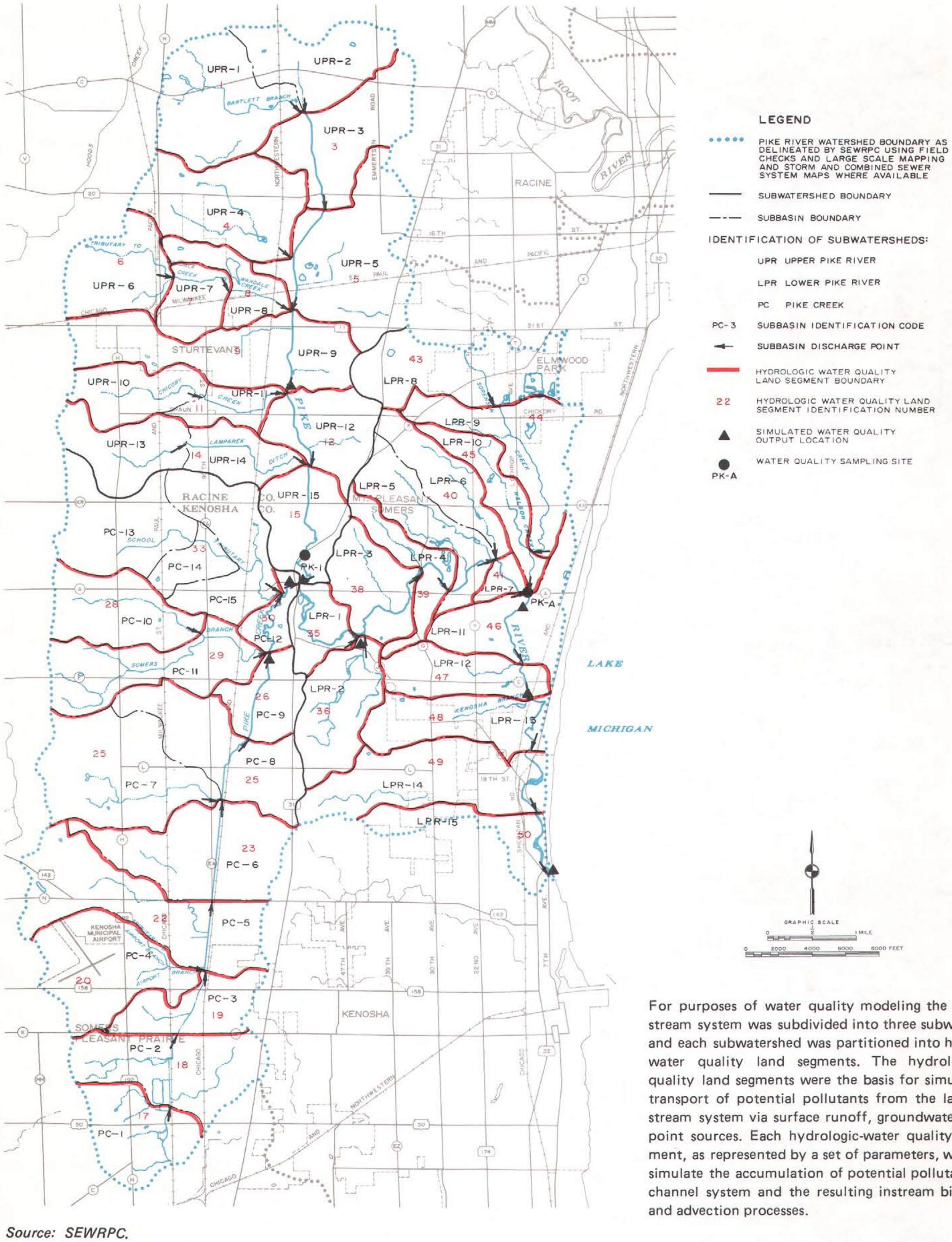




Point sources of discharge to the Pike River and its tributaries are important to successful hydrologic-hydraulic-water quality modeling since point sources account for much of the streamflow and input of potential pollutants during low flow periods. A total of seven significant point sources were identified in the watershed.

Map 39

REPRESENTATION OF THE PIKE RIVER WATERSHED FOR WATER QUALITY SIMULATION



Source: SEWRPC.

For purposes of water quality modeling the watershed stream system was subdivided into three subwatersheds, and each subwatershed was partitioned into hydrologic-water quality land segments. The hydrologic-water quality land segments were the basis for simulating the transport of potential pollutants from the land to the stream system via surface runoff, groundwater flow, or point sources. Each hydrologic-water quality land segment, 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.

Table 70

LAND SURFACE POLLUTANT LOADING RATES REPRESENTED IN THE WATER QUALITY SUBMODEL

Hydrologic—Water Quality Land Segment Type				Average Annual Land Surface Loading Rates (mg/l)[a]							
				Impervious Surface							
Meteorological Station	Soil Type	Impervious Category	Land Use	Biochemical Oxygen Demand	Ammonia Nitrogen	Nitrate Nitrogen	Organic Nitrogen	Phosphate Phosphorus	Chloride	Total Dissolved Solids	Fecal Coliform
Kenosha	Dominant C	Rural	Row Crop	0.175	0.020	0.013	0.017	0.002	0.25	2.5	200.0
			Vegetable and Other Agricultural	0.280	0.020	0.018	0.017	0.002	0.25	2.5	200.0
			Other Open Land	0.175	0.020	0.013	0.017	0.001	0.25	2.2	200.0
		High	Industrial	0.280	0.020	0.015	0.020	0.002	0.25	2.5	200.0
			Residential	0.174	0.020	0.041	0.017	0.001	0.25	2.5	200.0
	C-B	Rural	Row Crop	0.175	0.020	0.013	0.017	0.002	0.25	2.5	200.0
			Grain Crop	0.175	0.020	0.013	0.017	0.002	0.25	2.5	200.0
			Vegetable and Other Agricultural	0.280	0.020	0.018	0.017	0.002	0.25	2.5	200.0
			Hay	0.280	0.020	0.018	0.017	0.002	0.25	2.5	200.0
			Other Open Land	0.174	0.020	0.013	0.017	0.001	0.25	2.1	200.0
		High	Highway	0.575	0.020	0.030	0.020	0.002	0.25	2.5	200.0
			Airfield	0.570	0.020	0.060	0.020	0.002	0.25	2.5	200.0
Racine	Dominant C	Rural	Golf Course	0.200	0.020	0.003	0.017	0.001	0.07	2.5	200.0
			Other Recreation	0.320	0.024	0.004	0.017	0.002	0.25	2.5	200.0
			Row Crop	0.175	0.020	0.013	0.017	0.002	0.25	2.5	200.0
			Grain Crop	0.100	0.010	0.090	0.017	0.001	0.25	2.5	700.0
			Vegetable and Other Agricultural	0.280	0.020	0.018	0.017	0.002	0.25	2.5	200.0
			Hay	0.280	0.020	0.018	0.017	0.002	0.25	2.5	200.0
			Woodland	0.280	0.020	0.015	0.017	0.001	0.25	2.1	200.0
			Other Open Land	0.174	0.020	0.013	0.017	0.001	0.25	2.2	200.0
			Feed Lot	0.500	0.020	0.015	0.020	0.002	0.15	2.5	51,000.0
		Low	Residential	0.165	0.020	0.013	0.017	0.002	0.25	2.5	200.0
		Medium	Residential	0.165	0.020	0.013	0.017	0.002	0.25	2.5	200.0
		High	Residential	0.100	0.010	0.090	0.017	0.001	0.25	2.5	700.0
			Industrial	0.100	0.010	0.090	0.020	0.002	0.25	2.5	700.0
			Commercial	0.280	0.020	0.015	0.020	0.002	0.25	2.5	200.0
	Dominant B	Rural	Golf Course	0.200	0.020	0.003	0.017	0.002	0.07	2.5	200.0
			Row Crop	0.075	0.020	0.013	0.017	0.002	0.25	2.5	200.0
			Grain Crop	0.075	0.020	0.013	0.017	0.002	0.25	2.5	200.0
			Vegetable and Other Agricultural	0.280	0.020	0.013	0.017	0.002	0.25	2.5	200.0
			Hay	0.280	0.020	0.018	0.017	0.002	0.25	2.5	200.0
	C-B	Rural	Row Crop	0.075	0.020	0.013	0.017	0.002	0.25	2.5	200.0
			Grain Crop	0.075	0.020	0.013	0.017	0.002	0.25	2.5	200.0
			Sod Farm	0.100	0.010	0.090	0.017	0.001	0.25	2.5	700.0
			Vegetable and Other Agricultural	0.280	0.020	0.018	0.017	0.002	0.25	2.5	200.0
			Other Open Land	0.174	0.020	0.013	0.017	0.001	0.25	2.2	200.0
			Woodland	0.174	0.020	0.015	0.017	0.001	0.25	2.2	200.0
		Medium	Residential	0.174	0.020	0.013	0.017	0.001	0.25	2.5	200.0
		High	Residential	0.100	0.010	0.090	0.017	0.001	0.25	2.5	700.0
			Industrial	0.140	0.010	0.090	0.020	0.002	0.25	2.5	700.0

Successful calibration and testing of the first three submodels are of utmost importance because output from these submodels has direct bearing on the testing and evaluation of the floodland management elements of the watershed plan. Furthermore, the validity of results from the other two submodels—the Water Quality Submodel and the Flood Economics Submodel—are determined, in part, by the quality of the output of the first three submodels.

Previous Calibration Efforts

Prior to the initiation of the Pike River watershed planning program, calibration of the hydrologic-

Table 70 (continued)

Hydrologic—Water Quality Land Segment Type				Average Annual Land Surface Loading Rates (mg/l)[a]							
				Pervious Surface							
Meteorological Station	Soil Type	Impervious Category	Land Use	Biochemical Oxygen Demand	Ammonia Nitrogen	Nitrate Nitrogen	Organic Nitrogen	Phosphate Phosphorus	Chloride	Total Dissolved Solids	Fecal Coliform
Kenosha	Dominant C	Rural	Row Crop	2.434	0.021	0.012	0.004	0.0002	0.002	10.0	0.13
			Vegetable and Other Agricultural	3.895	0.012	0.020	0.018	0.0005	0.001	10.0	0.13
			Other Open Land	0.012	0.002	0.009	0.003	0.0012	0.010	14.0	10.00
		High	Industrial	0.390	0.200	0.003	0.007	0.0300	0.013	110.0	170.00
			Residential	0.083	0.021	0.001	0.011	0.0141	0.090	38.0	95.00
	C-B	Rural	Row Crop	2.434	0.021	0.011	0.004	0.0002	0.002	10.0	0.13
			Grain Crop	2.568	0.021	0.012	0.004	0.0002	0.002	10.0	0.13
			Vegetable and Other Agricultural	3.895	0.012	0.020	0.005	0.0005	0.001	10.0	0.13
			Hay	0.199	0.001	0.001	0.0002	0.0002	0.001	10.0	50.00
			Other Open Land	0.011	0.002	0.009	0.003	0.0012	0.001	14.0	10.00
		High	Highway	0.035	0.026	0.001	0.040	0.0050	0.050	40.0	800.00
			Airfield	0.035	0.051	0.002	0.080	0.0030	0.050	40.0	800.00
Racine	Dominant C	Rural	Golf Course	0.200	0.021	0.007	0.003	0.0039	0.002	10.0	10.00
			Other Recreation	0.320	0.023	0.008	0.005	0.0021	0.003	10.0	10.00
			Row Crop	2.434	0.021	0.012	0.004	0.0002	0.002	10.0	0.13
			Grain Crop	2.568	0.021	0.012	0.004	0.0002	0.002	10.0	10.00
			Vegetable and Other Agricultural	3.895	0.012	0.020	0.005	0.0050	- -	10.0	0.13
			Hay	0.199	0.003	0.001	0.0002	0.0002	- -	10.0	50.00
			Woodland	0.018	0.003	0.011	0.008	0.0017	0.006	14.0	10.00
			Other Open Land	0.012	0.002	0.021	0.003	0.0012	0.010	14.0	10.00
			Feed Lot	2.840	1.460	0.486	3.914	0.9520	0.030	5.0	51,000.00
		Low	Residential	0.026	0.002	0.001	0.003	0.0026	0.010	12.0	36.00
		Medium	Residential	0.044	0.021	0.001	0.006	0.0086	0.050	17.0	46.00
		High	Residential	0.083	0.021	0.001	0.011	0.0140	0.090	38.0	95.00
			Industrial	0.390	0.200	0.003	0.007	0.0300	0.013	110.0	170.00
			Commercial	0.460	0.150	0.002	0.010	0.0400	0.010	40.0	100.00
	Dominant B	Rural	Golf Course	0.200	0.021	0.007	0.004	0.0039	0.002	10.0	10.00
			Row Crop	2.434	0.021	0.012	0.004	0.0002	0.002	10.0	0.13
			Grain Crop	2.568	0.021	0.012	0.004	0.0002	0.002	10.0	0.13
			Vegetable and Other Agricultural	3.895	0.012	0.020	0.005	0.0005	- -	10.0	0.13
			Hay	0.199	0.001	0.001	0.0002	0.0002	0.001	10.0	50.00
	C-B	Rural	Row Crop	2.434	0.021	0.012	0.004	0.0002	0.002	10.0	0.13
			Grain Crop	2.568	0.021	0.012	0.004	0.0002	0.002	10.0	0.13
			Sod Farm	0.294	0.023	0.007	0.004	0.0001	0.002	10.0	10.00
			Vegetable and Other Agricultural	3.895	0.012	0.020	0.005	0.0005	0.001	10.0	0.13
			Other Open Land	0.012	0.002	0.009	0.002	0.0012	0.010	14.0	10.00
			Woodland	0.044	0.003	0.011	0.007	0.0017	0.010	14.0	10.00
		Medium	Residential	0.044	0.021	0.001	0.006	0.0086	0.050	17.0	46.00
		High	Residential	0.083	0.021	0.001	0.011	0.0141	0.090	38.0	95.00
			Industrial	0.390	0.200	0.003	0.007	0.0300	0.013	110.0	170.00

[a]*Except fecal coliforms, which are in MFFCC per 100 ml.*

Source: SEWRPC.

hydraulic-water quality submodels had been completed on the Pike River watershed as well as on other watersheds in the Region under the Commission areawide water quality management planning program. Further calibration of these submodels had also been completed under the Commission Menomonee and Kinnickinnic River watershed planning programs.

Once experience is gained using hydrologic-hydraulic-water quality submodels on watersheds having a variety of land segment types and channel systems and located within a given physiographic and climatic area such as the Southeastern Wisconsin Region, subsequent applications of the submodels in that same physiographic and climatic area can benefit immensely with respect to use of numerical values of parameters from the earlier studies. While model parameters may be expected to vary significantly from one part of the United States to another, they may be expected to exhibit a strong similarity within climatically and physiographically homogeneous areas such as southeastern Wisconsin. Thus, rather than "start from scratch," subsequent modeling work can concentrate on refinements to preceding efforts.

Hydrologic-Hydraulic Calibration for the Pike River Watershed Planning Program

Hydrologic Submodel and Hydraulic Submodel 1: Meteorological data sets, data sets for hydrologic land segment types, point source data, and channel data sets for stream reaches were prepared using the procedures described earlier in this chapter. The choice of numerical values for 28 parameters in each of the land data sets was strongly influenced by parameter values established under previous calibration efforts. This was feasible since, as noted above, combinations of soil type, slope and land use-cover present in the Pike River watershed are similar to those in previous watersheds and subwatersheds on which calibration work had been conducted.

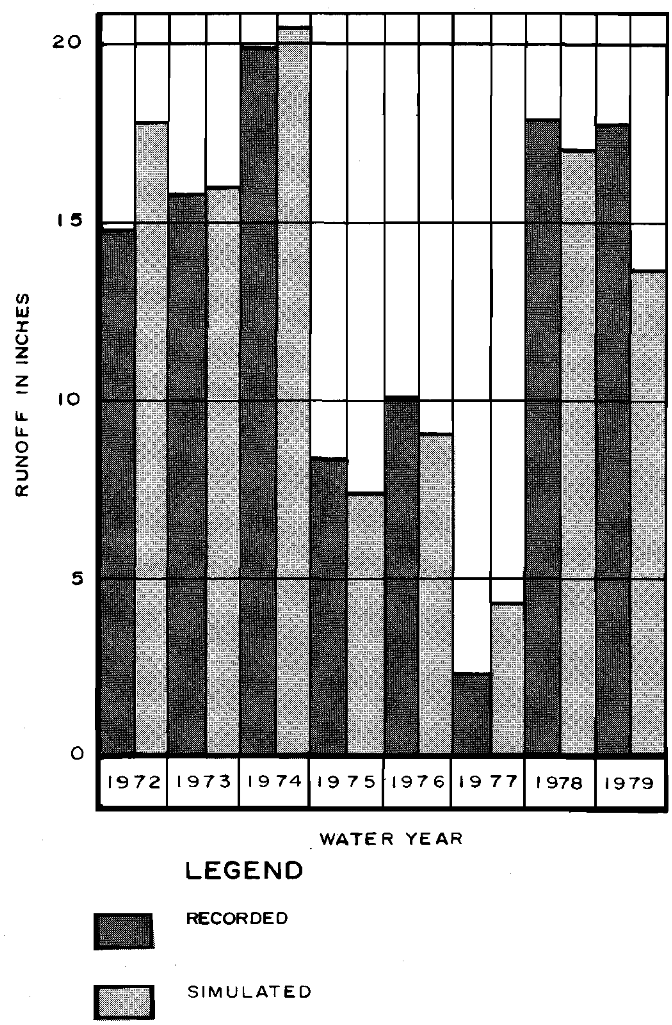
The Hydrologic Submodel and Hydraulic Submodel 1 were operated during the eight-year period from October 1971 through September 1979 for the 38.3 square-mile area—74 percent of the total area of the watershed—tributary to the continuous stream flow recording gage on the Pike River located at the University of Wisconsin-Parkside. The actual calibration interval for this operation was the period extending from July 1, 1971 through September 30, 1979 which allowed a three-month period for model initiation and start-up purposes.

The results obtained in the calibration process for the Pike River gaging station are presented below through a comparison of recorded and simulated annual and monthly runoff volumes, recorded and simulated flow-duration curves, and recorded and simulated hydrographs for major runoff events:

- Figure 44 presents a graphic comparison of recorded and simulated annual runoff volumes for the eight-year calibration period. Simulated annual runoff volumes range from 23 percent below to 40 percent above recorded values. The simulated cumulative annual runoff volume for the eight-year period is 107.72 inches, almost identical to the 107.68 inch cumulative recorded annual runoff volume for that same period.

Figure 44

RECORDED AND SIMULATED ANNUAL RUNOFF VOLUMES FOR THE PIKE RIVER AT THE UW-PARKSIDE GAGE: OCTOBER 1, 1971-SEPTEMBER 30, 1979



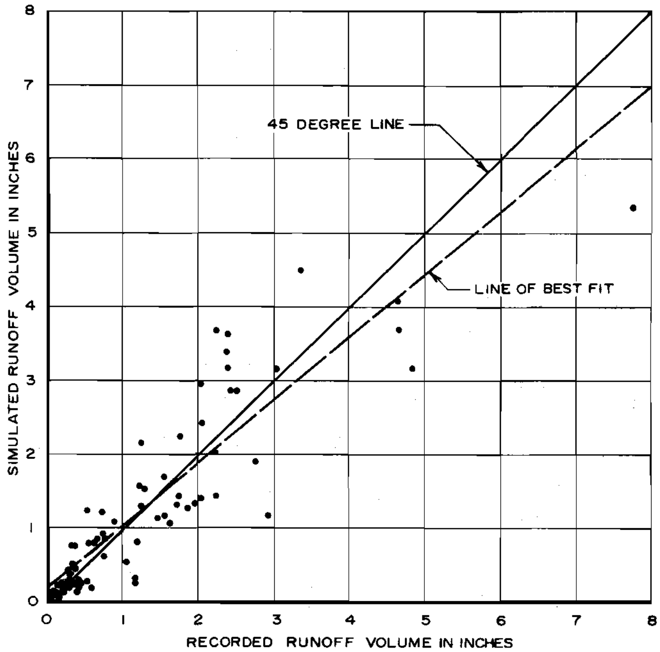
Source: SEWRPC.

- Recorded and simulated monthly runoff volumes are compared in Figure 45. The monthly runoff data points are seen to be grouped about a 45-degree line, indicating a tendency to exhibit the desired one-to-one correlation between the recorded and simulated monthly runoff volumes.

- Recorded and simulated flow duration curves based on average daily flows for the eight-year period for which recorded discharge data are available are shown in Figure 46. Each of the two flow duration curves indicates the percentage of time that specified average daily discharges may be expected to

Figure 45

LINEAR CORRELATION BETWEEN RECORDED AND SIMULATED MONTHLY RUNOFF VOLUMES FOR THE PIKE RIVER AT THE UW-PARKSIDE GAGE: OCTOBER 1, 1971-SEPTEMBER 30, 1979



Source: SEWRPC.

be equaled or exceeded. The flow duration curves based on simulated and recorded discharges exhibit close agreement.

- Recorded and simulated hydrographs for four runoff events drawn from various times of the year are shown in Figure 47. These four events were selected so as to illustrate the full range of correlations between recorded and simulated flows. Overall, the recorded and simulated hydrographs for rainfall and rainfall-snowmelt events occurring during the calibration period exhibited generally close agreement.

- Recorded and simulated peak flow values from 25 runoff events occurring since October 1971 are compared in Figure 48. These data are also seen to be grouped about a 45-degree line, indicating a tendancy to exhibit the desired one-to-one correlation between the recorded and simulated peak flow values. Two additional lines are shown in Figure 48: one which represents the line of best fit through the points plotted for all 25 runoff events, and another which represents the line of best fit through the points corresponding to the eight recorded peak annual runoff events. Both these lines closely approximate a 45-degree line, which suggests that the hydraulic submodel, in conjunction with the hydrologic submodel, is adequately simulating peak discharges without significant bias.

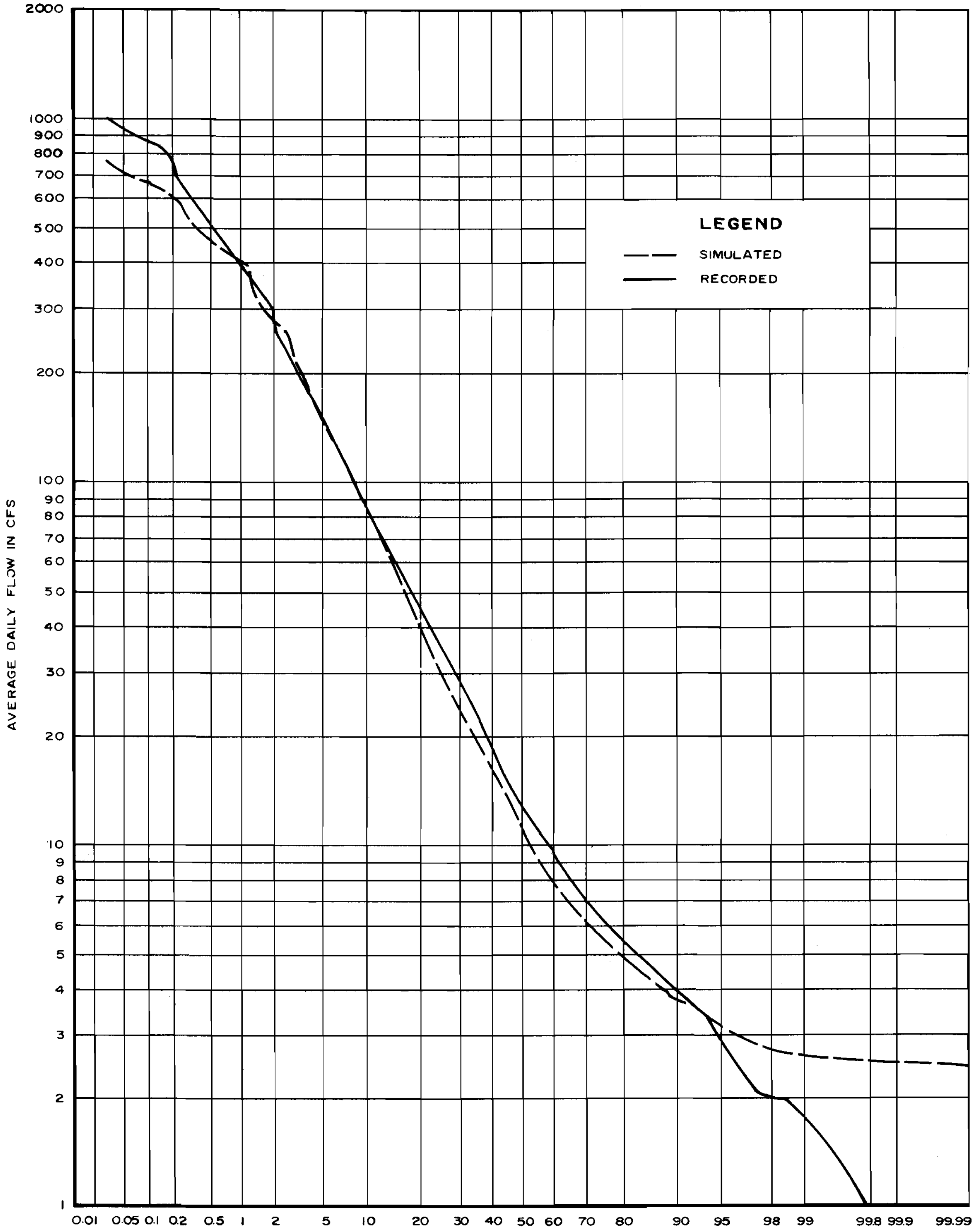
Over-simulation or under-simulation of flood discharge may be attributable to spatial variations in the amount of rainfall occurring over the subwatershed. That is, even though the two precipitation observation stations used to provide input data are located near the watershed, and even though the watershed is small, it is possible for portions of the basin to receive precipitation amounts, especially during brief events such as thunderstorms, that are significantly different from those recorded at the observation stations. Over-simulation or under-simulation may also be attributable to variations in the time at which a particular runoff event begins. It is unlikely that precipitation will begin throughout the watershed at exactly the same time at which it begins at the observation stations.

Over-simulation of flood discharges during early spring months or under-simulation during winter months may sometimes be attributable to the hydrologic submodel itself. The model, in simulating certain kinds of winter runoff events, may compute too much infiltration, thus somewhat under-simulating the actual runoff. The model may also, in simulating certain kinds of early spring runoff events, compute too little infiltration, thus somewhat over-simulating the actual runoff. However, improper simulation of certain runoff events due to the reasons noted above should not adversely affect overall long-term hydrologic-hydraulic modeling results. This is so because over the relatively long 40-year simulation period used in the Pike River watershed study, positive and negative simulation errors tend to compensate resulting in a relatively uniform frequency distribution of simulated annual peak discharges. This simulated frequency distribution should closely approximate the actual distribution for the 40-year period. Therefore, the simulated flood frequency curves are also expected to closely approximate actual flood frequency relationships even though simulation error for some individual flood events may exist.

Hydraulic Submodel 2: After successful calibration of the Hydrologic Submodel and Hydraulic Sub-

Figure 46

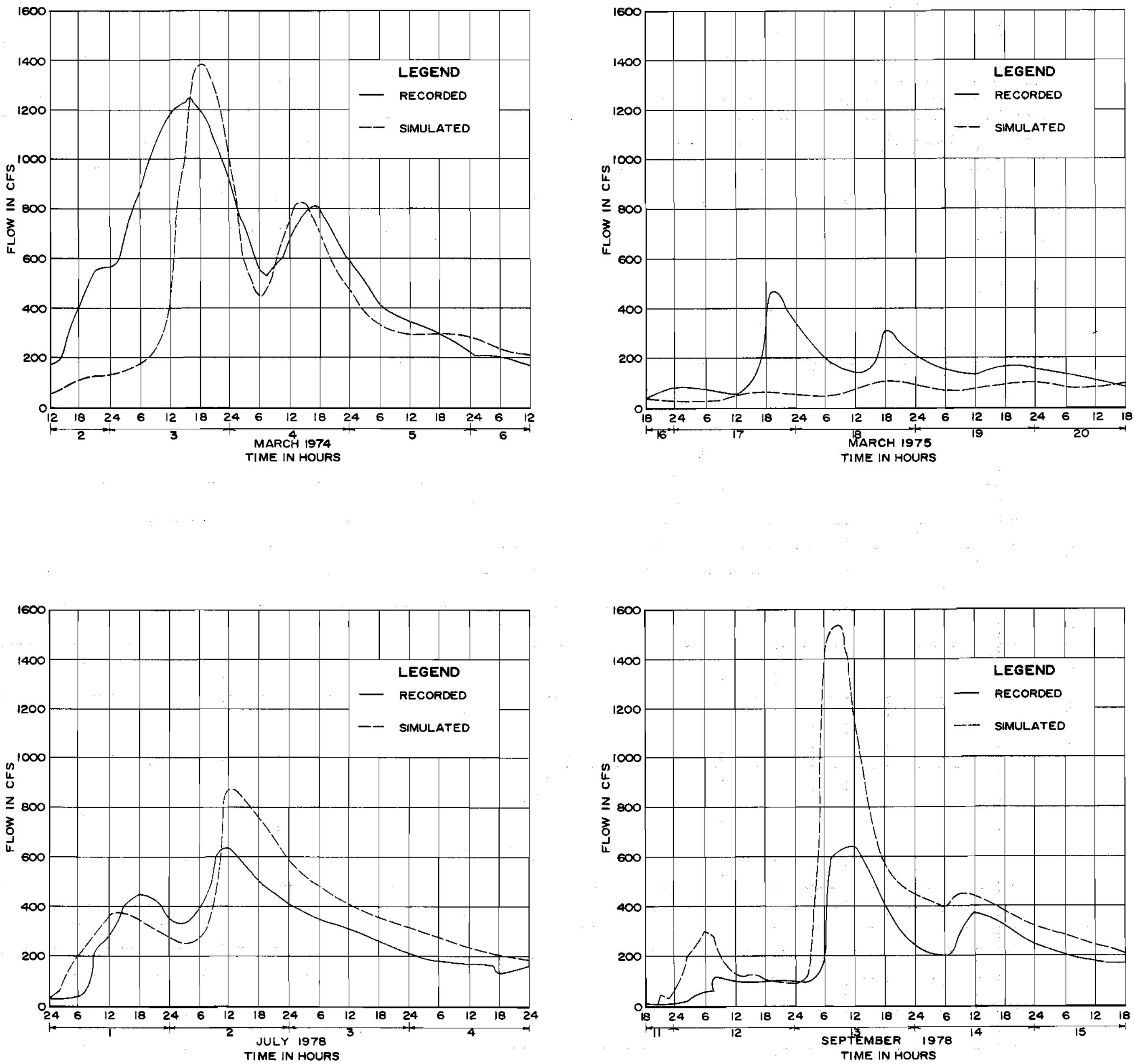
RECORDED AND SIMULATED FLOW DURATION CURVES FOR THE PIKE RIVER AT THE UW-PARKSIDE GAGE: OCTOBER 1971-SEPTEMBER 1979



Source: SEWRPC.

Figure 47

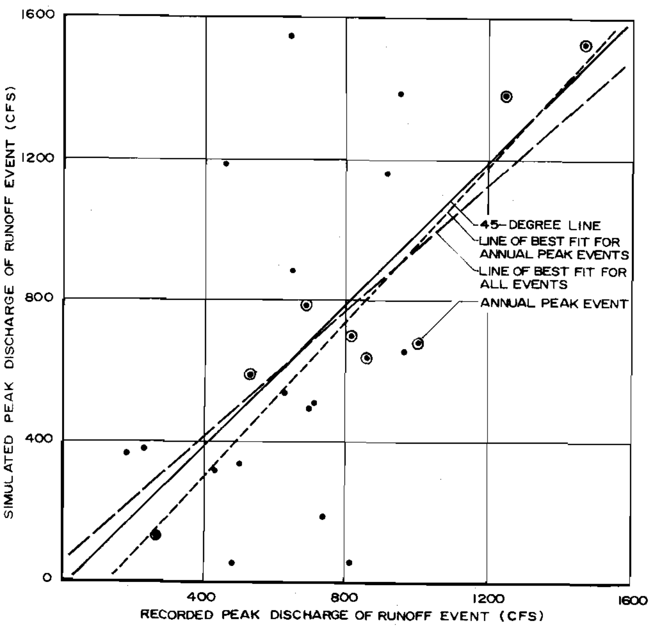
RECORDED AND SIMULATED HYDROGRAPHS FOR THE PIKE RIVER AT THE UW-PARKSIDE GAGE FOR SELECTED EVENTS: OCTOBER 1971-SEPTEMBER 1979



Source: SEWRPC.

Figure 48

LINEAR CORRELATION BETWEEN RECORDED AND SIMULATED PEAK DISCHARGES FOR 25 SELECTED RUNOFF EVENTS FOR THE PIKE RIVER AT THE UW-PARKSIDE GAGE: OCTOBER 1971-SEPTEMBER 1979



Source: SEWRPC.

model 1 on the Pike River watershed, and subsequent development of flood discharges as discussed earlier in this chapter, Hydraulic Submodel 2 was calibrated against historic flood stage information utilizing the developed flood discharges. The historic flood inventory described in Chapter VI resulted in the acquisition of historic high water data for streams in the Pike River watershed.

The calibration process involved comparing the plotted 10-, 50-, and 100-year flood stage profiles obtained using Hydraulic Submodel 2 to historic high water marks. The relative position of the recorded and simulated flood stages was examined for consistency. For example, because the 1978 flood was determined to be approximately a 10-year recurrence interval event, a close correlation would be expected between exisiting land use-floodland development 10-year recurrence interval flood stage profiles obtained from Hydraulic Submodel 2 and actual high water marks obtained during or immediately after that event.

In those instances in which an inconsistent relationship existed between simulated and historic flood stages, the problem was normally resolved by an adjustment in the channel or floodplain Manning roughness coefficient. In some cases, improvements were made in the manner in which the channel-floodplain shape or bridge or culvert geometry was represented.

Water Quality Calibrations on the Pike River Watershed

After completing calibration of the Hydrologic Submodel and Hydraulic Submodel 1, the Water Quality Submodel calibration process was initiated. This sequential approach was used since successful water quality simulation is contingent upon effective hydrologic-hydraulic modeling because runoff from the land surface and flow in the streams provide the transport mechanisms for water quality constituents. Meteorologic, channel, point pollution source, and nonpoint pollution source input data sets were prepared using the procedures described earlier in this chapter. With respect to calibration data, the Water Quality Submodel was calibrated using the result of the stream water index sampling program conducted under the areawide water quality management planning program.

The fall calibration period, September 7, 1976 to October 6, 1976, provided the primary data for calibration of the Water Quality Submodel at the two sampling stations. The calibration process consisted of comparison of the observed water quality and the model results for the upstream sampling location, and when acceptable results were achieved at that location, the downstream location was analyzed. After achieving successful calibration with emphasis on six parameters—temperatures, dissolved oxygen, phosphate phosphorus, the nitrogen forms, fecal coliform counts, and carbonaceous biochemical oxygen demand—the remaining simulated parameters—chlorides and total dissolved solids—were examined for reasonableness. After minor adjustments were made in the nonpoint loading rates for chlorides and total dissolved solids, the model produced acceptable results for the calibration period.

The recorded constituent values for the CTH A sampling site on the Pike River for the calibration period are presented in Figure 49 along with the simulations results. The figure indicates that the model well simulates flow, temperature, dissolved oxygen, phosphate phosphorus, the nitrogen forms, and carbonaceous biochemical oxygen demand while yielding overall acceptable results with respect to fecal coliform counts, chlorides, and total dissolved solids.

Figure 49

RECORDED AND SIMULATED WATER QUALITY DATA FOR THE PIKE RIVER AT THE UW-PARKSIDE GAGE: SEPTEMBER 5, 1978-OCTOBER 5, 1976

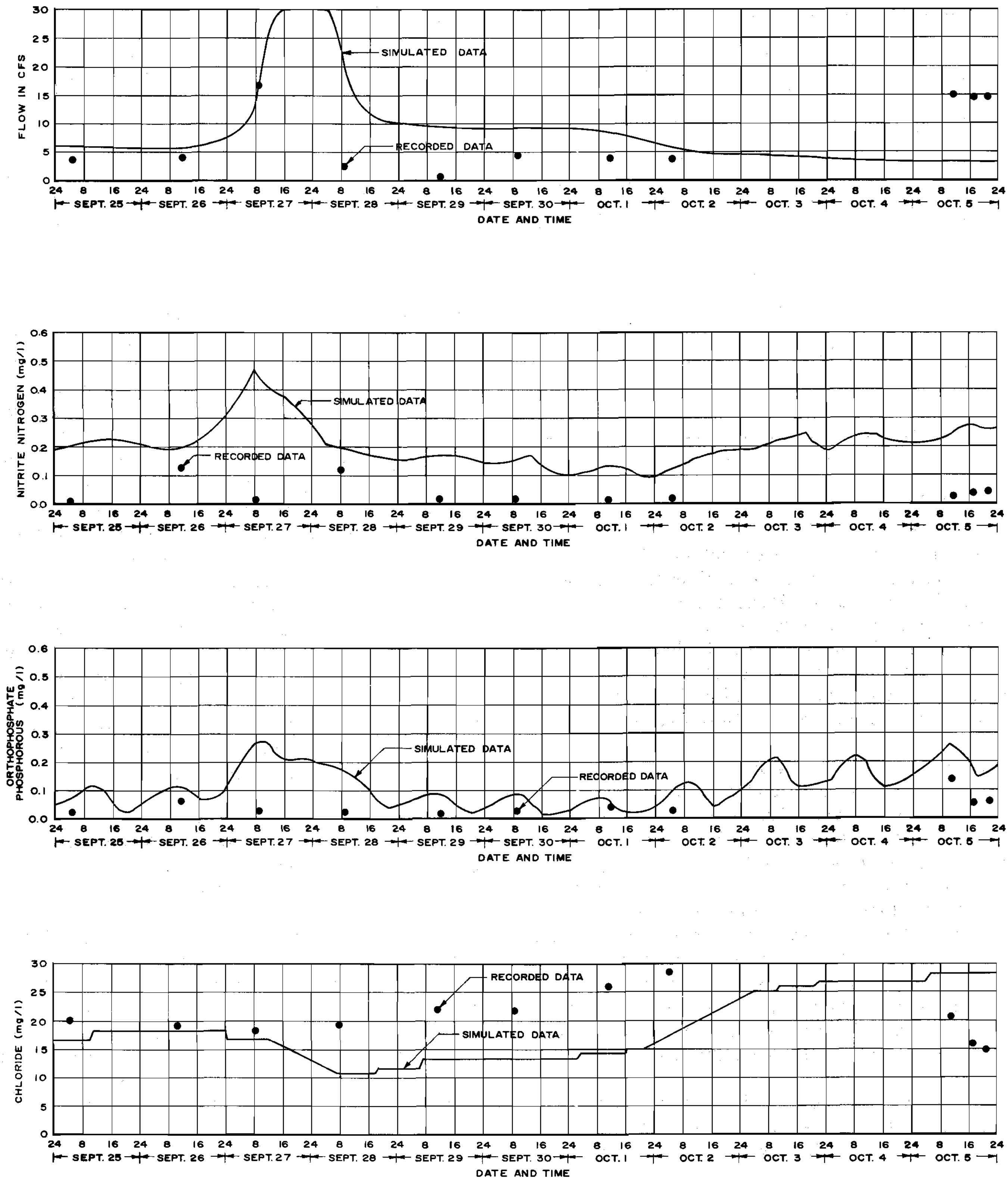


Figure 49 (continued)

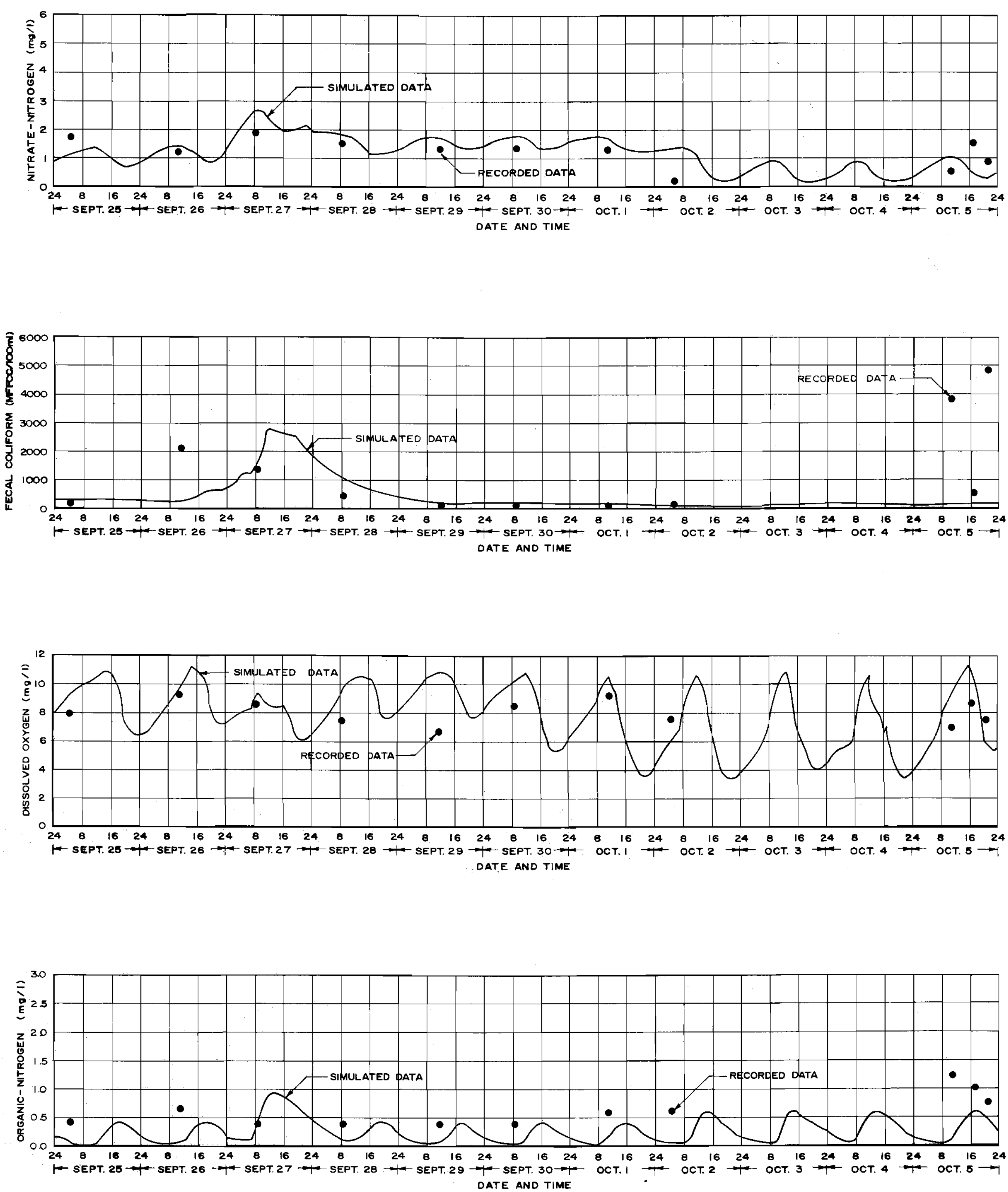
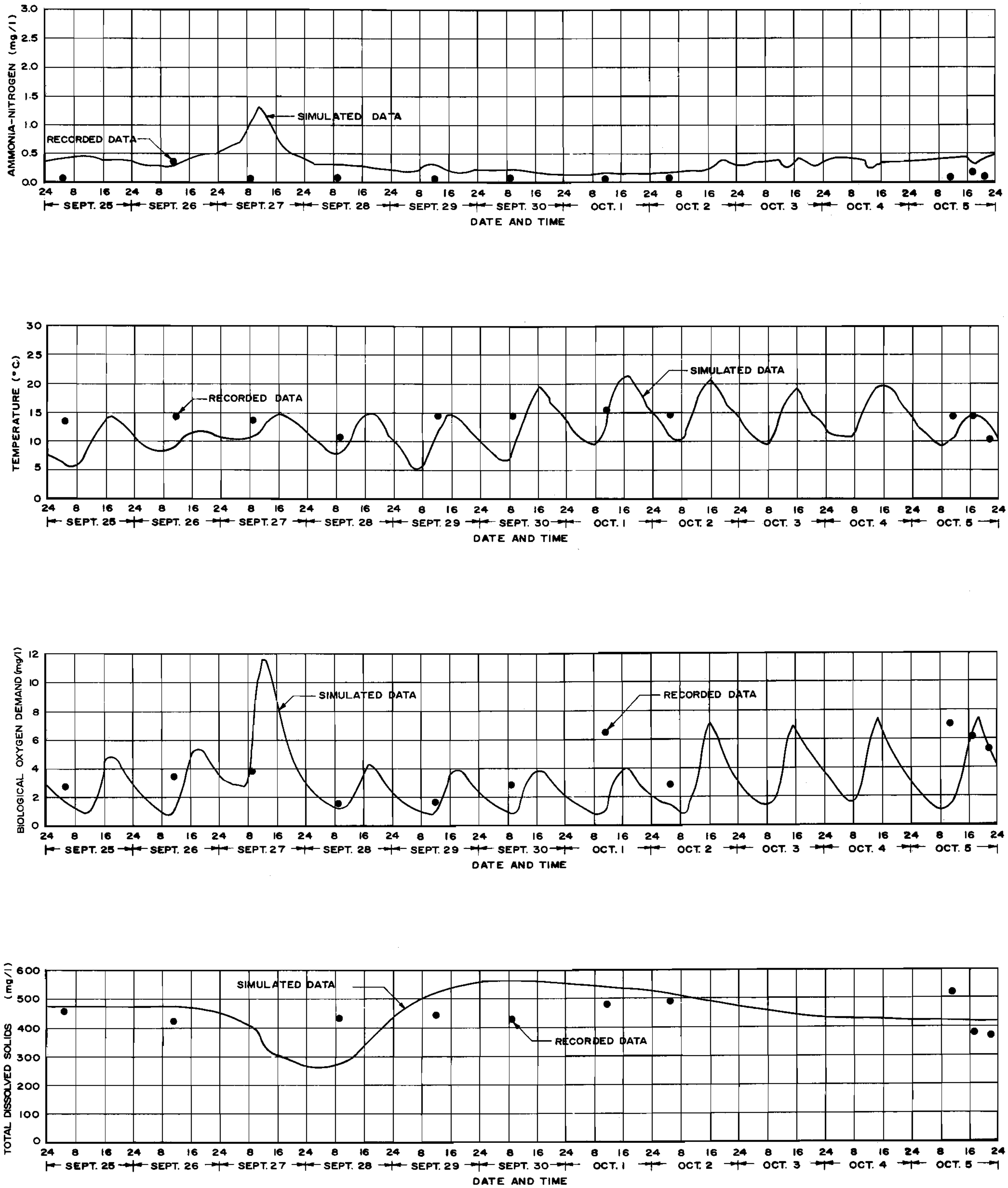


Figure 49 (continued)



SUMMARY

A quantitative analysis of streamflow and water quality conditions under existing and possible alternative future conditions is a fundamental requirement of any comprehensive watershed planning effort. Discharge, stage, and water quality at any point and time within the stream system of a watershed are a function of three factors: meteorological conditions and events, the nature and use of the land, and the characteristics of the stream system.

Hydrologic-hydraulic-water quality-flood economics simulation, accomplished with a set of interrelated digital computer programs, is an effective way to conduct the quantitative analysis required for watershed planning. Such a water resource model was developed for and used in the Pike River watershed planning program. The various submodels comprising the model were selected from existing computer programs or were developed by the Commission staff so that the composite model would meet the watershed study needs as stated in the form of nine criteria. The Water Resource Simulation Model used in the Pike River watershed planning program consists of the following five submodels: the Hydrologic Submodel, Hydraulic Submodel 1, Hydraulic Submodel 2, the Water Quality Submodel, and the Flood Economics Submodel.

The principal function of the Hydrologic Submodel is to determine the volume and temporal distribution of runoff from the land to the stream system. The basic conceptual unit on which this submodel operates is the hydrologic land segment. A hydrologic land segment type is defined as a land drainage unit exhibiting a unique combination of meteorological characteristics, such as precipitation and temperature; land characteristics, such as the proportion of land surface covered by impervious surfaces; soil types; and slopes. The submodel, operating on a time interval of one hour or less, continuously and sequentially maintains a water balance within and between the various interrelated hydrological processes as they occur with respect to the land segment. Meteorologic and land data constitute the two principal types of input for operation of the Hydrologic Submodel. The key output from the submodel consists of a continuous series of runoff quantities for each hydrologic land segment type in the watershed.

The function of Hydraulic Submodel 1 is to accept as input the runoff from the land surface as produced by the Hydrologic Submodel in combination with point and groundwater source discharges, to aggregate it, and to route it through the stream system, thereby producing a continuous series of discharge values at predetermined locations along the rivers and streams of the watershed. Application of this submodel requires that the stream system be divided into reaches and impoundment sites. Input for Hydraulic Submodel 1 consists of parameters describing the reaches and impoundment sites as well as the output from the Hydrologic Submodel and point source discharges.

Hydraulic Submodel 2 computes flood stages attendant to flood flows of specified recurrence intervals as produced by Hydraulic Submodel 1. Use of this submodel requires, in addition to the output of Hydraulic Submodel 1, a very detailed description of the watershed stream system including channel-floodplain cross sections, Manning roughness coefficients, and complete physical descriptions of all hydraulically significant culverts, bridges, and dams. The principal output from Hydraulic Submodel 2 consists of flood stage profiles which are used to delineate flood hazard areas and to provide input to the Flood Economics Submodel.

The Flood Economics Submodel performs two principal functions: calculation of average annual flood damages to floodland structures and computation of the costs of alternative flood control and floodland management measures such as floodproofing and removal of structures, earthen dikes and concrete floodwalls, and major channelization works. In addition to the flood stage and probability information obtained from Hydraulic Submodel 2, input to the Flood Economics Submodel includes basic cost data and parameters describing the physical aspects of riverine area structures, dikes and floodwalls, and channelized reaches. Output from the model consists of the monetary costs and benefits of each floodland management alternative that is formulated and tested.

The Water Quality Submodel simulates the time-varying concentration, or levels, of the following water quality indicators at selected points throughout the surface water system: temperature, dissolved oxygen, fecal coliform bacteria, phosphate phosphorus, total dissolved solids, carbonaceous biochemical oxygen demand, ammonia nitrogen, nitrate nitrogen, nitrite nitrogen and organic nitrogen. Operating on a reach-by-reach basis, the submodel continuously determines water quality as a function of reach inflow and outflow, dilution,

and biochemical processes. Input to the Water Quality Submodel consists of output from the Hydrologic Submodel, channel data, meteorologic data, and nonpoint and point pollution source data. Output from the submodel consists of a continuous series of water quality levels at selected points on the watershed stream system.

Data base development includes the acquisition, verification, and coding of the data needed to operate, calibrate, test, and apply the model. The model data base for the watershed consists of a large, primarily computer-based file divided into six categories: meteorological data, land data, channel data, riverine area structure data, diffuse or nonpoint source data, and point source data. The meteorological data set is the largest because it contains 40 years of daily or hourly information for eight types of meteorological data. The data base was assembled using data collected under other Commission planning programs, inventory data collected under the Commission areawide water quality management planning program, and data from other sources such as the National Weather Service.

Many of the algorithms incorporated within the Water Resource Simulation Model are approximations of complex natural phenomena. Therefore, before the model could be used to simulate hypothetical watershed conditions, it was necessary to calibrate the model. Calibration consists of comparing model results with factual historic data and, if a significant difference is found, making parameter adjustments to adapt the model to the effects of the natural and man-made features of the planning region and the watershed. The three types of validation data available for calibration of the Water Resources Simulation Model were streamflow data, flood stage data, and water quality data.

The Hydrologic Submodel and Hydraulic Submodels 1 and 2 were successfully calibrated by comparing the simulated discharges to daily streamflows at the stream gaging station on the Pike River at the University of Wisconsin-Parkside campus and by comparing simulated stages to historic stages available at locations around the watershed.

The Water Quality Submodel was then calibrated to the surface water system of the Pike River watershed by means of data obtained from the stream water index site sampling program conducted by the Commission. These data represented a range of meteorologic, hydrologic, and hydraulic conditions. When these data were used in conjunction with model input parameters already reported, an acceptable calibration was achieved.

Chapter IX

WATER LAW

INTRODUCTION

In any sound planning and engineering effort, it is necessary to investigate the legal as well as the physical and economic factors affecting the problem under consideration. In comprehensive watershed planning, the law can be as important as the hydrology of the basin or the benefits and costs of proposed water quantity and quality control facilities in determining the ultimate feasibility of a given watershed plan. If the legal constraints bearing on the planning problem are ignored during plan formulation, serious obstacles may be encountered during plan implementation. This is particularly true in the area of water resources.

Water constitutes one of the most important natural resources. It is essential not only to many of the primary economic activities of man but also to life itself. The available quantity and quality of this important resource are of concern to agricultural, commercial, manufacturing, conservation, and government interests. The rights to the availability and use of water are, accordingly, of vital concern to a host of public and private interest groups, and the body of law regulating these rights is far from simple or static. Moreover, changes in this complex, dynamic body of law may be expected to take place even more rapidly as pressure on regional, state, and national water resources becomes more intense. For example, the Wisconsin Supreme Court in recent years has expressly overruled the historic common law doctrine on both groundwater law [1] and diffuse surface water law,[2] finding the historic doctrines in these areas no longer applicable to modern water resource problems and conflicts.

To provide the basis for a careful analysis of existing water law in southeastern Wisconsin, a survey was undertaken of the legal framework of public and private water rights affecting water resources management, planning, and engineering. This undertaking was one of the important work elements of the first comprehensive watershed planning program in the Southeastern Wisconsin Region, that for the Root River watershed. The findings of this initial legal study, conducted under the direction of the late Professor J. H. Beuscher of the University of Wisconsin Law School, were set forth in the initial edition of SEWRPC Technical Report No. 2, Water Law in Southeastern Wisconsin, published in January 1966. This initial water law study included an inventory of existing powers and responsibilities of the various levels and agencies of government involved in water resource management, as well as a discussion of the structure of public and private water rights which must necessarily be considered in the formulation of a comprehensive watershed plan. Because of the dynamic nature of water law, including not only case law decisions but increasing intervention into the area of water law by both the U. S. Congress and the Wisconsin Legislature, the Commission in 1977 updated the findings of the legal study set forth in SEWRPC Technical Report No. 2. The results of this updated study of water law have been set forth in the second edition of SEWRPC Technical Report No. 2, Water Law in Southeastern Wisconsin.

This chapter consists of a summary presentation of a portion of the more detailed information concerning water law set forth in the technical report. For a detailed discussion of water law concepts and principles, including legal classifications of water, principal divisions of water law, riparian and public rights law, and diffuse surface water law, consult SEWRPC Technical Report No. 2, Water Law in Southeastern Wisconsin, Second Edition. The major purpose of this chapter is to summarize the salient legal factors bearing on the water-related problems of the Pike River watershed and on plans for their solution, thereby laying the basis for intelligent future action. This chapter does not, however, dispense with the need for continuing legal study with respect to water law, since this aspect of the overall planning effort becomes increasingly important as plan proposals reach the implementation stage.

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[1] *State v. Michels Pipeline Construction, Inc., 63 Wis. 2d 278 (1974).*

[2] *State v. Deetz, 66 Wis. 2d 1, 224 N. W. 2d 407 (1974).*

Attention in this chapter is focused first on those aspects of water law generally pertinent to the planning and management of the water resources of any watershed in southeastern Wisconsin. Included in this section are a discussion of the machinery for water quality management of the federal, state, and local levels of government; and a discussion of the development and operation of harbors. Finally, more detailed consideration is given to those aspects of water law that relate more specifically to the problems of the Pike River watershed, including inventory findings on state water regulatory permits and state water pollution abatement orders and permits.

WATER QUALITY MANAGEMENT

Because the Pike River watershed study is intended to deal with problems of water quality as well as water quantity, and to recommend water use objectives and water quality standards for the Pike River basin, it is necessary to examine the existing and potential legal machinery through which attainment of water quality goals may be sought at various levels of government and through private action.

Federal Water Quality Management

The federal government has long been involved in water quality management efforts, although it is only in recent years that the U. S. Congress has acted to secure the establishment of water use objectives and supporting standards for navigable waters. The 1899 Refuse Act prohibited the discharge of refuse matter of any kind, other than that flowing from streets and sewers, into any navigable waters of the United States or tributaries thereto without first obtaining a permit from the Secretary of the Army. The Secretary was directed to make a specific finding that the discharge of any refuse matter would not adversely affect anchorage and navigation; no finding on water quality was, however, required. This act and the permits issued thereunder were largely ignored until enactment of the National Environmental Policy Act of 1969 (NEPA), which required all federal agencies to consider the environmental impact in the administration of all public laws, and the Water Quality Improvement Act of 1970, which required applicants for federal permits to file a certification from the appropriate state that the proposed discharge would not violate any applicable state-adopted water quality standard.

A broader federal approach to water quality management began with the passage of the Federal Water Pollution Control Act on June 30, 1948. With the passage of this Act, the federal government began to take effective steps toward controlling and preventing pollution of the navigable waters of the United States. Initially, the Act was primarily directed at establishing a federal grant-in-aid program for the construction of publicly owned waste treatment facilities. In the mid-1960's, requirements were added relating to the establishment of interstate water quality standards. The Act was substantially revised by the Federal Water Pollution Control Act amendments of 1972, enacted into law on October 18, 1972. In general, the revised Act provides for an increased emphasis on enhancing the quality of all of the navigable waters of the United States, whether interstate or intrastate, and further places an increased emphasis on planning and on examining alternative courses of action to meet stated water use objectives and supporting water quality standards. The Act declares it to be a national goal to eliminate the discharge of pollutants into the navigable waters of the United States by 1985 and stipulates that, wherever obtainable, an interim goal of water quality be achieved by 1983 providing for the protection and propagation of fish and natural wildlife and for human recreation in and on the water; that substantial federal financial assistance be provided to construct publicly owned waste treatment works; and that areawide waste treatment management planning processes be developed and implemented to assure adequate control of sources of pollutants within each state. The requirements of the Act may be categorized under the following headings: water quality standards and effluent limitations, pollutant discharge permit system, continuing statewide water quality management planning processes, areawide waste treatment planning and management, and waste treatment works construction. In the following discussion, attention is focused on these relevant portions of the Federal Water Pollution Control Act, as well as on the requirements of the National Environmental Policy Act of 1969.

Water Quality Standards and Effluent Limitations:

Since 1965, the Federal Water Pollution Control Act has required states to adopt water use objectives and supporting water quality standards for all interstate waters. The Act as amended in 1972 incorporates by reference all existing interstate water quality standards and requires for the first time the adoption and submittal to the U. S. Environmental Protection Agency (EPA) for approval of all intrastate water use objectives and supporting water quality standards. Wisconsin, through the

Natural Resources Board and the Department of Natural Resources, has adopted the required interstate and intrastate water use objectives and supporting water quality standards. These objectives and standards as related to streams and watercourses in the Pike River watershed are discussed below. Under the new federal law, state governors are required to hold public hearings every three years for the purpose of reviewing the adopted water use objectives and supporting water quality standards and, in light of such hearings, appropriately modify and readopt such objectives and standards.

In addition to water use objectives and standards, the Act requires the establishment of specific effluent limitations for all point sources of water pollution. Such limitations require the application of the best practicable water pollution control technology currently available, as defined by the EPA Administrator. In addition, any waste source which discharges into a publicly owned treatment works must comply with applicable pretreatment requirements, also to be established by the EPA Administrator. By July 1, 1977, all publicly owned treatment works were to meet effluent limitations based upon a secondary level of treatment and through application of the best applicable waste treatment knowledge. In addition to these uniform or national effluent limitations, the Act further provides that any waste source must meet any more stringent effluent limitations as required to implement any applicable water use objective and supporting standard established pursuant to any state law or regulation or any other federal law or regulation.

Pollutant Discharge Permit System: The Federal Water Pollution Control Act, as amended in 1972, establishes a national pollutant discharge elimination system. Under this system the EPA Administrator, or a state upon approval of the EPA Administrator, may issue permits for the discharge of any pollutant or combination of pollutants upon the condition that the discharge will meet all applicable effluent limitations or upon such additional conditions as are necessary to carry out the provision of the Act. All such permits must contain conditions to assure compliance with all of the requirements of the Act, including conditions on data and information collection and reporting. For facilities other than publicly owned treatment works, Section 301 of the Act requires the application not later than July 1, 1983, of the best available technology economically achievable for each class of point sources which will result in reasonable further progress toward the national goal of elimination of the discharge of all pollutants into navigable waters. Publicly owned treatment works must provide for the application of the best practicable waste treatment technology over the life of the works no later than July 1, 1983. In essence, the Act stipulates that all dischargers to navigable waters must obtain a federal permit or, where a state is authorized to issue permits, a state permit. The intent of the permit system is to include in the permit, where appropriate, a schedule of compliance which will set forth the dates by which various stages of the requirements imposed in the permit shall be achieved. As discussed below, Wisconsin has an approved permit system operating under the national pollutant discharge elimination system.

Continuing Statewide Water Quality Management Planning Process: The Federal Water Pollution Control Act stipulates that each state must have a continuing planning process consistent with the objectives of the Act. States are required to submit a proposed continuing planning process to the EPA Administrator for his approval. The Administrator is prohibited from approving any state discharge permit program under the pollutant discharge elimination system for any state which does not have an approved continuing planning process.

The state continuing planning process must result in water quality management plans for the navigable waters within the state. Such plans must include at least the following items: effluent limitations and schedules of compliance to meet water use objectives and supporting water quality standards; the elements of any areawide wastewater management plan prepared for metropolitan areas; the total maximum daily pollutant load to all waters identified by the state for which the uniform or national effluent limitations are not stringent enough to implement the water use objectives and supporting water quality standards; adequate procedures for revision of plans; adequate authority for intergovernmental cooperation; adequate steps for implementation, including schedules of compliance with any water use objectives and supporting water quality standards; adequate control over the disposition of all residual waste from any water treatment processing; and an inventory and ranking in order of priority of needs for the construction of waste treatment works within the state.

In effect, the state planning process is designed to result in the preparation of comprehensive water quality management plans for natural drainage basins or watersheds. Such basin plans, however, are likely to be less comprehensive in scope than the comprehensive watershed plans prepared by the Regional Planning Commission. The statewide planning process is largely envisioned as one of synthesizing the various basin, watershed, and regional planning elements prepared throughout the State by various levels and agencies of government. The state planning process should become the vehicle for coordinating all state and local activities directed at securing compliance with the requirements of the Federal Water Pollution Control Act.

Areawide Waste Treatment Planning and Management: Section 208 of the Federal Water Pollution Control Act, as amended in 1972, provides for the development and implementation of areawide waste treatment management plans. Such plans are intended to become the basis upon which the EPA approves grants to local units of government for the construction of waste treatment works. The Act envisions that the Section 208 planning process would be most appropriately applied in the nation's metropolitan areas which, as a result of urban and industrial concentrations and other development factors, have substantial water quality control problems. Accordingly, the Act envisions the formal designation of a Section 208 planning agency for substate areas that are largely metropolitan in nature and the preparation of the required areawide water quality management plan by that agency.

Any areawide plan prepared under the Section 208 planning process must include the identification of both point and nonpoint sources of water pollution and the identification of cost-effective measures which will abate those sources. The plans must also identify the appropriate "management agency" responsibilities for implementation. All areawide waste treatment management plans must be updated annually and certified annually by the state governor to the EPA Administrator as being consistent with any applicable basin plans prepared under the continuing statewide water quality management planning process.[3]

On September 27, 1974, the seven-county Southeastern Wisconsin Region and the Southeastern Wisconsin Regional Planning Commission were formally designated as a Section 208 planning area and planning agency pursuant to the terms of the Federal Water Pollution Control Act. Following preparation of a detailed study design and after receiving a planning grant from the U. S. Environmental Protection Agency, the Commission started the planning program in July 1975. The program was continued through the July 12, 1979 formal adoption of the plan by the Commission. The plan adoption followed a series of public meetings and hearings, and is fully documented in SEWRPC Planning Report No. 30, A Regional Water Quality Management Plan for Southeastern Wisconsin, Volume One, Inventory Findings, Volume Two, Alternative Plans, and Volume Three, Recommended Plan. The plan was approved by the Wisconsin Natural Resources Board on July 25, 1979, by the Governor on December 3, 1979, and by the U. S. Environmental Protection Agency on April 30, 1980.

In general, the Section 208 water quality planning and management program for southeastern Wisconsin was used to update, extend, and refine the previous studies and plans completed by the Commission, and in so doing to fully meet the requirements of the Federal Water Pollution Control Act. Furthermore, the Commission has determined that the water quality-related plan recommendations set forth in the adopted Section 208 regional water quality management planning program will be fully integrated into and coordinated with the recommendations to be formulated under the Pike River watershed plan.

Waste Treatment Works Construction: One of the basic goals of the Federal Water Pollution Control Act is to provide for federal funding of publicly owned waste treatment works. Such funding must be based upon an approved areawide waste treatment management plan designed to provide for control of all point and nonpoint sources of pollution. The Act further encourages waste treatment management at specific treatment works which provide for the recycling of potential pollutants; the confined and contained disposal of any pollutants not recycled; the reclamation of wastewater; and the ultimate disposal of any sludge in an environmentally safe manner.

The Act stipulates that the EPA Administrator may not approve any grant unless the applicant demonstrates that the sewage collection system

[3] *The legal requirements are described in more detail in Chapter VI of SEWRPC Planning Report No. 30, A Regional Water Quality Management Plan for Southeastern Wisconsin: 2000, Volume One, Inventory Findings.*

discharging into the sewage treatment facility is not subject to excessive infiltration or clear water inflow. In addition, the EPA Administrator is required to find that alternative waste management techniques for a particular facility have been studied and evaluated and that the specific works proposed for federal assistance will provide for the application of the best practicable waste treatment technology over the life of the works. Federal funding for any grant for waste treatment works has been set at 75 percent of the construction costs. The applicant for federal funding must adopt a system of charges to assure that each recipient of waste treatment services within the applicant's jurisdiction will pay its proportionate share of the operation and maintenance costs of any waste treatment services provided. In addition, industrial users of treatment works must pay to the applicant that portion of the cost of construction which is allocable to the treatment of industrial wastes.

National Environmental Policy Act: One of the significant pieces of national legislation in recent years is the National Environmental Policy Act of 1969. This Act broadly declares that it is national policy to encourage a productive and enjoyable relationship between man and his environment; to promote efforts which will prevent or eliminate damage to the environment; and to enrich the understanding of the ecological systems and natural resources important to the nation. This Act has broad application to all projects in any way related to federal action. The mechanism for carrying out the intent of the National Environmental Policy Act of 1969 is the preparation of an environmental impact statement for each project. This statement must include documentation of the environmental impact of the proposed project; any adverse environmental effects which cannot be avoided should the project be constructed; any alternative to the proposed project; the relationship between the local short-term uses of man's environment and the maintenance and enhancement of long-term productivity; and any irreversible and irretrievable commitments of resources which would be involved in the proposed action should it be implemented. As discussed below, Wisconsin has a similar environmental policy accompanying state governmental action of all kinds within the State, whether or not such action is federally aided.

State Water Quality Management

Responsibility for water quality management in Wisconsin is centered in the Wisconsin Department of Natural Resources (DNR). Pursuant to the State Water Resources Act of 1965, the Department of Natural Resources acts as the central unit of state government to protect, maintain, and improve the quality and management of the ground and surface waters of the State. The only substantive water quality management authority not located in the Wisconsin Department of Natural Resources is the authority to regulate private septic tank sewage disposal systems, a function that joins general plumbing supervision as the responsibility of the Wisconsin Department of Health and Social Services, Division of Health. Attention in this section of the chapter will be focused on those specific functions of the Wisconsin Department of Natural Resources which directly bear upon water quality management and, hence, upon the preparation of those elements of the Pike River watershed plan pertaining to water pollution control.

Water Resources Planning: Section 144.025(2)(a) of the Wisconsin Statutes requires that the Department of Natural Resources formulate a long-range comprehensive state water resources plan for each region in the State. The seven-county Southeastern Wisconsin Planning Region coincides with one of the water resources districts established by the Department. This section of the statutes also stipulates that the Department formulate plans and programs for the prevention and abatement of water pollution and for the maintenance and improvement of water quality. In addition, Section 144.02 of the Wisconsin Statutes authorizes the Department to conduct drainage basin surveys. This statutory authority enables the Department of Natural Resources to conduct the continuing state water quality management planning process required by the Federal Water Pollution Control Act.

Water Use Objectives and Water Quality Standards: Section 144.025(2)(b) of the Wisconsin Statutes also requires that the Wisconsin Department of Natural Resources prepare and adopt water use objectives and supporting water quality standards that apply to all surface waters of the State. Such authority is essential if the State is to meet the requirements of the Federal Water Pollution Control Act. Water use objectives and supporting water quality standards were initially adopted for interstate waters in Wisconsin on June 1, 1967, and for intrastate waters on September 1, 1968. On October 1, 1973, the Wisconsin Natural Resources Board adopted revised water use objectives and supporting water quality standards which were set forth in Wisconsin Administrative Code Chapters

NR102, 103, and 104. On October 1, 1976, Administrative Code Chapter NR104 was further revised.

Revised water quality standards have been formulated for the following major water uses: ecological and environmental preserves use; recreational use; restricted recreational use; public water supply; warm water fishery; trout fishery; salmon spawning fishery; limited fishery (intermediate aquatic life); and marginal aquatic life. In addition, there are minimum standards which apply to all waters. The revised water use objectives and supporting water quality standards for the Pike River watershed are shown on Map 40 and in Table 71, respectively. These standards are statements of the physical, chemical, and biological characteristics of the water that must be maintained if the water is to be suitable for the specified uses. Chapter 144 of the Wisconsin Statutes recognizes that different standards may be required for different waters or portions thereof. According to the chapter, in all cases the "standards of quality shall be such as to protect the public interest which includes the protection of the public health and welfare and the present and prospective future use of such waters for public and private water supplies, propagation of fish and aquatic life and wildlife, domestic and recreational purposes and agricultural, commercial, industrial and other legitimate uses."[4]

Minimum Standards: All surface waters must meet certain conditions at all times and under certain flow conditions. "Practices attributable to municipal, industrial, commercial, domestic, agricultural, land development or other activities shall be controlled so that all waters including the mixing zone and the effluent channel meet the following conditions at all times and under all flow conditions:

(a) Substances that will cause objectionable deposits on the shore or in the bed of a body of water shall not be present in such amounts as to interfere with public rights in the waters of the State.

(b) Floating or submerged debris, oil scum or other material shall not be present in such amounts as to interfere with public rights in the waters of the State.

(c) Materials producing color, odor, taste or unsightliness shall not be present in such amounts as to interfere with public rights in the waters of the State.

(d) Substances in concentrations or combinations which are toxic or harmful to humans shall not be present in amounts found to be of public health significance, nor shall substances be present in amounts which are acutely harmful to animal, plant, or aquatic life."[5]

Ecological and Environmental Preserves Use: A body of surface water may be placed under this classification if it is determined by the Department of Natural Resources that the specified water is important to the overall environmental integrity of the area. For such waters the Department of Natural Resources may require other effluent limitations including allocations of wastelands for organic material, toxicants, and chlorine residuals. In waters identified as trout streams or located in scientific, wild, or scenic areas, or identified as having high recreation potential, effluent criteria will be evaluated on a case-by-case basis.

Recreational Use: Waters to be used for recreational purposes should be aesthetically attractive, free of substances that are toxic upon ingestion or irritating to the skin upon contact, and void of pathogenic organisms. The first two conditions are satisfied if the water meets the minimum standards for all waters as previously described, whereas the third condition requires that a standard be set to ensure the safety of water from the standpoint of health. The concentration of fecal bacteria is the indicator now used for this purpose. Since the fecal coliform count is only an indicator of a potential public health hazard, the Wisconsin Standards specify that a thorough sanitary survey to assure protection from fecal contamination be the chief criterion for determining recreational suitability.

Restricted Recreational Use: This objective applies to continuous and noncontinuous streams for restricted use downstream from an area of intense urban development or where wastewater has a predominant influence. The significant characteristics of this category are the maximum fecal coliform level of 1,000 per 100 milliliters (ml) based on not less than five samples per month, or 2,000 per 100 ml in more than 10 percent of all samples during any month, and a minimum dissolved oxygen level of 2.0 milligrams per liter (mg/l). The restricted recreational use objective is used to signify conditions which may be hazardous to health upon whole or partial body contact.

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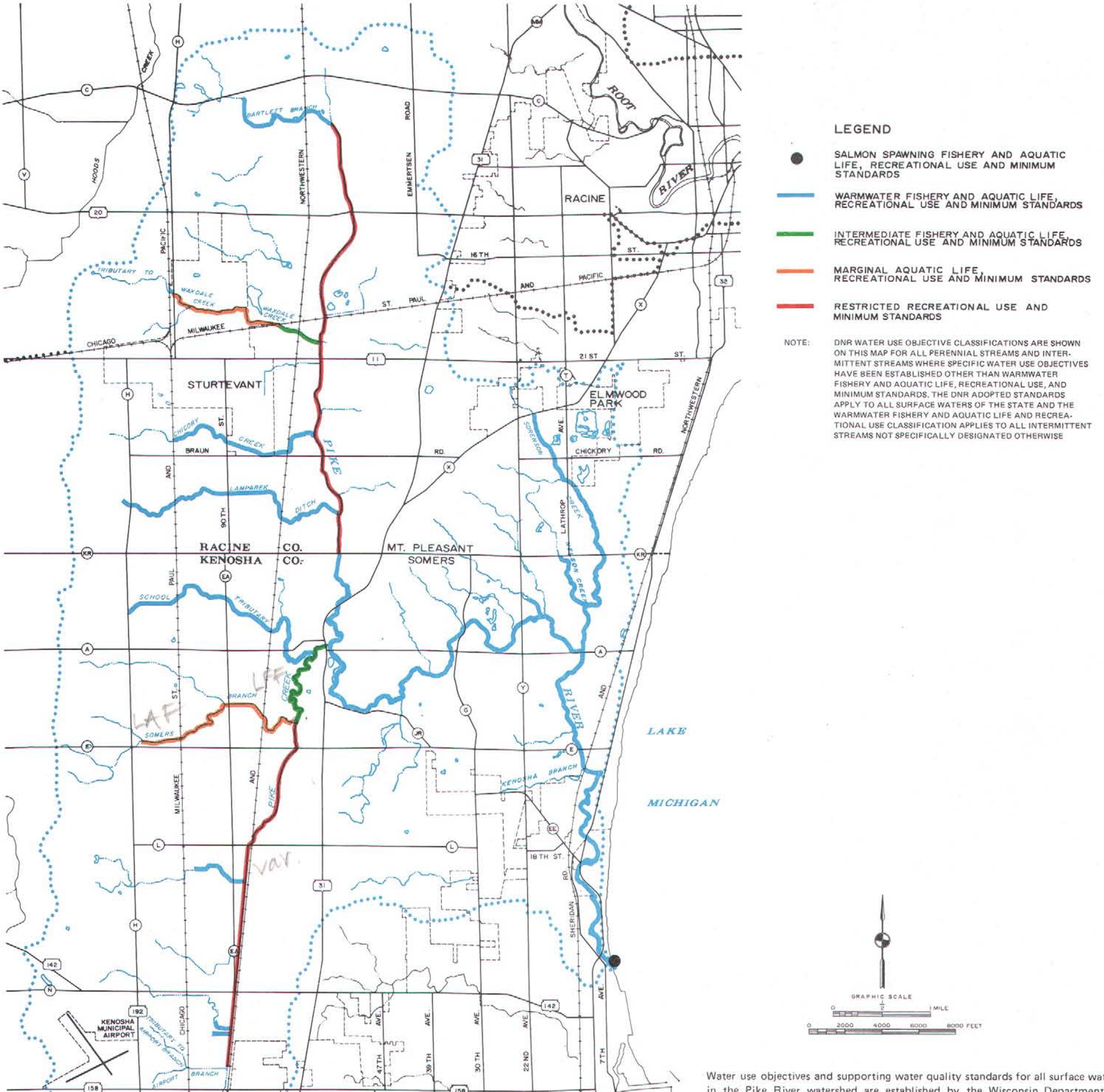
[4] *Wisconsin Statute Section 144.025(2)(b).*

[5] *Wisconsin Administrative Code Chapter NR102.02.*

Map 40

WATER USE OBJECTIVES FOR SURFACE WATERS IN THE PIKE RIVER WATERSHED ADOPTED BY THE WISCONSIN NATURAL RESOURCES BOARD: 1979



Water use objectives and supporting water quality standards for all surface waters in the Pike River watershed are established by the Wisconsin Department of Natural Resources and are reviewed and revised, as appropriate, at least every three years under the provision of the Federal Water Pollution Control Act, as amended. In accordance with the national goal of having water quality suitable for "protection and propagation of fish, shellfish, and wildlife and . . . for recreation in and on the water," most of the streams within the Pike River watershed are presently designated for maintenance of a warmwater fishery and for recreational use. In addition to enhancing human use of the water resources, the maintenance of a fishery provides in-place biological monitoring to assure confirmation that public health is not endangered by water pollutants harmful to both human and aquatic life. The relatively short-range DNR water use objectives shown above served as a point of departure for the development of the objectives, principles, and standards for the Commission's areawide water quality management planning program, the results of which constitute the basic water quality management elements of the Pike River Watershed Plan. The SEWRPC recommended water use objectives and supporting standards which were used in the development of the comprehensive plan of the Pike River watershed are set forth on Map 43 and in Table 80, respectively, in Chapter X of this report.

Source: Wisconsin Department of Natural Resources and SEWRPC.

Table 71

WATER USE OBJECTIVES AND WATER QUALITY STANDARDS FOR LAKES AND STREAMS IN THE SOUTHEASTERN WISCONSIN REGION: 1979

Water Quality Parameters	Individual Water Use Objectives[a,b,c]								Combinations of Water Use Objectives Adopted for Southeastern Wisconsin Inland Lakes and Stream					
				Fish and Aquatic Life										
	Recreational Use	Restricted Use[q]	Public Water Supply	Warmwater Fishery	Trout Fishery	Salmon Spawning Fishery	Limited Fishery[w,x] (Intermediate Aquatic Life)	Marginal Aquatic Life[d,w]	Restricted Use and Minimum Standards[b]	Marginal Aquatic Life Recreational Use, and Minimum Standards[b]	Limited Fishery (Intermediate Aquatic Life), Recreational Use, and Minimum Standards[b]	Warmwater Fishery and Aquatic Life, Recreational Use, and Minimum Standards[b]	Trout Fishery and Aquatic Life, Recreational Use, and Minimum Standards[b]	Salmon Spawning Fishery and Aquatic Life, Recreational Use, and Minimum Standards[b]
Maximum Temperature (°F)	--[e]	--[e]	--[e]	89[e,h]	--[e,f]	--[e,f]	89[e]	89[e]	--[e]	--[e]	89[e]	89[e]	--[e,f]	--[e,f]
pH Range (S.U.)	--	6.0-9.0[g]	6.0-9.0[g]	6.0-9.0[g]	6.0-9.0[g]	6.0-9.0[g]	6.0-9.0[g]	6.0-9.0[g]	6.0-9.0[g]	6.0-9.0[g]	6.0-9.0[g]	6.0-9.0[g]	6.0-9.0[g]	6.0-9.0[g]
Minimum Dissolved Oxygen (mg/l)	--	2.0	--	5.0[h]	6.0[i]	5.0[j]	3.0	2.0	2.0	1.0	3.0	5.0[h]	6.0[i]	5.0[j]
Maximum Fecal Coliform (counts per 100 ml)	200-400[k]	1,000-2,000[l]	200-400[k]	--	--	--	--	200-400[k]	1,000-2,000[l]	200-400[k]	200-400[k]	200-400[k]	200-400[k]	200-400[k]
Maximum Total Residual Chlorine (mg/l)	--	--	--	0.01	0.002[y]	0.002[y]	0.5	0.5	--	0.5	0.5	0.01[y]	0.002[y]	0.002[y]
Maximum Unionized Ammonia-Nitrogen (mg/l)	--	--	--	0.02[u]	0.02[u]	0.02[u]	0.2[v]	--	--	--	0.2[v]	0.02[u]	0.02[u]	0.02[u]
Maximum Nitrate-Nitrogen (mg/l)	--	--	10	--	--	--	--	--	--	--	--	--	--	--
Maximum Total Dissolved Solids (mg/l)	--	--	500-750[m]	--	--	--	--	--	--	--	--	--	--	--
Other[r,s,t]	--	--	--[n]	--[p]	--[o,p]	--[p]	--[p]	--	--[q]	--	--[p]	--[p]	--[o,p]	--[p]

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

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

[c] *Standards presented in the table are applicable to lakes over 50 acres in surface area and to major streams of the Region.*

[d] *Includes all effluent channels used predominantly for waste carriage and assimilation, wetlands, and diffuse surface waters and includes selected continuous and noncontinuous streams as specified by the DNR on the basis of field surveys and identified as "marginal surface waters." (See Wisconsin Administrative Code, Chapter NR 104.02(3)(b).)*

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

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

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

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

Table 71 (continued)

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

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

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

[l] Shall not exceed a monthly geometric mean of 1,000 per 100 ml based on not less than five samples per month nor a monthly geometric mean of 2,000 per 100 ml in more than 10 percent of all samples during any month.

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

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

[o] Streams classified as trout waters by the DNR (Wisconsin Trout Streams, publication 213-72) shall not be altered from natural background by effluents that influence the stream environment to such an extent that trout populations are adversely affected.

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

[q] The parametric values presented are those typically assigned; although the term "restricted" best describes the intended use, the specific chemical parameters may vary from one such reach of stream to another, since these criteria are established by the Wisconsin Department of Natural Resources on a case-by-case basis, as noted in Wisconsin Administrative Code Chapter NR 104.

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

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

January, February, March	45°F	July, August, September	80°F
April	55°F	October	65°F
May	60°F	November	60°F
June	70°F	December	50°F

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

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

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

[w] May include explicitly designated agricultural drainage ditches.

[x] Includes selected continuous and noncontinuous streams as specified by the DNR on the basis of field surveys and identified as "surface waters not supporting a balanced aquatic community (intermediate aquatic life)."

[y] Based on the level recommended in Quality Criteria for Water EPA-440/9-76-003, U. S. Environmental Protection Agency, Washington, D.C., 1976.

Source: Wisconsin Department of Natural Resources and SEWRPC.

Public Water Supply: The principal criterion of quality standards in raw water intended to be used for public water supply is that the water, after appropriate treatment, be able to meet Wisconsin Department of Natural Resources drinking water standards established in 1974. The DNR standards of raw water to be used for water supply include an allowable pH range and maximum limits on temperature, dissolved solids, and fecal coliform.

Warmwater Fishery: As indicated in Table 71, this objective is intended to result in water quality adequate to support fish and aquatic life and whole body contact recreational use. The most significant characteristics of this category are the inclusion of an 89°F maximum temperature and a minimum dissolved oxygen requirement of 5.0 mg/l.

Trout Fishery: Standards for water to be used for the preservation and enhancement of fish and aquatic life generally are specified in terms of parameters that affect the physiological condition of the fish, the food chain that sustains the fish, and the aquatic environment. The DNR standards for the trout fishery are set forth in Table 71. This category requires that no significant artificial temperature increases occur where natural trout reproduction occurs, and requires minimum dissolved oxygen levels of not less than 7.0 mg/l during spawning season.

Salmon Spawning Fishery: This standard is applicable to those continuous streams used by stocked salmonoids for spawning runs. No significant artificial temperature increases from background levels will be allowed where natural salmon spawning occurs. In contrast to the trout fishery objective, a minimum dissolved oxygen level of 5.0 mg/l is allowed. This level is not to be lowered below natural background levels during the period of habitation.

Limited Fishery (Intermediate Aquatic Life): This water use objective is applied to continuous and noncontinuous streams for intermediate aquatic life not supporting a balanced aquatic community. This intermediate aquatic life objective is one of the variance categories provided by Wisconsin Administrative Code Section NR104.02(3). The most significant characteristics of this intermediate aquatic life objective are the maximum temperature of 89°F, minimum dissolved oxygen level of 0.2 mg/l, and maximum un-ionized ammonia nitrogen level of 0.2 mg/l.

Marginal Aquatic Life: This objective applies to continuous and noncontinuous streams and effluent channels, wetlands, and surface waters. Marginal uses supporting only very tolerant life forms are allowed. The most significant standards supporting the marginal aquatic life objective, as shown in Table 71, are a maximum temperature of 89°F, a minimum dissolved oxygen level of 2.0 mg/l, a maximum fecal coliform count of 200 per 100 ml based on not less than five samples per month or 400 per 100 ml in more than 10 percent of all samples during any month, and a maximum total residual chlorine level of 0.5 mg/l.

Application of the Water Use Objectives to the Pike River Watershed: The application of the aforementioned 10 basic categories of water use objectives required specification of a design low flow at or above which the water quality standards commensurate with each water use objective are to be met. The water use objectives state that compliance with the supporting standards is to be evaluated on the basis of streamflow as low as the 7 day-10 year low flow, which is defined as the minimum 7-day mean low flow expected to occur once on the average of every 10 years. That is, for a given water use objective, the stream water quality is to be such as to satisfy the supporting standards for all streamflow conditions at or above the 7 day-10 year low flow.

The water use objectives established in 1976 by the Wisconsin Department of Natural Resources for the surface waters of the Pike River watershed include the following five categories: salmon spawning fishery and aquatic life, recreational use, and minimum standards; warmwater fishery and aquatic life, recreational use, and minimum standards; limited fishery and aquatic life, recreational use, and minimum standards; marginal aquatic life, recreational use, and minimum standards; and restricted recreational use and minimum standards. The established water use objectives apply to all perennial streams in the watershed, which include the Pike River, Waxdale Creek, Chicory Creek, Lamparek Ditch, Sorenson Creek, School Tributary, Somers Branch, and Pike Creek. A comparison of the state-adopted water use objectives to the SEWRPC-recommended objectives is set forth in Table 79 in Chapter X of this report. As noted in that table, the Commission-adopted regional water quality management plan generally envisions an upgrading of the water use objectives in the Pike River watershed, in recognition of the potential pollution abatement possible as a result of nonpoint pollution controls, coupled with the recommended point source pollution controls.

Water Pollution Abatement Orders: Pursuant to Section 144.025(2)(c) of the Wisconsin Statutes, the Department of Natural Resources is given authority to issue general orders applicable throughout the State to the construction, installation, use, and operation of systems, methods, and means for preventing and abating water pollution. This section also stipulates that the Department may adopt specific rules relating to the installation of water pollution abatement systems. Pursuant to this authority, the Department has adopted requirements for sewage disposal in Chapter NR108 of the Wisconsin Administrative Code and for the design and operation of sewerage systems in Chapter NR110 of the Wisconsin Administrative Code.

Special pollution abatement orders directing particular polluters to secure appropriate operating results at sewage treatment facilities in order to control water pollution or to cease the discharge of pollutants at a particular point are authorized to be issued by the Department in Section 144.025(2)(d) of the Wisconsin Statutes. Such orders may prescribe a specific time for compliance with provisions of the order. Such orders are directed not only at municipal units of government that operate sewage treatment plants but also at private corporations and individuals who in any way discharge wastes to the surface or groundwaters of the State. The Department has the power to make such investigations and inspections as are necessary to ensure compliance with any pollution abatement orders which it issues. In cases of noncompliance with any pollution abatement order, the Department has the authority to take any action directed by the order and to collect the costs thereof from the owner to whom the order was directed. Such charges become a lien against the property involved. To a large extent, the issuance of waste discharge permits as discussed below has become a substitute for the issuance of water pollution abatement orders by the Department, since such permits contain specified performance and operating standards.

Effluent Reporting and Monitoring System: Section 144.54 of the Wisconsin Statutes directs the Department of Natural Resources to require by rule that persons discharging industrial wastes, toxic and hazardous substances, or air contaminants submit a report on such discharges to the Department. The law further specifically exempts municipalities from the rules and establishes an annual monitoring fee to provide for the cost of administering the program. In response to this statutory mandate, the Department prepared and adopted Chapter NR101 of the Wisconsin Administrative Code setting forth specific rules by which the reporting and monitoring program is to be conducted. Of particular importance to water quality management are the effluent reports required in this chapter.

The rules require every person discharging industrial wastes or toxic and hazardous substances to file an effluent report with the Department if: 1) treated or untreated effluent is discharged directly to surface waters; 2) a minimum of 10,000 gallons of effluent per day one or more days a year is discharged to a land disposal system or to a municipal sewerage system; 3) less than 10,000 gallons per day is discharged to a land disposal system or a municipal sewerage system if the Department finds that reporting is necessary to protect the environment; and 4) more than 1,000,000 British Thermal Units are contributed per day one or more days per year to the effluent discharged to surface waters. Certain discharges are exempted from reporting, primarily if the discharge contributes none of the particular industrial wastes or toxic and hazardous substances specified in the Code. In addition, agricultural land runoff from land used exclusively for crop production need not be reported. Generally, the reports required by the Department must provide specific locations where effluent is being discharged to either surface waters, a sanitary sewerage system, or a land disposal system; estimates of the annual and average daily quantity of effluent discharged; concentrations and quantities of industrial wastes or toxic and hazardous substances contributed to the effluent in excess of the required reporting level; temperatures and volumes of thermal discharges; pH range of effluent; and a brief description of the manner and amount of raw materials used to produce wastes being reported.

Pollutant Discharge Permit System: Section 147.02 of the Wisconsin Statutes requires a permit for the legal discharge of any pollutant into the waters of the State, including groundwaters. This state pollutant discharge permit system was established by the Wisconsin Legislature in direct response to the requirements of the Federal Water Pollution Control Act of 1972, as discussed above. While the federal law envisioned requiring a permit only for the discharge of pollutants into navigable waters, in Wisconsin permits are required for discharges from point sources of pollution to all surface waters of the State and, additionally, to land areas where pollutants may percolate or seep to, or be leached to, groundwaters. Rules relating to the pollutant discharge elimination system are set forth in Chapter NR200 of the Wisconsin Administrative Code.

Discharges for which permits are required include the following:

1. The direct discharge of any pollutant to any surface water.

2. The discharge of any pollutant, including cooling waters, to any surface water through any storm sewer system not discharging to publicly owned treatment works.

3. The discharge of pollutants other than from agriculture for the purpose of disposal, treatment, or containment on land areas, including land disposal systems such as ridge and furrow, irrigation, and ponding systems.

Certain discharges are exempt from the permit system, including discharges to publicly owned sewerage works; discharges from vessels; discharges from properly functioning marine engines; and discharges of domestic sewage to septic tanks and drain fields, which are regulated under another chapter of the Wisconsin Administrative Code. Also exempted are the disposal of septic tank pumpage and other domestic waste, also regulated by another chapter of the Wisconsin Administrative Code, and the disposal of solid wastes, including wet or semiliquid wastes, when disposed of at a site licensed pursuant to another chapter of the Wisconsin Administrative Code.

The establishment of the Wisconsin pollution discharge permit system (WPDES) is a significant step both in terms of the data provided concerning point sources of pollution and in terms of the regulatory aspects of the permit system, including a listing of the treatment requirements and a schedule of compliance setting forth dates by which various stages of the requirements imposed by the permit shall be achieved. It is envisioned that the water quality management plans prepared pursuant to the terms of the Federal Water Pollution Control Act will be fully reflected in the permits issued under the pollutant discharge elimination system. As such, the pollutant discharge permit system is the primary vehicle for implementation of the basic goal of achieving the water use objectives for the receiving waters.

Septic Tank Regulation: In performing its functions of maintaining and promoting the public health, the Wisconsin Division of Health is charged with the responsibility of regulating the installation of private septic tank sewage disposal systems. Such systems often contribute to the pollution of surface and groundwaters. Pursuant to Chapter 236 of the Wisconsin Statutes, the Division of Health reviews plats of all land subdivisions not served by public sanitary sewerage systems and may object to such plats if sanitary waste disposal facilities are not properly provided for in the layout of the plat. The Division has promulgated regulations governing lot size and elevation in Chapter H-65 of the Wisconsin Administrative Code. Basic regulations governing the installation of septic tank systems are set forth in Chapter H-62 of the Wisconsin Administrative Code. The Wisconsin Department of Natural Resources, however, must approve the provisions of the state plumbing code which sets specifications for septic tank systems and their installation. That Department also may prohibit the installation or use of septic tanks in any area of the State where , based on Department findings, the use of septic tanks would impair water quality. All septic tanks in the State must be registered by permit pursuant to Section 144.03 of the Wisconsin Statutes.

Wisconsin Environmental Policy Act: The Wisconsin Legislature in April 1972 created Section 1.11 of the Wisconsin Statutes relating to governmental consideration of environmental impact. In many ways the state legislation parallels the National Environmental Policy Act of 1969 discussed earlier in this chapter. Under this state legislation, all agencies of the State must include a detailed environmental impact statement in every recommendation or report on proposals for legislation or other major actions which would significantly affect the quality of the human environment. The required contents of this statement parallel the contents required in the federal environmental impact statements. The effect of the state legislation is, therefore, to extend the environmental impact statement concept to all state action not already covered under the federal action.

Local Water Quality Management

All towns, villages, and cities in Wisconsin have, as part of the broad grant of authority by which they exist, sufficient police power to regulate by ordinance any condition or set of circumstances bearing upon the health, safety, and welfare of the community. Presumably, the water quality of a receiving stream or the polluting capability of effluent generated within the municipal unit would fall within the regulative sphere by virtue of its potential danger to health and welfare. Such local ordinances could not, however, conflict with the federal and state legislation in this area.

Local and county boards of health have powers to adopt and enforce rules and regulations designed to improve the public health. This broad grant of authority includes regulatory controls relating to environmental sanitation and, hence, water pollution. County boards of health, established by action of the county board of supervisors pursuant to Section 140.09 of the Wisconsin Statutes, can provide an effective vehicle for the enactment of countywide regulations designed in part to prevent and control further pollution of surface waters and groundwaters.

County park commissions established pursuant to Section 27.02 of the Wisconsin Statutes have powers to investigate the pollution of streams and lakes throughout the entire county and to engage in weed control and treatment practices in order to ameliorate one effect of such pollution: weed growth. In so doing, county park commissions may cooperate and contract with other counties and municipalities to provide for pollution control and lake and stream treatment.

Special Units of Government: In addition to the broad grant of authority to general-purpose units of local government, the Wisconsin Statutes currently provide for the creation of four types of special-purpose units of government through which water pollution can be abated and water quality protected. These are: 1) metropolitan sewerage districts; 2) utility districts; 3) joint sewerage systems; and 4) cooperative action by contract.

Metropolitan Sewerage Districts: In 1972 the Wisconsin Legislature enacted into law new enabling legislation for the creation of metropolitan sewerage districts outside Milwaukee County. This legislation is set forth in Sections 66.20 and 66.26 of the Wisconsin Statutes. This legislation stipulates that proceedings to create a metropolitan sewerage district may be initiated by resolution of the governmental body of any municipality. Such resolution, which must set forth a description of the territory proposed to be included in the district and a description of the functions proposed to be performed by the district, is submitted to the Wisconsin Department of Natural Resources. Upon receipt of the resolution, the Department is required to schedule a public hearing for the purpose of permitting any persons to present any information relating to the matter of the proposed metropolitan sewerage district. Within 90 days of the hearing, the Department must either order or deny the formation of the proposed district. The Department must order the formation of the district if it finds that the district consists of at least one municipality in its entirety and all or part of other municipalities; if the district is determined to be conducive to management of a unified system of sewage collection and treatment; if the formation of the district will promote sound sewerage management policies and operation and is consistent with adopted plans of municipal, regional, and state agencies; and if the formation of the district will promote the public health and welfare and effect efficiency and economy in sewerage management. No territory of a city or village jointly or separately owning or operating a sewage collection or disposal system may be included in the district, however, unless it has filed with the Department of Natural Resources a certified copy of a resolution of its governing body consenting to the inclusion of its territory within the proposed district. No metropolitan sewerage districts had been created in the Pike River watershed as of 1979.

Utility Districts: Section 66.072 of the Wisconsin Statutes permits towns, villages, and cities of the third and fourth class to establish utility districts for a number of municipal improvement functions, including the provision of sanitary sewer service. Funds for the provision of services within the district are provided by levying a tax upon all property within the district. The establishment of utility districts requires a majority vote in towns and a three-fourths vote in cities and villages. Prior to establishing such a district, the local governing bodies are required to hold a formal public hearing. Three such districts—the Town of Mt. Pleasant Utility District No. 1, the Town of Pleasant Prairie Sewer Utility District D, and the Town of Somers Utility District No. 1—have been established in the Pike River watershed.

Town Sanitary Districts: Town sanitary districts may be created, pursuant to Section 60.30 of the Wisconsin statutes, to plan, construct, and maintain sanitary and storm sewers and sewage treatment and disposal systems. A town sanitary district may offer its services outside its jurisdictional area on a reimbursable basis. In addition, the Wisconsin Legislature, in Section 60.30(2) of the Wisconsin Statutes, evidenced an intent that town sanitary districts be created to provide auxiliary sewer construction in unincorporated areas of metropolitan sewerage districts. Town sanitary districts are usually created by the town board upon petition of 51 percent of the property owners or the owners of 51 percent of the property within the proposed district. The Wisconsin Department of Natural Resources may, however, upon finding that private sewage disposal or water supply systems constitute a public health menace and that there is no local action evident to correct the situation, order the creation of such districts. One such district, the Town of Somers Sanitary District No. 1, has been created in the Pike River watershed.

Joint Sewerage Systems: Section 144.07 of the Wisconsin Statutes provides the authority for a group of governmental units, including city, village, and town sanitary or utility districts, to construct and operate a joint sewerage system following hearing and approval by the Wisconsin Department of Natural Resources. The Statute stipulates that when one governmental unit renders such service as sewage conveyance and treatment to another unit under this section, reasonable compensation is to be paid. Such reasonable charges are to be determined by the governmental unit furnishing the service. If the governmental unit receiving this service deems the charge unreasonable, the Statutes provide for either binding arbitration by a panel of three reputable and experienced engineers or for judicial review in the circuit court of the county of the governmental unit furnishing the service. As an alternative, the jointly acting governmental units may create a sewerage commission to project, plan, construct, and maintain in the area sewerage facilities for the collection, transmission, and treatment of sewage. Such a sewerage commission becomes a municipal corporation and has all the powers of a common council and board of public works in carrying out its duties. However, all bond issues and appropriations made by such a sewerage commission are subject to approval by the governing bodies of the units of government which initially formed the commission. The Statutes stipulate that each governmental unit must pay its proportionate share of constructing, operating, and maintaining the joint sewerage system. Grievances concerning same may be taken to the circuit court of the county in which the aggrieved governmental unit is located. No joint sewerage systems had been formed in the Pike River watershed as of 1979.

Cooperative Action by Contract: Section 66.30 of the Wisconsin Statutes permits the joint exercise by municipalities, broadly defined to include the State or any department or agency thereof or any city, village, town, county, school district, public library system, sanitary district, or regional planning commission, of any power or duty required of or authorized to individual municipalities by statute. To jointly exercise any such power, such as the transmission, treatment, and disposal of sanitary sewage, municipalities would have to create a commission by contract. Appendix A of SEWRPC Technical Report No. 6, Planning Law in Southeastern Wisconsin, contains a model agreement creating such a cooperative contract commission.

Shoreland Regulation: The State Water Resources Act of 1965 provides for the regulation of shoreland uses along navigable waters to assist in water quality protection and pollution abatement and prevention. In Section 59.97(1) of the Wisconsin Statutes, the Legislature defines shorelands as all that area lying within the following distances from the normal high water elevation of all natural lakes and of all streams, ponds, sloughs, flowages, and other waters which are navigable under the laws of the State of Wisconsin: 1,000 feet from the shoreline of a lake, pond, flowage, or glacial pothole lake and 300 feet from the shoreline of a stream or to the landward side of the floodplain, whichever is greater.

Section 144.26 of the Wisconsin Statutes specifically authorizes municipal zoning regulations for shorelands. This Statute defines municipality as meaning a county, city, or village. The shoreland regulations authorized by this Statute have been defined by the Wisconsin Department of Natural Resources to include land subdivision controls and sanitary regulations. The purposes of zoning, land subdivision, and sanitary regulations in shoreland areas include the maintenance of safe and healthful conditions in riverine areas; the prevention and control of water pollution; the protection of spawning grounds, fish, and aquatic life; the control of building sites, placement of structures, and land use; and the preservation of shore cover and natural beauty. A more complete discussion of local shoreland regulatory powers is contained in SEWRPC Planning Guide No. 5, Floodland and Shoreland Development Guide.

Private Steps for Water Pollution Control

The foregoing discussion deals exclusively with water pollution control machinery available to units and agencies of government. Direct action may also be taken, however, by private individuals or organizations to effectively abate water pollution. In seeking direct action for water pollution control there are two legal categories of private individuals: riparians, or owners of land along a natural body of water, and nonriparians.

Riparians: It is not enough for a riparian proprietor seeking an injunction to show simply that an upper riparian is polluting the stream and thus he, the lower riparian, is being damaged. Courts will often inquire as to the nature and the extent of the defendant's activity; its worth to the community; its suitability to the area; and its present attempts, if any, to treat wastes. The utility of the defendant's activity is weighed against the extent of the plaintiff's damage within the framework of reasonable alternatives open to both. On the plaintiff's side, the court may inquire into the size and scope of his operations, the degree of water purity that he actually requires, and the extent of his actual damages. This approach may cause the court to conclude that the plaintiff is entitled to a judicial remedy. Whether this remedy will be an injunction or merely an award of damages depends on the balance which the court strikes after reviewing all the evidence. For example, where a municipal treatment plant or industry is involved, the court, recognizing equities on both sides, might not grant an injunction stopping the defendant's activity but might compensate the plaintiff in damages. In addition, the court may order the defendant to install certain equipment or to take certain measures designed to minimize the future polluting effects of his waste disposal. It is not correct to characterize this balancing as simply a test of economic strengths. If it were simply a weighing of dollars and cents, the rights of small riparians would never receive protection. The balance that is struck is one of reasonable action under the circumstances, and small riparians can be and have been adequately protected by the courts.

Riparians along water bodies in the Southeastern Wisconsin Region are not prevented by the existence of federal, state, or local pollution control efforts from attempting to assert their common law rights in courts. The court may ask the Wisconsin Department of Natural Resources to act as its master in chancery, especially where unbiased technical evidence is necessary to determine the rights of litigants. The important point, however, is that nothing in the Wisconsin Statutes can be found which expressly states that, in an effort to control pollution, all administrative remedies must first be exhausted before an appeal to the courts may be had or that any derogation of common law judicial remedies is intended. Thus, the courts are not prevented from entertaining an original action brought by a riparian owner to abate pollution.

Nonriparians: The rights of nonriparians to take direct action through the courts are less well defined than in the case of riparians. The Wisconsin Supreme Court set forth a potentially far-reaching conclusion in Muench v. Public Service Commission[6] when it concluded that:

> The rights of the citizens of the state to enjoy our navigable streams for recreational purposes, including the enjoyment of scenic beauty, is a legal right that is entitled to all the protection which is given financial rights.

This language, however, was somewhat broader than necessary to meet the particular situation at hand, since the case involved an appeal from a state agency ruling. The case has not yet arisen where a private nonriparian citizen is directly suing to enforce his public rights in a stream. Only when such a case does arise can it be determined if the Court will stand behind the broad language quoted above or draw back from its implications. The more traditional view would be that a nonriparian citizen must show special damages in a suit to enforce his public rights.

It should be noted that Section 144.537 of the Wisconsin Statutes presently enables six or more citizens, whether riparian or not, to file a complaint leading to a full-scale public hearing by the Department of Natural Resources on alleged or potential acts of pollution. In addition, a review of Department orders may be had pursuant to Section 144.56 of the Wisconsin Statutes by "any owner or other person in interest." This review contemplates eventual court determination under Chapter 227 of the Wisconsin Statutes when necessary. The phrase "or other person" makes it clear that nonriparians may ask such judicial review.

The Federal Water Pollution Control Act also provides for citizen suits. Under this law, any citizen, meaning a person or persons having an interest which is or may be adversely affected, may commence a civil action on his or her own behalf

[6] *261 Wis. 492, 53 N. W. 2d 514 (1952).*

against any person, including any governmental agency, alleged to be in violation of any effluent standard, limitation, or prohibition of any pollution discharge permit or condition thereof; or against the EPA Administrator when there is alleged failure by the Administrator to duly carry out any nondiscretionary duty or act under the Federal Water Pollution Control Act. Prior to bringing such action, however, the citizen commencing the action must give notice to the alleged violator. The courts when issuing final orders in any action under this section may award costs of litigation to any party.

FLOODLAND REGULATION AND CONSTRUCTION OF FLOOD CONTROL FACILITIES

Effective abatement of flooding can be achieved only by a comprehensive approach to the problem. Certainly, physical protection from flood hazards through the construction of dams, flood control reservoirs, levees, channel improvements, and other water control facilities is not to be completely abandoned in favor of floodland regulation. As urbanization proceeds within a watershed, however, it becomes increasingly necessary to develop an integrated program of land use regulation of the floodlands within the entire watershed to supplement required water control facilities if efforts to provide such facilities are not to be self-defeating.

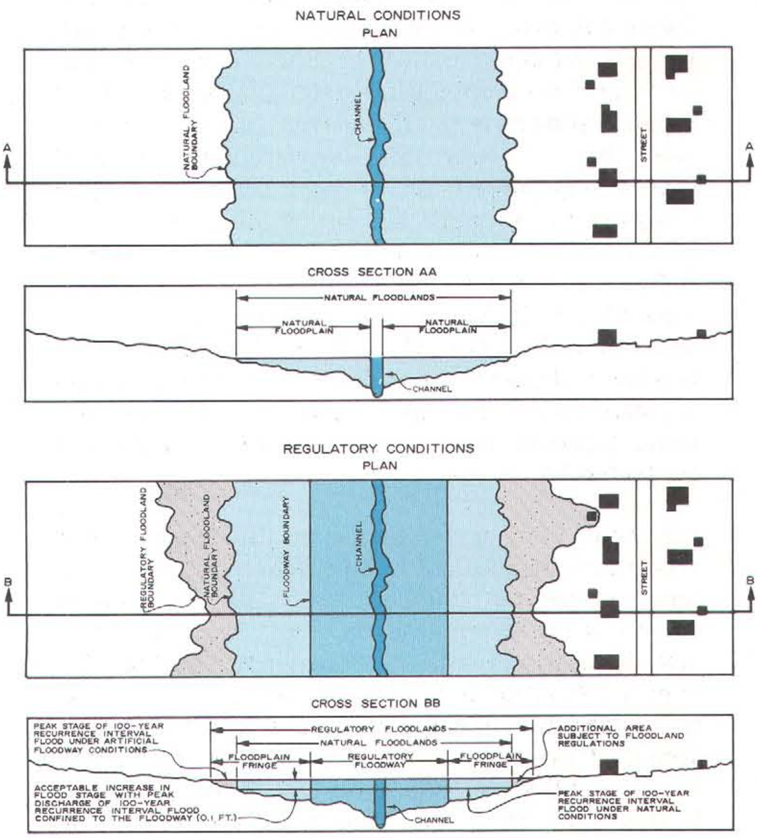
Definition of Floodlands

The precise delineation of floodlands is essential to the sound, effective, and legal administration of floodland regulation. This is particularly true in rapidly urbanizing areas, such as the Pike River watershed. A precise definition of floodlands is not found in the Wisconsin Statutes. Section 87.30(1) speaks only of those areas within a stream valley within which "serious (flood) damage may occur" or "appreciable (flood) damage . . . is likely to occur." This statutory description is not adequate per se for floodland determination. For example, as a watershed urbanizes, and as the hydraulic characteristics of a stream are altered, additional areas of a stream valley become subject to flooding. It becomes necessary, therefore, to regulate the entire potential, as well as existing, floodland areas.

In planning for the proper use of floodlands, it is useful to subdivide the total floodland area on the basis of the hydraulic function which the various subareas are to perform, as well as on the basis of the differing degrees of flood hazard that may be present (see Figure 50). Under natural conditions, the floodlands may be considered as consisting of two components: the channel of the river or stream itself and the adjacent natural floodplains. The channel may be defined as the continuous linear area occupied by the river or stream in times of normal flow. The natural floodplain may be defined as the wide, flat-to-gently sloping area contiguous with and lying adjacent to the channel, usually on both sides. The floodplain is normally bounded on its outer edges by higher topography. A river may be expected to overflow its channel banks and occupy some portion of its floodplains on the average of once every two years. How much of the natural floodplain will be occupied by any given flood will depend upon the severity of that flood and, more particularly, upon its elevation or stage. Thus, an infinite number of outer limits of the natural floodplain may be delineated, with each delineation relating to a corresponding specified flood recurrence interval. The Commission has, therefore, recommended that the natural floodplains of a river or stream be specifically defined as those being confined to a flood having a 1 percent chance of occurring in any given year.

Figure 50

FLOODLAND COMPONENTS UNDER NATURAL AND REGULATORY CONDITIONS



Source: SEWRPC.

This definition corresponds to the regulatory flood selected for use by the Wisconsin Department of Natural Resources in administering Wisconsin's floodplain management program set forth in Chapter NR116 of the Wisconsin Administrative Code.

Under ideal regulatory conditions, the entire natural floodplains as defined above would be maintained in an open, essentially natural state, and, therefore, would not be filled and utilized for incompatible, intensive urban land uses. Conditions permitting an ideal approach to floodland regulation, however, generally occur only in rural areas. In areas which have already been developed for intensive urban use without proper recognition of the flood hazard, a practical regulatory approach must embrace the concept of a floodway. A floodway may be defined as a designated portion of the floodlands—which includes the channel—that will safely convey the 100-year recurrence interval flood discharge, with small upstream and downstream stage increases allowed, generally limited in Wisconsin to 0.1 foot if the stage increase does not increase the flood damage potential. Increases greater than 0.1 foot are permissable only when accompanied by appropriate legal arrangements with the affected local units of government and private property owners. Land use controls applied to the regulatory floodway should recognize that the designated floodway area is not suited for human habitation and should essentially prohibit all fill, structures, and other development that would impair floodwater conveyance by adversely increasing flood stages or velocities.

The floodplain fringe is that remaining portion of the floodlands lying outside or beyond the floodway. Because the use of a regulatory floodway may result in increases in the stage of a flood of a specified recurrence interval that would not occur under natural conditions, the floodplain fringe may include at its very edges areas that would not be subject to inundation under natural conditions, but which would be subject to inundation under regulatory floodway conditions and, therefore, come within the scope of necessary floodplain fringe regulation. Normally, floodwater depths and velocities are low in the floodplain fringe, and accordingly, filling and urban development may be permitted, although regulated to minimize flood damages. Under "real world" conditions, the floodplain fringe usually includes many existing buildings constructed in natural floodlands prior to the advent of sound floodland regulations.

The delineation of the limits of the floodland regulatory area should be based upon careful hydrologic and hydraulic studies such as have been conducted under the Pike River watershed study for the Pike River and its major tributaries.

Principles of Floodland Regulation

Certain legal principles must be recognized in the development of land use regulations that would be designed to implement a comprehensive watershed plan. With respect to the floodland areas of the watershed, those are as follows:

1. Sound floodland regulation must recognize that the flood hazard is not uniform over the entire floodland area. Restrictions and prohibitions in floodlands should, in general, be more rigorous in the channels themselves and in the floodways than in the floodplain fringe areas.

2. While it is most desirable that floodland regulations seek to retain floodlands in open space uses, sound floodland regulation may contemplate permitting certain buildings and structures at appropriate locations in the floodplain fringe. Any such structure, however, should comply with special design, anchorage, and building material requirements.

3. Sound floodland regulation must recognize, and be adjusted to, existing land uses in the floodlands. Structures already may exist in the wrong places. Fills may be in place restricting flood flows or limiting the flood storage capacities of the river. The physical effects of such misplaced structures and materials on flood flows, stage, and velocities can be determined. Floodland regulation based on such determinations must include legal measures to bring about the removal of at least the most troublesome of offenders.

4. In addition to the physical effects of structures and materials, sound floodland regulation must be concerned with the social and economic effects, particularly the promotion of public health and safety. Beyond this, sound floodland regulation must take into account such diverse and general welfare items as impact upon property values, the property tax base, human anguish, aesthetics, and the need for open space.

5. Sound floodland regulation must coordinate all forms of land use controls, including zoning, subdivision control, and official map ordinances and housing, building, and sanitary codes.

Land Use Regulations in Floodlands

Based upon the above principles and upon the definition of floodplains set forth above, the Commission has proposed that the local units of government within the entire Region utilize a variety of land use controls to effect proper floodland development. The use of these controls is discussed in SEWRPC Planning Guide No. 5, Floodland and Shoreland Development Guide, and, therefore, will not be repeated here. The following section, however, will summarize the various land use regulatory powers available to state, county, and local units of government for use in regulating floodland development.

Channel Regulation: Sections 30.11, 30.12, and 30.15 of the Wisconsin Statutes establish rules for the placement of material and structures on the bed of any navigable water and for the removal of material and structures illegally placed on such beds. With the approval of the Wisconsin Department of Natural Resources, pursuant to Section 30.11 of the Wisconsin Statutes, any town, village, city, or county may establish bulkhead lines along any section of the shore of any navigable water within its boundaries. Where a bulkhead line has been properly established, material may be deposited and structures built out to the bulkhead line, consistent with the appropriate floodway zoning ordinance. A Wisconsin Department of Natural Resources permit is required for the deposit of material or the erection of a structure beyond the bulkhead line. Where no bulkhead line has been established, it is unlawful to deposit any material or build any structure upon the bed of any navigable water unless a Wisconsin Department of Natural Resources permit has first been obtained.

The delineation of the outer boundary of the bed of a navigable lake or stream thus becomes a crucial legal issue, and the Statutes provide no assistance in this problem. Where the lake or stream has sharp and pronounced banks, it will ordinarily be possible, using stage records, the testimony of knowledgeable persons, and evidence relating to types of vegetation and physical characteristics of the bank, to establish the outer limits of the stream or lake bed. The task can present a difficult practical problem, however, particularly where the stream is bordered by low-lying wetlands. Where bulkhead lines have been established, however, or where the outer limits of navigable waters can be defined, existing encroachments in the beds of these navigable waters can be removed and new encroachments prevented under existing Wisconsin legislation.

Floodway and Floodplain Fringe Regulation: The regulation of floodlands in Wisconsin is governed primarily by the rules and regulations adopted by the Wisconsin Department of Natural Resources pursuant to Section 87.30 of the Wisconsin Statutes. In addition, with the advent of the federal flood insurance program, the enactment of floodland regulation in Wisconsin is further governed by rules promulgated by the U. S. Department of Housing and Urban Development. In essence, floodland regulation in Wisconsin is a partnership between the local, state, and federal levels of government.

State Floodplain Management Program: While the Wisconsin Legislature long ago recognized that the regulation of stream channel encroachments was an areawide problem transcending county and municipal boundaries and, therefore, provided for state regulation, it was not until passage of the State Water Resources Act in August 1966 that a similar need was recognized for floodway and floodplain fringe regulation. In that Act, the Legislature created Section 87.30 of the Wisconsin Statutes. This section authorizes and directs the Wisconsin Department of Natural Resources to enact floodland zoning regulations where it finds that a county, city, or village has not adopted reasonable and effective floodland regulations. The cost of the necessary floodplain determination and ordinance promulgation and enforcement by the State must, under the Statute, be assessed and collected as taxes from the county, city, or village by the State. Chapter NR116 of the Wisconsin Administrative Code sets forth the general criteria for counties, cities, and villages to follow in enacting reasonable and effective floodland regulations. In addition to providing for the proper administration of a sound floodland zoning ordinance, the criteria include a stipulation that, where applicable, floodland zoning ordinances should be supplemented with land subdivision regulations, building codes, and sanitary regulations.

In practice, the Department of Natural Resources issues orders to counties, cities, and villages when sound flood hazard data become available for use in floodland regulation. In the Southeastern Wisconsin Region, this has generally meant that such orders are issued to communities upon completion of comprehensive watershed studies developed by the Regional Planning Commission, which include the definitive determination of flood hazard areas. These orders normally provide a period of six months upon receipt of the flood hazard data for the enactment of the necessary local regulations.

State Agency Coordination: On November 26, 1973, Governor's Executive Order No. 67 was issued. It was designed to promote a unified state policy of comprehensive floodplain and shoreland management. The key provisions of the executive order are as follows:

1. State agencies are now required to consider flooding and erosion dangers in the administration of grant, loan, mortgage insurance, and other financing programs.

2. All state agencies that are involved in land use planning are required to consider flooding and erosion hazards when preparing and evaluating plans. In addition, all state agencies directly responsible for new construction of state facilities, including buildings, roads, and other facilities, are required to evaluate existing and potential flood hazards associated with such construction activities.

3. All state agencies that are responsible for the review and approval of subdivision plats, buildings, structures, roads, and other facilities are required to evaluate existing or potential flood hazards associated with such construction activities.

4. In its license review, suspension, and revocation procedures, the State Real Estate Examining Board must consider the failure of real estate brokers, salesmen, or agents to properly inform a potential purchaser that property under consideration lies within an area subject to flooding or erosion hazards.

The provisions of this executive order are extremely important in that all state agencies are now required to utilize the flood hazard data that have been and are being developed. Thus, the provisions will assist in assuring that state-aided action, such as highway construction, will not contribute to increasing flooding and erosion hazards or to changing the character of the flooding. The order also assures that state agency actions will be consistent with local floodland regulations.

Federal Flood Insurance Program: A program to enable property owners to purchase insurance to cover losses caused by floods was established by the U. S. Congress in the National Flood Insurance Act of 1968. Taking note that many years of installation of flood protection works had not reduced losses caused by flood damages, Congress sought to develop a reasonable method of sharing the risk of flood losses through a program of flood insurance, while at the same time setting in motion local government land use control activity that would seek to ensure, on a nationwide basis, that future urban development within floodlands would be held to a minimum.

The Act created a national flood insurance program under the direction of the Secretary of the U. S. Department of Housing and Urban Development (HUD). The Secretary was given broad authority to conduct all types of studies relating to the determination of floodlands and the risks involved in insuring development that may be situated in natural floodland areas. The Act provided for the establishment of a national flood insurance fund, part of which would be established by congressional appropriations, designed to assist in subsidizing insurance rates where necessary to encourage the purchase of flood insurance by individual landowners and thus reduce the need for periodic federal disaster assistance. Congress emphasized, however, that the establishment of such a program was not intended to encourage additional future development in flood-prone areas, but rather to assist in spreading the risks created by existing floodland development while taking effective action to ensure that local land use control measures effectively reduce future flood losses by prohibiting unwise floodland development.

Participation in the national flood insurance program is on a voluntary, community-by-community basis. A community must act affirmatively to make its residents eligible to purchase flood insurance. Once a community makes it known to the Secretary of the U. S. Department of Housing and Urban Development that it wishes to participate in the program, the Secretary authorizes appropriate studies to be made to determine the special flood hazard areas that may exist within the community and the rates at which flood insurance may be made available. In the Southeastern Wisconsin Region, such flood insurance studies build upon and at times supplement the flood hazard data made available by the Regional Planning Commission under the comprehensive watershed planning programs. When the federal studies are completed, the Secretary publishes a flood hazard boundary map or maps, which identify the areas of "special flood hazard," and a flood insurance rate map or maps, which divide the community into various zones for insurance purposes. A landowner is then eligible to go to any private insurance agent and purchase flood insurance up to certain specified maximums at the rates established by the Secretary. Such rates can be federally subsidized if the actuarial rates would result in a likelihood of widespread nonparticipation in the program. For its part, the community must enact land use controls which meet federal standards for floodland protection and development. For all practical purposes, once a community enacts floodland regulations that meet the state requirements set forth in Chapter NR116 of the Wisconsin Administrative Code, it will have been deemed to meet all federal requirements for similar controls.

In 1973 the U. S. Congress expanded the national flood insurance program through enactment of the Federal Flood Disaster Protection Act of 1973. In addition to increasing the amount of both subsidized and unsubsidized flood insurance coverage available for all types of properties, this act expanded the insurance program to include erosion losses caused by abnormally high water levels. In addition, the Act stipulates that the purchase of flood insurance is required for all structures within flood hazard areas when a purchaser seeks a mortgage through a federally supervised lending institution. And, as a condition of future federal disaster assistance in flood hazard areas, the Act requires flood insurance to be purchased so as to ensure that the next time a property is damaged by floods, the losses will be covered by insurance and federal disaster assistance will not be needed.

On May 24, 1977, the President of the United States issued Executive Order 11988 concerning floodplain management. Appropriate federal agencies were directed to accomplish the following tasks:

- Evaluate the potential effects of any actions the agency may take in a floodplain;
- Ensure that the agency's planning programs and budget requests reflect consideration of flood hazards and floodplain management;
- Identify any proposed action to take place in a floodplain in any new requests for appropriations from the Office of Management and Budget;
- Consider floodplain management when formulating or evaluating any water resource use appropriate to the degree of hazard involved; and
- Issue new or amend existing regulations to comply with the Executive Order.

The Executive Order was issued in furtherance of the National Environmental Policy Act of 1969, the National Flood Insurance Act of 1968, and the Flood Disaster Protection Act of 1973.

Construction of Flood Control Facilities

Sound physical planning principles dictate that a watershed be studied in its entirety if practical solutions are to be found to water-related problems, and that plans and plan implementation programs, including the construction of flood control facilities, be formulated to deal with the interrelated problems of the watershed as a whole. A watershed, however, typically is divided in a most haphazard fashion by a complex of man-made political boundaries—county, city, village, town, and special district. When public works projects such as flood control works, covering and serving an entire watershed, are required, these artificial demarcations become extremely important because they limit the jurisdiction—the physical area—within which any one particular arm of local government may act. With respect to the Pike River watershed, this limitation may be overcome by delegation of the planning tasks to SEWRPC with resulting designation of the implementation roles of the various existing units of government, or, if dictated by the physical plan recommendations, by the creation of a special-purpose development district.

Interbasin Water Diversion

The legal problems encountered concerning interbasin water diversion are discussed in Chapter IX of SEWRPC Technical Report No. 2, Water Law in Southeastern Wisconsin. The traditional common-law riparian doctrine, which for the most part is still in effect today in Wisconsin, forbade the transfer of water between watersheds. However, states via legislative action can and have created exceptions to this general doctrine. In contemplating a stream diversion two major groups of individuals may be in a position, depending upon the quantity of water involved and the duration of the diversion, to assert their private property rights against the private or municipal agencies carrying out the diversion. The first group consists of those riparians along the stream from which the diversion is made. The reasonableness of the diversion, the "taking" of private property involved, and the issue of compensation are all legal factors to be considered. The second group of individuals who may be in a position to assert legal rights are those whose lands abut the streams or lakeshore into which the diversion is made. Again, the diverter is liable to these riparians for land taken or damages caused as a consequence of the unnaturally increased flow.

Wisconsin Statutes Section 30.18 dealing with water diversions stipulates that "... no water shall be so diverted to the injury of public rights in the streams. . . . " The Statute also states that only "surplus water," i.e., any water of a stream which is not being beneficially used, can be diverted and such diversions can be made only for the purpose of maintaining normal stream or lake levels in other watercourses. The only apparent exception to this section applies to agricultural and irrigation purposes, for which water other than "surplus water" may be diverted but only with the consent of all of the riparians who would be injured by the diversion. To effect even these limited types of diversions, hearings would have to be held and permits issued by the Wisconsin Department of Natural Resources. The recent Wisconsin Supreme Court case of Omernik v. State stated that Section 30.18 applied to nonnavigable streams from which water was diverted as well as to navigable streams.[7] If the anticipated use of diverted water is other than for one of the categories stipulated under Section 30.18 of the Wisconsin Statutes, then the common law test of reasonableness will be invoked.

SPECIFIC LEGAL CONSIDERATIONS AND INVENTORY FINDINGS IN THE PIKE RIVER WATERSHED

Inventories were conducted with respect to state water regulatory permits, state water pollution abatement orders and permits, federal water regulatory permits, floodland regulation, flood insurance eligibility, and other local water-related regulatory matters.

State Water Regulatory Permits

As noted earlier in this chapter, the Wisconsin Department of Natural Resources has broad authority under the Wisconsin Statutes to regulate the water resources of the State. An inventory was made under the Pike River watershed study of all permits issued by the Department of Natural Resources in the Pike River watershed with respect to water regulation.

Bulkhead Lines: Municipalities are authorized by Section 30.11 of the Wisconsin Statutes to establish by ordinance bulkhead lines, subject to review and approval by the Wisconsin Department of Natural Resources. Bulkheads are required to conform as nearly as practicable to existing shores and must be found by the Department of Natural Resources to be in the public interest. It was determined that no bulkhead lines exist in the Pike River watershed as of 1979.

Waterway Enlargement and Protection: Section 30.19 of the Wisconsin Statutes requires any person who wishes to establish artificial waterways, canals, channels, ditches, lagoons, ponds, lakes, or other waterways to first secure a permit from the Wisconsin Department of Natural Resources. Permits are also required to connect any natural or artificially constructed waterway with an existing body of navigable water. In addition, Section 30.195 requires permits for straightening or changing in any other way the course of navigable streams. These permits are listed in Table 72.

Other Water Regulatory Permits: In a search of the records of the Wisconsin Department of Natural Resources, permits were found for the Pike River watershed for the following types of water-related activities: placement of structures and deposits in navigable waters (Wisconsin Statutes Section 30.12); water diversion from lakes and streams (Wisconsin Statutes Section 30.18); dredging (Wisconsin Statutes Section 30.20); dam and bridge construction, operation, and maintenance (Wisconsin Statutes Chapter 31); and the installation of high-capacity wells (Wisconsin Statutes Section 144.025(2)(c)). These permits are listed in Table 72.

State Water Pollution Abatement Orders and Permits

An inventory was made of all effluent discharge permits and of all outstanding pollution abatement orders in the Pike River watershed. The following section presents the results of that inventory.

Effluent Discharge Permits: As noted earlier in this chapter, a new Wisconsin pollution discharge elimination system permit structure was established by the Wisconsin Department of Natural Resources pursuant to statutory authorization contained in Chapter 147 of the Wisconsin Statutes. A permit is required for all industrial and municipal waste discharges. The inventory revealed that to date (1979) a total of five industrial waste discharge permits have been applied for and/or issued in the Pike River watershed and to date (1979) a total of two municipal waste discharge permits have been applied for and/or issued. All of the industrial discharge outfalls involve the discharge of cooling water. Pertinent characteristics pertaining to each of these permits are set forth in Tables 73 and 74, respectively.

[7] *64 Wis. 2d 6, 218 N. W. 2d 734 (1974).*

Table 72

STATE WATER REGULATORY PERMITS IN THE PIKE RIVER WATERSHED: 1979

Statute	Permit Number	Description
Section 30.12	3-SE-78-713	Washington Court Company—placement of rip rap on the bed of Pike Creek
Section 30.18	2-WP-1829	Town of Somers—diversion of water from the Pike River for irrigation
	3-SE-77-306	Kenosha Country Club—diversion of water from the Pike River for irrigation
	3-WR-1963	Town of Mt. Pleasant—diversion of water from the North Branch Pike River for irrigation
Section 30.195	3-WR-1908	Mt. Pleasant Storm Water Drainage District No. 1—change in the course of the Pike River in the Town of Somers
Section 30.20	3-SE-125	Wisconsin Natural Gas Company—removal of materials from the bed of the Pike River
	3-SE-310	Mt. Pleasant Storm Water Drainage District No. 1—dredge materials from the bed of the Pike River in the Towns of Mt. Pleasant and Somers
	3-SE-400	Town of Mt. Pleasant—removal of materials from the bed of the Pike River
	3-SE-452	Kenosha County Park Commission—removal of materials from the bed of the Pike River
	3-SE-484	Town of Mt. Pleasant—removal of materials from the bed of an unnamed tributary to the Pike River in the SW ¼ of the SE ¼ of Section 14, T3N, R22E
	3-SE-78-007	Johnson Real Estate Corporation—removal of materials from the bed of an unnamed tributary to Sorenson Creek in the Town of Somers
	3-SE-176	Kenosha County Park Commission—removal of materials from the bed of the Pike River in the Town of Somers
	3-SE-549	Kenosha Water Utility—removal of materials from the bed of the Pike River
	3-SE-77-056	Village of Sturtevant, Town of Mt. Pleasant—removal of materials from the beds of the Pike River and the Worthington Lateral
	3-SE-77-57	Village of Sturtevant, Town of Mt. Pleasant—removal of materials from the bed of the Pike River
	3-SE-77-058	Wisconsin Natural Gas Company—removal of materials from the bed of the Pike River in the Town of Somers
	3-SE-77-059	Wisconsin Natural Gas Company—removal of materials from the bed of the Pike River in the Town of Somers
	3-SE-77-055	Town of Mt. Pleasant—removal of materials from the beds of Sorenson Creek and an unnamed tributary to Sorenson Creek
Section 144.025	80-411	Maple Crest Country Club—installation of a high capacity well in the Town of Somers
	80-413, 80-414	Eagle Chateau Apartment Complex—installation of two high capacity wells in the Town of Somers

Source: Wisconsin Department of Natural Resources and SEWRPC.

Table 73

INDUSTRIAL WASTE DISCHARGE PERMITS ON FILE IN THE PIKE RIVER WATERSHED: 1979

Permittee	Location		Type of Discharge	Pre-Treatment (if known)	Receiving Stream	Permit Number
	Address	Civil Division				
AMETEK/Lamb Electric Division	2745 Chicory Road	City of Racine	Cooling Water	None	Sorenson Creek	WI-0001775-2
J. I. Case Company	7000 Durand Avenue	City of Racine	Cooling Water	None	Pike River	WI-0039691-2
S. C. Johnson & Son, Inc.	2512 Willow Road	Village of Sturtevant	Cooling Water	None	Waxdale Creek Tributary to the Pike River	WI-0027758-2
Metal-Lab, Inc.	7316 Durand Avenue	Village of Sturtevant	Cooling Water	None	Unnamed Tributary to Pike River	WI-0041602-2
Rexnord, Inc.	7505 Highway 11	City of Racine	Cooling Water	None	Pike River	WI-0021997-2

Source: Wisconsin Department of Natural Resources and SEWRPC.

Table 74

MUNICIPAL WASTE DISCHARGE PERMITS IN THE PIKE RIVER WATERSHED: 1979

Permittee	Location	Type of Discharge	Receiving Stream	Permit Number
Town of Somers Utility District No. 1	Town of Somers	Wastewater Treatment Plant Effluent	Somers Tributary (Branch)	WI-0022314-2
Village of Sturtevant	2701 87th Street, Sturtevant	Wastewater Treatment Plant Effluent	Pike River	WI-0021652-2

Source: Wisconsin Department of Natural Resources and SEWRPC.

Pollution Abatement Orders: In addition to the inventory of effluent discharge permits, an inventory was made to determine if outstanding pollution abatement orders in the Pike River watershed existed. It was determined that only one such order has been issued in the Pike River watershed, which was issued to the Village of Sturtevant. However, this order, as well as all previous pollution abatement orders related to point source discharge, is no longer enforced owing to the recent pollution discharge elimination system permit structure.

Federal Water Regulatory Permits

The U. S. Department of the Army, Corps of Engineers, requires permits for work or structures in navigable waters of the U. S., waste outfalls in navigable waters, the discharge of dredged or fill materials into navigable waters, and the transportation of dredged material for the purpose of dumping into ocean waters. Federal laws prohibit such activities unless the activity is authorized by a Department of the Army permit. It was determined that no such permits have been issued in the Pike River watershed. However, the inventory of these permits did reveal the following three projects which were reviewed by the Corps of Engineers, but for which Department of the Army permits were not required: 1) fills associated with the replacement of two structures on CTH A crossing Pike Creek, proposed by the Kenosha County Highway Department; 2) the Sturtevant-Mt. Pleasant interceptor sewer crossings of the Pike River; and 3) riprap implacement to facilitate storm sewer outfall construction on the Pike River Canal.

Floodland Regulation and Flood Insurance Eligibility

In 1980 only one unit of government regulated floodplains in the Pike River watershed. Racine County, through its Shoreland-Floodland Zoning Ordinance, regulates floodplains in the Pike River watershed within the Town of Mt. Pleasant (see Map 41). The floodplains being regulated by Racine County were derived from the floodplain information report prepared for the Pike River watershed by the U. S. Soil Conservation Service. While the Soil Conservation Service floodplain data in other portions of the Pike River watershed are available for floodplain zoning purposes, neither the Village of Sturtevant, the City of Kenosha, nor Kenosha County for the unincorporated area in the Town of Somers have as yet taken steps to incorporate this data within their zoning ordinances. Kenosha County informally uses the data in working with the landowners and developers in the Town of Somers.

Only residents of the Villages of Elmwood Park and Sturtevant are not at the present time eligible to purchase subsidized flood insurance under the federal flood insurance program. The Cities of Kenosha and Racine and Kenosha and Racine Counties on behalf of the Towns of Mt. Pleasant, Somers, and Pleasant Prairie have all taken steps to participate formally in the flood insurance program. At the present time, federal flood insurance studies, including the determination of floodplains under existing conditions, are underway throughout the Pike River watershed. Map 42 identifies the stream reaches that are being studied under this program.

Local Water-Related Regulatory Matters

An inventory was conducted under the Pike River watershed study of other local ordinances relating to water quality and water use. This inventory indicated that the sanitary sewerage systems of the Village of Sturtevant and Town of Somers Utility District No. 1, which discharge treated effluent to the surface waters of the Pike River watershed, prohibit the introduction of clear water from sump pumps, roof drains, or other sources into the sanitary sewerage system.

In addition, the inventory indicated the existence of regulations relative to water-related recreational activities. Under Section 30.77 of the Wisconsin Statutes, any town, village, or city may adopt local boating regulations not inconsistent with specified uniform statewide regulations set forth in Sections 30.50 through 30.71 of the Wisconsin Statutes. Such local supplementary boating regulations may pertain to the equipment, use, and operation of a boat on a navigable body of water, including rivers and streams. Such regulations must also be found to be in the interest of public health, safety, or welfare. Locally adopted boating regulations exist for both Petrifying Springs Park and Carthage College, and in both cases prohibit the launching or landing of any boat within the respective real property boundaries.

SUMMARY

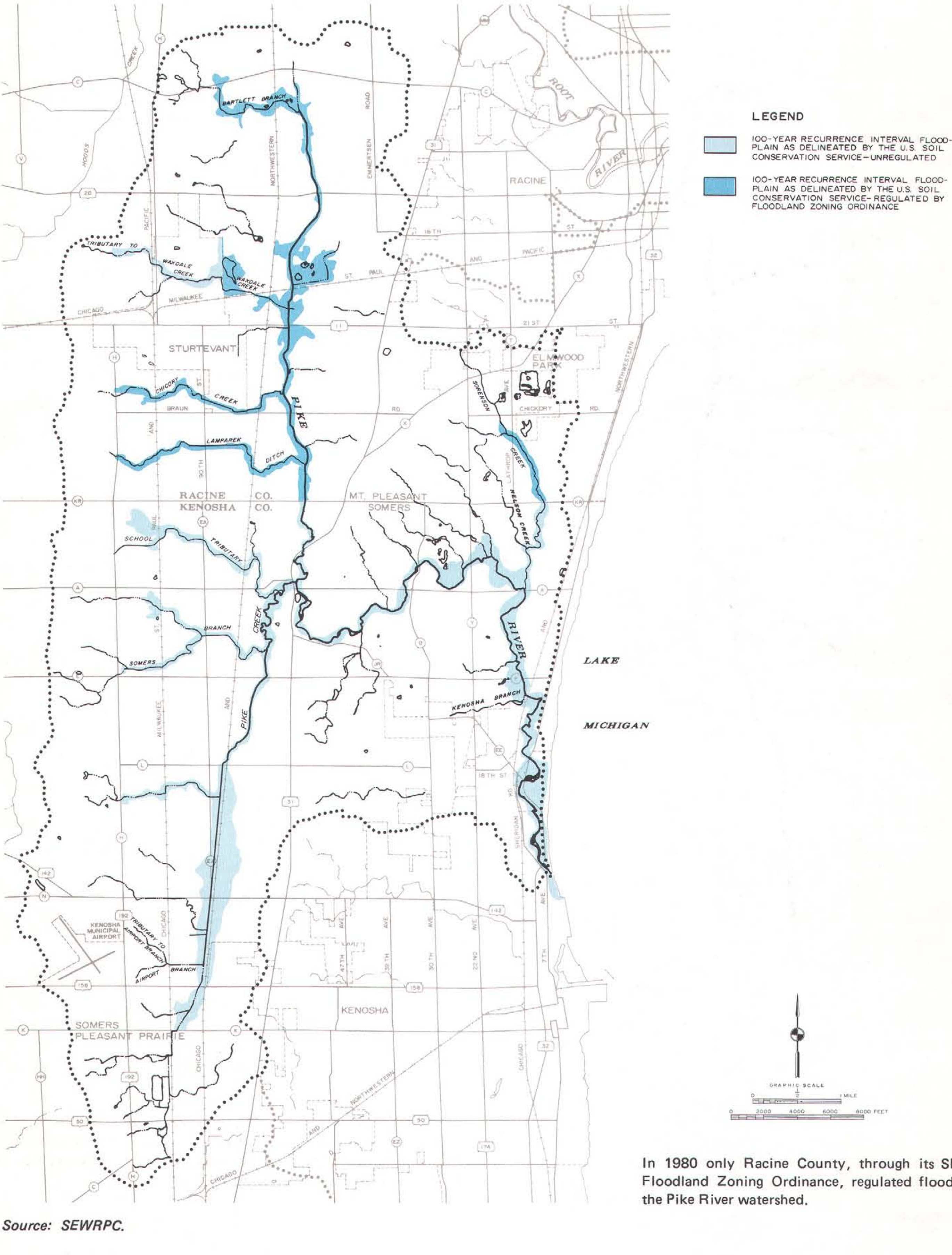
This chapter has described in summary form the legal framework within which comprehensive watershed planning and plan implementation must take place in southeastern Wisconsin. The salient findings having particular importance for planning in the Pike River watershed include the following:

Water law is not a simple or fixed body of law. It has historical roots which reach back beyond the common law. Three principal divisions of water law may be identified: riparian and public rights law, groundwater law, and diffuse surface water law. Riparian and public rights law applies to the use of surface water occurring in natural rivers, streams, lakes, and ponds. Groundwater law applies to the use of water occurring in the saturated zone below the water table. Diffuse surface water law applies to water draining over the surface of the land. The field of water law has never been in a greater or more continuous state of change than it is in today. In 1974 alone, the Wisconsin Supreme Court in landmark cases expressly overruled the historic common law doctrine with respect to both groundwater law and diffuse surface water law, finding that the historic doctrines no longer applied to modern water resource problems and conflicts.

With passage of the Federal Water Pollution Control Act amendments of 1972, the U. S. Congress set in motion a series of actions which will have many ramifications for water quality management within the Region and the Pike River watershed. Water use objectives and supporting water quality standards now are required for all navigable waters in the United States. It is a national goal to eliminate the discharge of pollutants into the navigable waters of the United States by 1985. To meet this goal, the Act requires the enactment of specific effluent limitations for all point sources of water

Map 41

FLOODLAND DELINEATIONS AND FLOODLAND REGULATION IN THE PIKE RIVER WATERSHED: 1980

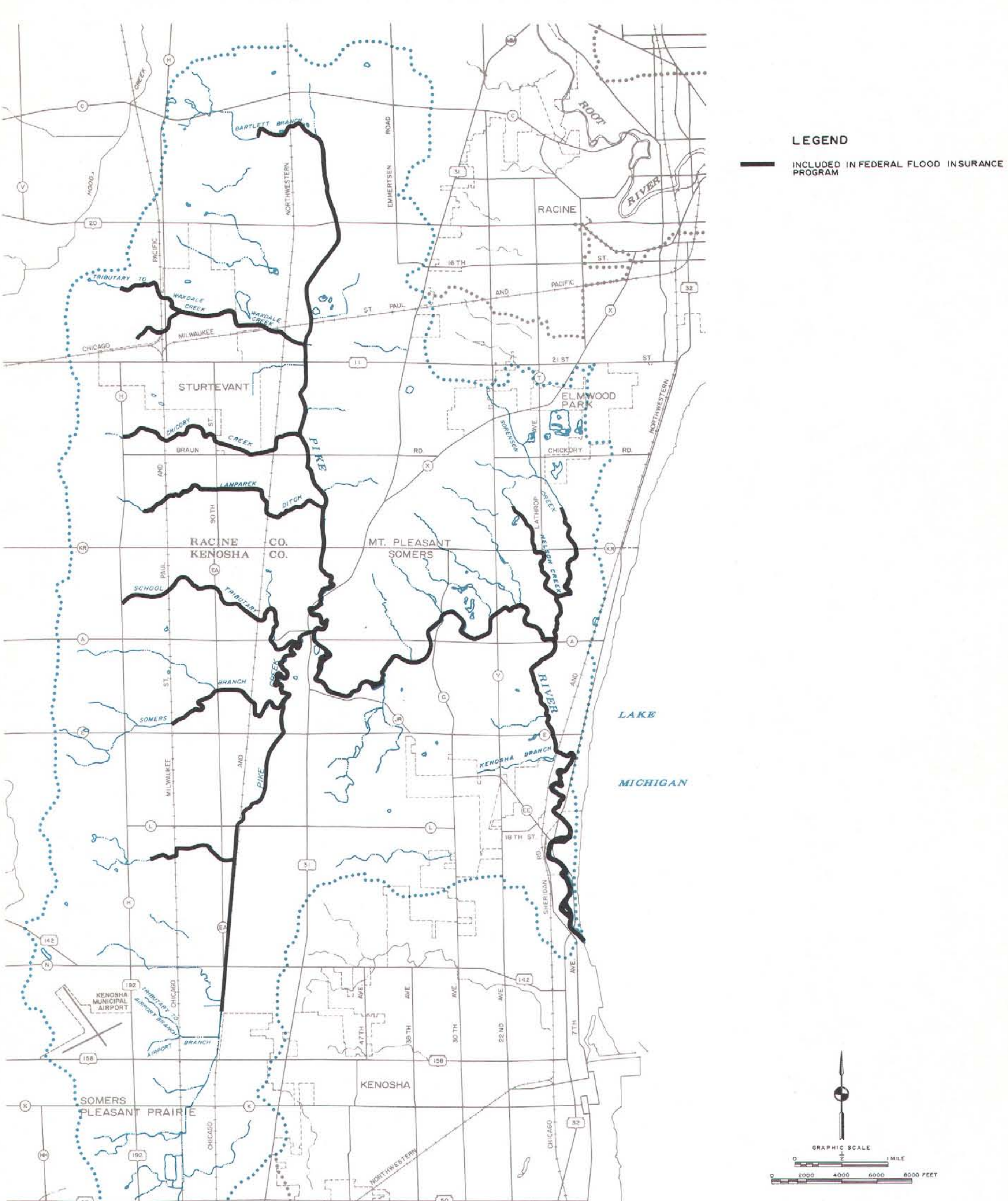


In 1980 only Racine County, through its Shoreland-Floodland Zoning Ordinance, regulated floodplains in the Pike River watershed.

Source: SEWRPC.

Map 42

STREAM REACHES STUDIED UNDER THE FEDERAL FLOOD INSURANCE PROGRAM IN THE PIKE RIVER WATERSHED



In 1980 federal flood insurance studies, including the determination of floodplains under existing conditions, were underway for the Cities of Kenosha and Racine and Kenosha and Racine Counties.

Source: SEWRPC.

pollution. The Act also establishes a pollutant discharge permit system. Under such a system, permits are issued for the discharge of any pollutants with the stipulation that the discharge must meet all applicable effluent limitations and contribute toward achieving the water use objectives and supporting water quality standards.

Responsibility for water quality management in Wisconsin is centered in the Wisconsin Department of Natural Resources. The Department is given authority to prepare long-range water resources plans and to establish water use objectives and supporting water quality standards applicable to all waters of the State, to establish a pollutant discharge permit system, and to issue pollution abatement orders. New water use objectives and supporting water quality standards applicable to all perennial streams of the Pike River watershed were adopted by the Wisconsin Natural Resources Board in 1973 and revised in 1976. These include the following five categories: salmon fishery and aquatic life, recreational use, and minimum standards; warmwater fishery and aquatic life, recreational use, and minimum standards; limited fishery and aquatic life, recreational use, and minimum standards; marginal aquatic life, recreational use, and minimum standards; and restricted recreational use and minimum standards. The Commission-adopted regional water quality management plan includes upgrading the water use objectives in the Pike River watershed to only the two following categories: 1) salmon spawning fishery and aquatic life, recreational use, and minimum standards; and 2) warmwater fishery and aquatic life, recreational use, and minimum standards.

In addition to the broad grant of authority to general-purpose units of local government to regulate in the interests of health, safety, and welfare, Wisconsin Statutes currently provide for the creation of five types of special-purpose units of government through which water pollution can be abated and water quality protected. These five types are metropolitan sewerage districts, utility districts, sanitary districts, joint sewerage systems, and cooperative action by contract. Three utility districts and one sanitary district have been established in the Pike River watershed. No metropolitan sewerage districts or joint sewerage systems had been created in the watershed as of 1979.

Inventories were conducted in the Pike River watershed with respect to state water regulatory permits, state water pollution abatement orders and permits, federal water regulatory permits, floodland regulation, flood insurance eligibility, and local water-related regulatory matters. A total of 20 state water regulatory permits were issued in the watershed under Chapters 30 and 144 of the Wisconsin Statutes. A total of seven state effluent discharge permits had been issued in the watershed, of which a total of five were industrial waste discharge permits. At the present time Racine County is the only unit of government that regulates floodplains in the Pike River watershed. The Cities of Kenosha and Racine and Kenosha and Racine Counties have all taken steps to participate formally in the federal flood insurance program.

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Chapter X

WATERSHED DEVELOPMENT OBJECTIVES, PRINCIPLES, AND STANDARDS

INTRODUCTION

As noted in Chapter II of this report, the formulation of watershed development objectives and supporting standards is the second step in the SEWRPC seven-step watershed planning process. 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 public officials and citizen leaders in the overall regional planning program is implicit in the composition of the Southeastern Wisconsin Regional Planning Commission itself. Moreover, the Commission very early in its existence recognized the need to provide an even broader opportunity for the active participation of elected and appointed public officials, technicians, and citizens in the regional planning process. To meet this need the Commission established advisory committees to assist the Commission and its staff in the conduct of the regional planning program. One of these committees is the Pike River Watershed Committee, the composition of which was described in Chapter I. One of the important functions of this Committee is to assist in the formulation of a set of watershed development objectives and standards which can provide a sound basis for watershed plan design, test, and evaluation.

This chapter sets forth the set of watershed development objectives and supporting principles and standards approved by the Committee. Some of these objectives, principles, and standards were originally adopted by the Commission under related regional planning programs but were deemed relevant to formulation of a comprehensive plan for the Pike River watershed. Others were formulated specifically as a basis for the preparation of the watershed plan.

In addition to presenting watershed development objectives, principles, and standards, this chapter discusses certain engineering design criteria and analytic procedures used in the watershed study to design alternative plan subelements, test the physical feasibility of those subelements, and make necessary economic comparisions between such subelements. The description of these criteria and procedures in this chapter is intended to document the level of detail entailed in the watershed plan preparation and thereby provide a better understanding, by all concerned, of the plan itself as well as of the need for refinement of some aspects of that plan prior to implementation. 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 the plan design, test, and evaluation.

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 similarly subject to a wide range of interpretation and application. The following definitions have, therefore, been adopted by the Commission in order to provide a common frame of reference:

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

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

3. Standard: a criterion used as a basis 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 watershed development objectives, principles, and standards.

WATERSHED DEVELOPMENT OBJECTIVES

In order to be useful in the watershed planning process, objectives 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, a number of regional development objectives relating to land use, housing, transportation, water quality management, flood control, and recreation and open space preservation. These objectives, 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 Pike River watershed planning effort, and are hereby recommended for adoption as development objectives for the Pike River watershed.

Land Use Development Objectives

All of the eight specific regional land use development objectives adopted by the Commission under its regional land use planning program are directly applicable to the Pike River watershed planning effort. These are:

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

2. A spatial distribution of the various land uses which will result in a compatible arrangement of land uses.

3. A spatial distribution of the various land uses which will result in the protection and wise use of the natural resources of the Region, including its soils, inland lakes and streams, wetlands, woodlands, and wildlife.

4. A spatial distribution of the various land uses which is properly related to the supporting transportation, utility, and public facility systems in order to assure the economical provision of transportation, utility, and public services.

5. The development and conservation of residential areas within a physical environment that is healthy, safe, convenient, and attractive.

6. The preservation, development, and redevelopment of a variety of suitable industrial and commerical sites both in terms of physical characteristics and location.

7. 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.

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

Sanitary Sewerage System and Water Quality Management Planning Objectives

All of the five specific water quality management objectives adopted by the Commission under its regional water quality management planning effort are directly applicable to the Pike River watershed planning effort. These are:

1. The development of land management and water quality control practices and facili-

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

2. The development of land management and water quality control practices and facilities—inclusive of sanitary sewerage systems—so as to meet the recommended water use objectives and supporting water quality standards as set forth on Map 43 and in Table 80.

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

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

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

Park and Open Space Objectives

Three of the seven specific park and open space objectives adopted by the Commission under its regional park and open space planning program are directly applicable to the Pike River watershed planning effort.[1] These are:

1. The provision of an integrated system of public general use outdoor recreation sites and related open space areas which will allow the resident population of the Region adequate opportunity to participate in a wide range of outdoor recreation activities.

2. The preservation of sufficient high-quality open space lands for the protection of the underlying and sustaining natural resource base and the enhancement of the social and economic well being and environmental quality of the Region.

3. The efficient and economical satisfaction of outdoor recreation and related open space needs meeting all other objectives at the lowest possible cost.

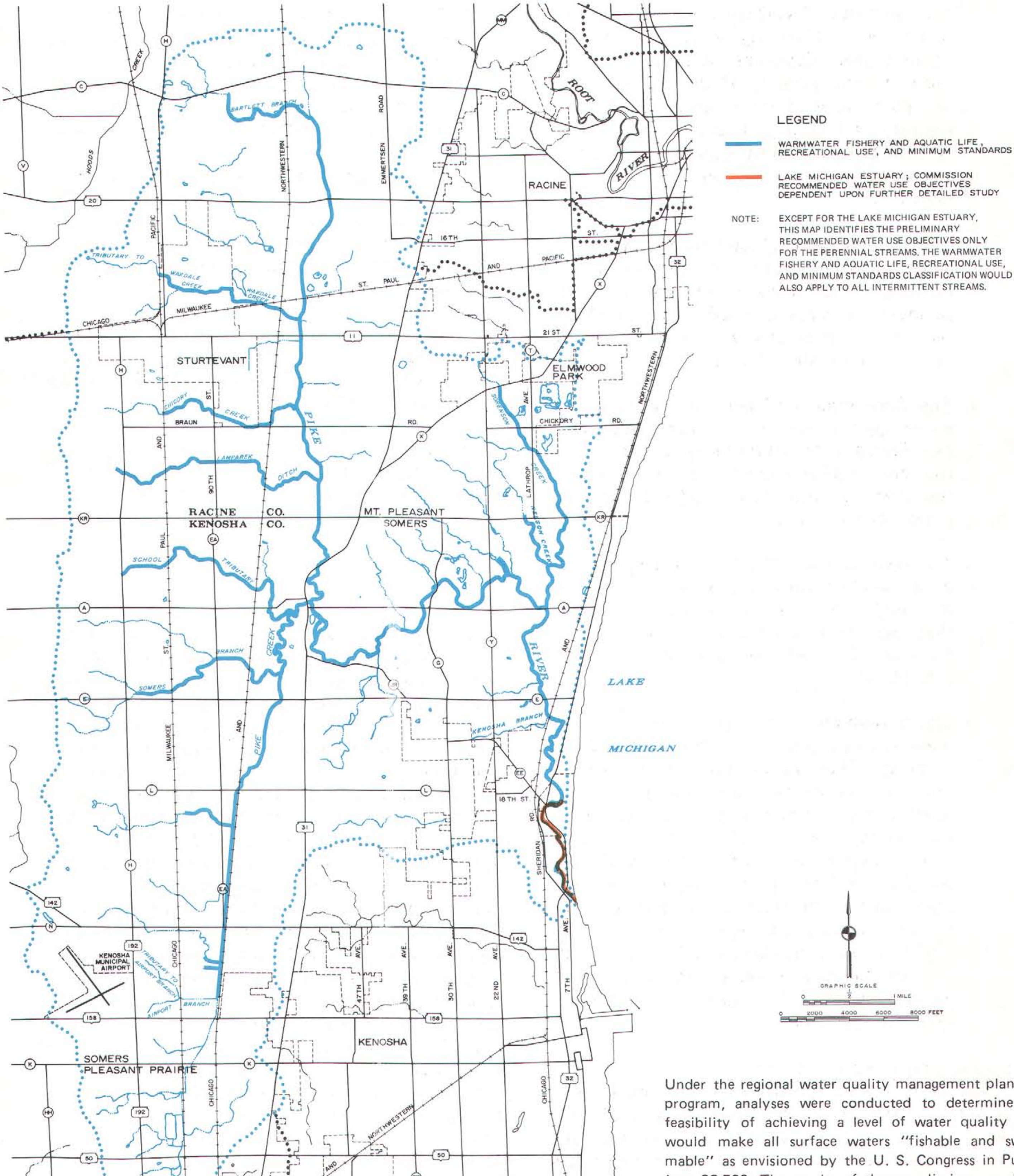
Water Control Facility Development Objectives

Two of the four specific water control facility development objectives adopted by the Commis-

[1] *The other four specific park and open space objectives are: 1) the provision of sufficient outdoor recreation facilities to allow the resident population of the Region adequate opportunity to participate in intensive nonresource-oriented outdoor recreation activities; 2) the provision of sufficient outdoor recreation facilities to allow the resident population of the Region adequate opportunity to participate in intensive resource-oriented outdoor recreation activities; 3) the provision of sufficient outdoor recreation facilities to allow the resident population of the Region adequate opportunity to participate in extensive land-based outdoor recreation activities; and 4) the provision of opportunities for participation by the resident population of the Region in extensive waterbased outdoor recreation activities on the major inland lakes and rivers and on Lake Michigan, as consistent with safe and enjoyable lake use and maintenance of good water quality. While these recreation facility-oriented park objectives are applicable to the watershed planning program, they should be applied at the local level as a joint effort by county, school districts, and local community recreation agencies.*

Map 43

PRELIMINARY RECOMMENDED WATER USE OBJECTIVES FOR SURFACE WATERS IN THE PIKE RIVER WATERSHED: 2000



Source: SEWRPC.

Under the regional water quality management planning program, analyses were conducted to determine the feasibility of achieving a level of water quality that would make all surface waters "fishable and swimmable" as envisioned by the U. S. Congress in Public Law 92-500. The results of these preliminary analyses indicated that all of the streams analyzed in the Pike River watershed could be brought to "fishable and swimmable" standards.

sion under its other comprehensive watershed planning programs are also applicable to the Pike River watershed planning effort.[2] 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 the quality of surface water necessary to meet the established water use objectives and supporting water quality standards.

Principles and Standards

Complementing each of the foregoing specific land use, sanitary sewerage system and water quality management, park and open space, and water control facility 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 75, 76, 77, and 78 and serve to facilitate quantitative application of the objectives during plan design, test, and evaluation.

[2] *The other two specific water control facility development objectives are: 1) 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; and 2) the attainment of sound groundwater resource development and protective practices to minimize the possibility for pollution and depletion of the groundwater resources. The inland lake-oriented water control facility objective is not applicable to the Pike River watershed planning program since there are no major lakes in the watershed. The groundwater-oriented objective is not applicable to the Pike River watershed planning program since the study prospectus did not identify groundwater quantity or quality as being significant existing or potential problems in this watershed.*

With respect to water use objectives, the Wisconsin Department of Natural Resources currently classifies selected portions of the Pike River watershed stream system for limited fishery and aquatic life, recreational use and minimum standards; marginal aquatic life, recreational use and minimum standards; restricted recreational use and minimum standards; warmwater fishery and aquatic life, recreational use and minimum standards; and salmon spawning fishery and aquatic life, recreational use, and minimum standards. These currently adopted water use objectives and the supporting standards are set forth on Map 40 and in Table 71 in Chapter IX—entitled "Water Law"—of this report. Table 79 sets forth a comparison of these water use objectives as adopted by the Wisconsin Natural Resources Board, in 1976, to the recommended water use objectives as set forth in Chapter II, "Water Quality Management Objectives, Principles, and Standards" of Volume Two, Alternative Plans, of SEWRPC Planning Report No. 30, A Regional Water Quality Management Plan for Southeastern Wisconsin: 2000. Under the SEWRPC-recommended water use objectives, all parts of the perennial stream system of the Pike River watershed are designated to support warmwater fishery and aquatic life, recreational use, and minimum standards. In addition, the mouth of the Pike River at its discharge to Lake Michigan is recommended to support water use for salmon fishery and other aquatic life, recreational use, and minimum standards. The water quality standards supporting these recommended water use objectives are set forth in Table 80. These recommendations are in conformance with the national water use objectives cited in Public Law 92-500, which call for the attainment wherever possible of water quality which is sufficient to support the protection and propagation of fish, shellfish, and other wildlife, and for the support of human recreation in and on the waters. Analyses conducted in development of the adopted regional water quality management plan indicate that the attainment of these full fishable-swimmable water use objectives and the supporting water quality standards is feasible and realistic, if all of the water pollution sources in the Pike River watershed are properly abated.

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, mini-

Table 75

LAND USE DEVELOPMENT OBJECTIVES, PRINCIPLES, AND STANDARDS FOR THE PIKE 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 100 dwelling units to be accommodated within the Region at each residential density, the following minimum amounts of residential land should be set aside:

No.	Residential Density Category	Net Area[a] (Acres/100 Dwelling Units)*	Gross Area[b] (Acres/100 Dwelling Units)*
1a	High-Density Urban[c]	8	13
1b	Medium-Density Urban[c]	23	32
1c	Low-Density Urban[c]	83	109
1d	Suburban[d]	167	204
1e	Rural[d]	500	588

*NOTE: In order to convert dwelling units to resident population, anticipated year 2000 persons-per-dwelling-unit averages were used. These averages range from a minimum of 2.6 persons per dwelling unit in Milwaukee County to a maximum of 3.5 persons per dwelling unit in Ozaukee and Washington Counties with an anticipated average of 2.9 persons per dwelling unit for the Region as a whole in 2000. According to the 1970 federal census, the average number of persons per dwelling unit ranged from a minimum of 3.0 persons per dwelling unit in Milwaukee County to a maximum of 3.7 persons per dwelling unit in Ozaukee and Waukesha Counties with an average of 3.2 persons per dwelling unit for the Region as a whole. In 1975, it is estimated that the average number of persons per dwelling unit ranged from a minimum of 2.8 persons per dwelling unit in Milwaukee County to a maximum of 3.6 persons per dwelling unit in Ozaukee and Waukesha Counties with an average of 3.0 persons per dwelling unit for the Region as a whole.

2. For each additional 1,000 persons to be accommodated within the Region, the following minimum amounts of public park and recreation land should be set aside:

No.	Public Park and Recreation Land Category[e]	Net Area[a] (Acres/1,000 Persons)	Gross Area[f] (Acres/1,000 Persons)
2a	Major	4	5
2b	Other	8	9

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

No.	Industrial Land Category	Net Area[a] (Acres/100 Employees)	Gross Area[g] (Acres/100 Employees)
3a	Major and Other	7	9

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

No.	Commercial Land Category	Net Area[a] (Acres/100 Employees)	Gross Area[g] (Acres/100 Employees)
4a	Major	1	3
4b	Other	2	6

5. For each additional 1,000 persons to be accommodated within the Region, the following minimum amounts of governmental and institutional land should be set aside:

No.	Governmental and Institutional Land Category	Net Area[a] (Acres/1,000 Persons)	Gross Area[h] (Acres/1,000 Persons)
5a	Major and Other	9	12

OBJECTIVE NO. 2

A spatial distribution of the various land uses which will result in a compatible arrangement of land uses.

PRINCIPLE

The proper allocation of uses to land can avoid or minimize hazards and dangers to health, safety, and welfare and maximize amenity and convenience in terms of accessibility to supporting land uses.

STANDARDS

1. Urban high-, medium-, and low-density residential uses should be located within planning units which are served with centralized public sanitary sewerage and water supply facilities and contain, within a reasonable walking distance, necessary supporting local service uses, such as neighborhood park, local commercial, and elementary school facilities, and should have reasonable access through the appropriate component of the transportation system to employment, commercial, cultural, and governmental centers and secondary school and higher educational facilities.

2. Rural and suburban density residential uses should have reasonable access through the appropriate component of the transportation system to local service uses; employment, commercial, cultural, and governmental centers; and secondary school and higher educational facilities.

3. Industrial uses should be located to have direct access to arterial street and highway facilities and reasonable access through an appropriate component of the transportation system to residential areas and to railway, seaport, and airport facilities and should not be intermixed with commercial, residential, governmental, recreational, or institutional land uses.

4. Regional commercial uses should be located in centers of concentrated activity on only one side of an arterial street and should be afforded direct access[i] to the arterial street system.

OBJECTIVE NO. 3

A spatial distribution of the various land uses which will result in the protection and wise use of the natural resources of the Region, including its soils, inland lakes and streams, wetlands, woodlands, and wildlife.

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.

1. 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

1a. 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.

1b. 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.

1c. 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 development.

2. Inland Lakes and Streams

Principle

Inland lakes and streams contribute to the atmospheric water supply through evaporation; provide a suitable environment for desirable and sometimes unique plant and animal life; provide the population with opportunities for certain scientific, cultural, and educational pursuits; constitute prime recreational areas; provide a desirable aesthetic setting for certain types of land use development; serve to store and convey flood waters; and provide certain water withdrawal requirements.

STANDARDS

2a (1). A minimum of 25 percent of the perimeter or shoreline frontage of lakes having a surface area in excess of 50 acres should be maintained in a natural state.

2a (2). Not more than 50 percent of the length of the shoreline of inland lakes having a surface area in excess of 50 acres should be allocated to urban development, except for park and outdoor recreational uses.

2a (3). A minimum of 10 percent of the shoreline of each inland lake having a surface area in excess of 50 acres should be maintained for public uses, such as a beach area, pleasure craft marina, or park.

2b (1). It is desirable that 25 percent of the shoreline of each inland lake having a surface area less than 50 acres be maintained in either a natural state or some low-intensity public use, such as park land.

2c (1). A minimum of 25 percent of both banks of all perennial streams should be maintained in a natural state.

2c (2). Not more than 50 percent of the length of perennial streams should be allocated to urban development, except for park and outdoor recreational uses.

2d. Floodlands[j] should not be allocated to any urban development[k] which would cause or be subject to flood damage.

2e. No unauthorized structure or fill should be allowed to encroach upon and obstruct the flow of water in the perennial stream channels[l] and floodways.[m]

3. 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

3a. All wetland areas[n] 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.

4. Woodlands[o]

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

4a. A minimum of 10 percent of the land area of each watershed[p] within the Region should be devoted to woodlands.

4b. 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 presettlement vegetation should be maintained in a natural condition and be made available for research and educational use.

4c. A minimum regional aggregate of five acres of woodland per 1,000 population should be maintained for recreational pursuits.

5. Wildlife[q]

Principle

Wildlife, when provided with a suitable habitat, will supply 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; offers an economic resource for the recreation industries; and serves as an indicator of environmental health.

STANDARD

5a. 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 achieved by preserving or maintaining in a wholesome state other resources 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. 4

A spatial distribution of the various land uses which is properly related to the supporting transportation, utility, and public facility systems in order to assure the economical provision of transportation, utility, and public facility 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. Urban development should be located so as to maximize the use of existing transportation and utility systems.

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. 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 a system.

4. 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.

5. 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.

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

7. Transportation terminal facilities, such as off-street parking, off-street truck loading, and mass transit loading facilities, should be located in close proximity to the principal land uses to which they are accessory.

OBJECTIVE NO. 5

The development and conservation of residential areas within a physical environment that is healthy, safe, convenient, and attractive.

PRINCIPLE

Residential areas developed in designed neighborhood units can assist in stabilizing community property values, preserving residential amenities, and promoting efficiency in the provision of public and community service facilities; can best provide a desirable environment for family life; and can supply the population with improved levels of safety and convenience.

STANDARDS

1. Urban high-, medium-, and low-density residential development should be located in neighborhood units which are physically self-contained within clearly defined and relatively permanent isolating boundaries, such as arterial streets and highways, major park and open space reservations, or significant natural features such as rivers, streams, or hills.

2. Urban residential neighborhood units should contain enough area to provide: housing for the population served by one elementary school and one neighborhood park; an internal street system which discourages penetration of the unit by through traffic; and all of the community and commercial facilities necessary to meet the day-to-day living requirements of the family within the immediate vicinity of its dwelling unit.

3. Suburban and rural density residential development should be located in areas where onsite soil absorption sewage disposal systems and private wells can be accommodated and access to other services and facilities can be provided through appropriate components of the transportation system at the community or regional level, thereby properly relating such development to a rural environment.

To meet the foregoing standards, land should be allocated in each urban and rural development category as follows:

	Percent of Area in Land Development Category					
Land Use Category	Urban High-Density (7.0 - 17.9 Dwelling Units/Net Residential Acre)	Urban Medium-Density (2.3 - 6.9 Dwelling Units/Net Residential Acre)	Urban Low-Density (0.7 - 2.2 Dwelling Units/Net Residential Acre)	Suburban Density (0.2 - 0.6 Dwelling Units/Net Residential Acre)	Rural Density (0.1 - 0.2 Dwelling Units/Net Residential Acre)	Agricultural (<0.2 Dwelling Units/Net Residential Acre)
Residential	66.0	71.0	76.5	82.0	85.0	6.0
Streets and Utilities	25.0	23.0	20.0	18.0	15.0	4.0
Parks and Playgrounds	3.5	2.5	1.5	--	--	--
Public Elementary Schools	2.5	1.5	0.5	--	--	--
Other Governmental and Institutional	1.5	1.0	1.0	--	--	--
Retail and Service	1.5	1.0	0.5	--	--	--
Nonurban	--	--	--	--	--	90.0
Total	100.0	100.0	100.0	100.0	100.0	100.0

OBJECTIVE NO. 6

The preservation, development, and redevelopment of a variety of suitable industrial and commercial sites both in terms of physical characteristics and location.

PRINCIPLE

The production and sale of goods and services are among the principal determinants of the level of economic vitality in any society, and the important activities related to these functions require areas and locations suitable to their purpose.

STANDARDS

1. Regional industrial development should be located in planned industrial districts which meet the following standards:

   a. Minimum gross site area of 320 acres or a minimum employment of 3,500 persons.

   b. Direct access to the arterial street and highway system and access within two miles to the freeway system.

   c. Direct access to railroad facilities.

   d. Direct access to primary, secondary, and tertiary mass transit service.

   e. Access to a basic transport airport within a maximum travel time of 30 minutes and access to seaport facilities within a maximum travel time of 60 minutes.

   f. Available adequate water supply.

   g. Available adequate public sanitary sewer service.

h. Available adequate storm water drainage facilities.

i. Available adequate power supply.

j. Site should be covered by soils identified in the regional soils survey as having very slight, slight, or moderate limitations for industrial development.

2. Regional commercial development, which would include activities primarily associated with the sale of shopper's goods, should be concentrated in regional commercial centers which meet the following minimum standards:

a. Accessibility to a population of between 75,000 and 150,000 persons located within either a 20-minute one-way travel period or a 10-mile radius.

b. A minimum gross site area of 60 acres.

c. At least two general sales and service department stores offering a full range of commodities and price levels.

d. Direct access to the arterial street system.

e. Direct access to the primary, secondary, and tertiary mass transit service.

f. Available adequate water supply.

g. Available adequate sanitary sewer service.

h. Available adequate storm water drainage facilities.

i. Available adequate power supply.

j. The site should be covered by soils identified in the regional soils survey as having very slight, slight, or moderate limitations for commercial development.

In addition to the above minimum standards, the following site development standards are desirable:

k. Provision of off-street parking for at least 5,000 cars.

l. Provision of adequate off-street loading facilities.

m. Provision of well-located points of ingress and egress which are controlled to prevent traffic congestion on adjacent arterial streets.

n. Provision of adequate screening to serve as a buffer between the commercial use and adjacent noncommercial uses.

o. Provision of adequate building setbacks from major streets.

3. Local industrial development should be located in planned industrial districts which meet the following standards:

a. Direct access to the arterial street and highway system.

b. Direct access to mass transit facilities.

c. Available adequate water supply.

d. Available adequate public sanitary sewer service.

e. Available adequate storm water drainage facilities.

f. Available adequate power supply.

g. Site should be covered by soils identified in the regional soils survey as having very slight, slight, or moderate limitations for industrial development.

4. Local commercial development, which includes activities primarily associated with the sale of convenience goods and services, should be contained within the residential planning units, the total area devoted to the commercial use varying with the residential density:

a. In urban low-density areas, land devoted to local commercial centers should comprise at least 0.5 percent of the total gross neighborhood area, or about 3.2 acres per square mile of gross neighborhood area.

b. In urban medium-density areas, land devoted to local commercial centers should comprise at least 1.0 percent of the total gross neighborhood area, or about 6.4 acres per square mile of gross neighborhood area.

c. In urban high-density areas, land devoted to local commercial centers should comprise at least 1.5 percent of the total gross neighborhood area, or about 9.6 acres per square mile of gross neighborhood area.

OBJECTIVE NO. 7

The preservation and provision of open space[r] 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 spirtual growth of the population; it enhances the economic and aesthetic value of certain types of development; and it is essential to outdoor recreational pursuits.

STANDARDS[s]

1. Major or regional park and recreation sites should be provided within a 10-mile service radius of every dwelling unit in the Region and should have a minimum gross site area of 250 acres.

2. Local park and recreation sites should be provided within a maximum service radius of one mile of every dwelling unit in an urban area and should have a minimum gross site area of 5 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. 8

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

PRINCIPLE

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

STANDARDS

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

2. All agricultural lands surrounding adjacent high-value scientific, educational, or recreational resources 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 having moderate limitations 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.

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[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 require neighborhood facilities.*

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

[e] *These categories do not include large open space areas not developed for active recreation use or school playgrounds.*

[f] *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.*

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

[h] *Gross governmental and institutional area is defined as the net area devoted to governmental and institutional uses plus the area devoted to supporting land uses, including streets and onsite parking.*

[i] *Direct access implies adjacency or immediate proximity.*

[j] *Floodlands are herein defined as those lands inundated by a flood having a recurrence interval of 100 years where hydrologic and hydraulic engineering data are available, and as those lands inundated by the maximum flood of record where such data are not available.*

[k] *Urban development, as used herein, refers to all land uses except agriculture, water, woodlands, wetlands, open lands, and quarries.*

[l] *A stream channel is herein defined as that area of the floodplain lying either within legally established bulkhead lines or within sharp and pronounced banks marked by an identifiable change in flora and normally occupied by the stream under average annual high-flow conditions.*

[m] *Floodway lands are herein defined as those designated portions of the floodlands that will safely convey the 100-year recurrence interval flood discharge with small, acceptable upstream and downstream stage increases.*

[n] *Wetland areas, as used herein, are defined as those lands which are partially covered by marshland flora and generally covered with shallow standing water, open lands intermittently covered with water, or lands which are wet and spongy due to a high water table or character of the soil and encompassing an area of one acre or more.*

[o] *The term woodland, as used herein, is defined as a dense, concentrated stand of trees and underbrush encompassing an area of one acre or more.*

[p] *A watershed, as used herein, is defined as a portion of the surface of the earth occupied by a surface drainage system discharging all surface water runoff to a common outlet and an area 25 square miles or larger in size.*

[q] *Includes all fish and game.*

[r] *Open space is defined as land or water areas which are generally undeveloped for urban 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.*

[s] *It was deemed impractical to establish spatial distribution standards for open space, per se. Open spaces which are not included in the spatial distribution standards 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. It is intended that the park and open space standards set forth herein be supplemented by the more detailed park and open space standards set forth in SEWRPC Planning Report No. 27, A Regional Park and Open Space Plan for Southeastern Wisconsin.*

[t] *Prime agricultural areas are defined as those areas which have been designated as exceptionally good for agricultural production by agricultural specialists and 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.*

Source: SEWRPC.

Table 76

WATER QUALITY MANAGEMENT OBJECTIVES, PRINCIPLES, AND STANDARDS FOR THE PIKE RIVER WATERSHED

OBJECTIVE NO. 1

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

PRINCIPLE

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

STANDARDS

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

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

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

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

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

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

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

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

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

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

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

OBJECTIVE NO. 2

The development of land management and water quality control practices and facilities—inclusive of sanitary sewerage systems—so as to meet the recommended water use objectives and supporting water quality standards as set forth on Map 43 and in Table 80.

PRINCIPLE

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

STANDARDS

1. The level of treatment to be provided at each sewage treatment plant industrial wastewater outfall should be determined by water quality analyses directly related to the established water use objectives for the receiving surface water body. These analyses should demonstrate that the proposed treatment level will aid in achieving the water quality standards supporting each major water use objective as set forth on Map 43 and in Table 80.

2. The type and extent of storm water treatment or associated preventive land management practices to be applied within a hydrologic unit should be determined by water quality analyses directly related to the established water use objectives for the receiving surface water body. These analyses should demonstrate that the proposed treatment level or land management practices will aid in achieving the water quality standards supporting each major water use objective as set forth on Map 43 and in Table 80.

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

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

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

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

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

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

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

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

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

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

13. By 1985, no pollutants should be discharged by sanitary or industrial sewage treatment plants in amounts which would preclude the achievement of the recommended water use objectives or the supporting standards as set forth on Map 43 and Table 80.

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

OBJECTIVE NO. 3

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

PRINCIPLE

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

STANDARDS

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

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

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

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

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

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

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

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

OBJECTIVE NO. 4

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

PRINCIPLE

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

STANDARDS

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

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

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

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

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

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

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

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

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

OBJECTIVE NO. 5

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

PRINCIPLE

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

STANDARDS

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

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

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

4. Each designated management group should have legal authority, financial resources, technical capability, and practical autonomy sufficient to assure the timely accomplishment of its responsibilities in the achievement of the recommended water use objectives and supporting standards as set forth on Map 43 and in Table 80.

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

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

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

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

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

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

Source: SEWRPC.

Table 77

WATER CONTROL FACILITY DEVELOPMENT OBJECTIVES, PRINCIPLES, AND STANDARDS FOR THE PIKE 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 b 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 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 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 0.1[a] 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 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 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 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 0.1[a] foot in any unprotected upstream or downstream stream reaches. Increases in flood stages in excess of 0.1[a] 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.[b]

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 0.1[a] foot. Larger stage increases may be acceptable if appropriate legal arrangements are made with affected local units of government and property owners.

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 support recreational use, a warmwater fishery, other aquatic life, and a salmon fishery.

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 80 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.

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[a] *Although Commission watershed studies conducted prior to the Kinnickinnic River watershed study have used a standard of 0.5 foot—a standard that is interpreted by the Commission staff to mean no significant stage increase—that standard was reduced in the Kinnickinnic River and Pike River watershed reports in order to be consistent with revisions to the Wisconsin Administrative Code. Chapter NR 116 of the Code, "Wisconsin's Floodplain Management Program," was revised by the Wisconsin Department of Natural Resources in July 1977 so as to specify a maximum computed stage increase of only 0.1 foot. This Department standard, which is numerically more stringent than the standard adopted earlier by the Commission and previously used by the Wisconsin Department of Natural Resources, may be waived by the Department only if "appropriate legal arrangements have been made with all affected local units of government and all property owners for any increased flood elevations on those properties."*

Although the Commission has adopted the numerically more stringent allowable stage increase in order to be consistent with the Wisconsin Administrative Code, the Commission staff has expressed concern with the use of 0.1 foot and, more particularly, with the accuracy of hydraulic computations that is implied by that standard. The Commission staff, in an April 18, 1977 letter to Mr. Thomas P. Fox, Chairman, Wisconsin Natural Resources Board, stated that "while it is true that the output from a computer backwater program may be stated with a precision of 0.1 foot—given the state of the art—no one can presently claim an accuracy of such work within 0.1 foot. It would appear to us that an accuracy level of 0.5 foot would be more reasonable."

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

Source: SEWRPC.

Table 78

OUTDOOR RECREATION AND OPEN SPACE PLANNING OBJECTIVES, PRINCIPLES, AND STANDARDS FOR THE PIKE RIVER WATERSHED

OBJECTIVE NO. 1

The provision of an integrated system of public general use outdoor recreation sites and related open space areas which will allow the resident population of the Region adequate opportunity to participate in a wide range of outdoor recreation activities.

PRINCIPLE

Attainment and maintenance of good physical and mental health is an inherent right of all residents of the Region. The provision of public general use outdoor recreation sites and related open space areas contributes to the attainment and maintenance of physical and mental health by providing opportunities to participate in a wide range of both intensive and extensive outdoor recreation activities. Moreover, an integrated park and related open space system properly related to the natural resource base, such as the existing surface water network, can generate the dual benefits of satisfying recreational demands in an appropriate setting while protecting and preserving valuable natural resource amenities. Finally, an integrated system of public general use outdoor recreation sites and related open space areas can contribute to the orderly growth of the Region by lending form and structure to urban development patterns.

A. PUBLIC GENERAL USE OUTDOOR RECREATION SITES

PRINCIPLE

Public general use outdoor recreation sites promote the maintenance of proper physical and mental health by providing opportunities to participate in such athletic recreational activities as baseball, swimming, tennis, and ice-skating—activities that facilitate the maintenance of proper physical health because of the exercise involved—as well as opportunities to participate in such less athletic activities as pleasure walking, picnicking, or just rest and reflection. These activities tend to reduce everyday tensions and anxieties and thereby help maintain proper physical and mental well being. Well-designed and properly located public general use outdoor recreation sites also provide a sense of community, bring people together for social and cultural as well as recreational activities, and thus contribute to the desirability and stability of residential neighborhoods and therefore the communities in which such facilities are provided.

STANDARDS

1. The public sector should provide general use outdoor recreation sites sufficient in size and number to meet the recreation demands of the resident population. Such sites should contain the natural resource or man-made amenities appropriate to the recreational activities to be accommodated therein and be spatially distributed in a manner which provides ready access by the resident population. To achieve this standard, the following public general use outdoor recreation site requirements should be met:

		Publicly Owned General Use Sites							
		Parks				Schools[a]			
				Maximum Service Radius (miles)[b]				Maximum Service Radius (miles)[c]	
Site Type	Size (gross acres)	Minimum Per Capita Public Requirements (acres per 1,000 persons)[d]	Typical Facilities	Urban[e]	Rural	Minimum Per Capita Public Requirements (acres per 1,000 persons)[f]	Typical Facilities	Urban[e]	Rural
I[g] Regional	250 or more	5.3	Camp sites, swimming beach, picnic areas, golf course, ski hill, ski touring trail, boat launch, nature study area, playfield, softball diamond, passive activity area[h]	10.0	10.0	--	--	--	--
II[i] Multicommunity	100-249	2.6	Camp sites, swimming pool or beach, picnic areas, golf course, ski hill, ski touring trail, boat launch, nature study area, playfield, softball and/or baseball diamond, passive activity area[h]	4.0[j]	10.0[j]	--	--	--	--
III[k] Community	25-99	2.2	Swimming pool or beach, picnic areas, boat launch, nature study area, playfield, softball and/or baseball diamond, tennis court, passive activity area[h]	2.0[l]	--	0.9	Playfield, baseball diamond, softball diamond, tennis court	0.5-1.0[m]	--
IV[n] Neighborhood	Less than 25	1.7	Wading pool, picnic areas, playfield, softball and/or baseball diamond, tennis court, playground, basketball goal, ice-skating rink, passive activity area[h]	0.5-1.0[o]	--	1.6	Playfield, playground, baseball diamond, softball diamond, tennis court, basketball goal	0.5-1.0[m]	--

2. Public general use outdoor recreation sites should, as much as possible, be located within the designated primary environmental corridors of the Region.

B. RECREATION-RELATED OPEN SPACE

PRINCIPLE

Effective satisfaction of recreation demands within the Region cannot be accomplished solely by providing public general use outdoor recreation sites. Certain recreational pursuits such as hiking, biking, pleasure driving, and ski touring are best provided for through a system of recreation corridors located on or adjacent to linear resource-oriented open space lands. A well-designed system of recreation corridors offered as an integral part of linear open space lands also can serve to physically connect existing and proposed public parks, thus forming a truly integrated park and recreation related open space system. Such open space lands, in addition, satisfy the human need for natural surroundings, serve to protect the natural resource base, and ensure that many scenic areas and areas of natural, cultural, or historic interest assume their proper place as form determinants for both existing and future land use patterns.

STANDARDS

The public sector should provide sufficient open space lands to accommodate a system of resource-oriented recreation corridors to meet the resident demand for extensive trail-oriented recreation activities. To fulfill these requirements the following recreation-related open space standards should be met:

1. A minimum of 0.16 linear mile of recreation related open space consisting of linear recreation corridors[p] should be provided for each 1,000 persons in the Region.

2. Recreation corridors should have a minimum length of 15 miles and a minimum width of 200 feet.

3. The maximum travel distance to recreation corridors should be five miles in urban areas and 10 miles in rural areas.

4. Resource-oriented recreation corridors should maximize use of:

   a. Primary environmental corridor as location for extensive trail-oriented recreation activities.

   b. Outdoor recreation facilities provided at existing public park sites.

   c. Existing recreation trail-type facilities within the Region.

OBJECTIVE NO. 2

The preservation of sufficient high-quality open space lands for protection of the underlying and sustaining natural resource base and enhancement of the social and economic well being and environmental quality of the Region.

PRINCIPLE

Ecological balance and natural beauty within the Region are primary determinants of the ability to provide a pleasant and habitable environment for all forms of life and to maintain the social and economic well being of the Region. Preservation of the most significant aspects of the natural resource base, that is, primary environmental corridors and prime agricultural lands, contributes to the maintenance of the ecological balance, natural beauty, and economic well being of the Region.

A. PRIMARY ENVIRONMENTAL CORRIDORS

PRINCIPLE

The primary environmental corridors are a composite of the best individual elements of the natural resource base including surface water, streams, and rivers and their associated floodlands and shorelands; woodlands, wetlands, and wildlife habitat; areas of groundwater discharge and recharge; organic soils, rugged terrain, and high relief topography; and significant geological formations and physiographic features. By protecting these elements of the natural resource base, flood damage can be reduced, soil erosion abated, water supplies protected, air cleansed, wildlife population enhanced, and continued opportunities provided for scientific, educational, and recreational pursuits.

STANDARD

All remaining nonurban lands within the designated primary environmental corridors in the Region should be preserved in their natural state.

B. PRIME AGRICULTURAL LANDS

PRINCIPLE

Prime agricultural lands constitute the most productive farmlands in the Region and, in addition to providing food and fiber, contribute significantly to maintaining the ecological balance between plants and animals; provide locations close to urban centers for the production of certain food commodities which may require nearby population concentrations for an efficient production-distribution relationship; provide open spaces which give form and structure to urban development; and serve to maintain the natural beauty and unique cultural heritage of southeastern Wisconsin.

STANDARDS

1. All prime agricultural lands should be preserved.

2. All agricultural lands should be preserved that surround adjacent high-value scientific, educational, or recreational sites and are covered by soils rated in the regional detailed operational soil surveys as having very slight, slight, or moderate limitations for agricultural use.

OBJECTIVE NO. 3

The efficient and economical satisfaction of outdoor recreation and related open space needs meeting all other objectives at the lowest possible cost.

PRINCIPLE

The total resources of the Region are limited, and any undue investment in park and open space lands must occur at the expense of other public investment.

STANDARD

The sum total of all expenditures required to meet park demands and open space needs should be minimized.

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[a] *In urban areas the facilities commonly located in Type III or Type IV school outdoor recreation areas often provide a substitute for facilities usually located in parks by providing opportunities for participation in intensive nonresource-oriented activities.*

[b] *The identification of a maximum service radius for each park type is intended to provide another guideline to assist in the determination of park requirements and to assure that each resident of the Region has ready access to the variety of outdoor recreation facilities commonly located in parks.*

[c] *The identification of a maximum service radius for each school site is intended to assist in the determination of outdoor recreation facilities requirements and to assure that each urban resident has ready access to the types of facilities commonly located in school recreation areas.*

[d] *For Type I and Type II parks, which generally provide facilities for resource-oriented outdoor recreation activities for the total population of the Region, the minimum per capita acreage requirements apply to the total resident population of the Region. For Type III and Type IV sites, which generally provide facilities for intensive nonresource-oriented outdoor recreation activities primarily in urban areas, the minimum per capita acreage requirements apply to the resident population of the Region residing in urban areas.*

[e] *Urban areas are defined as areas containing a closely spaced network of minor streets which include concentrations of residential, commercial, industrial, governmental, or institutional land uses having a minimum total area of 160 acres and a minimum population of 500 persons. Such areas usually are incorporated and are served by sanitary sewerage systems. These areas have been further classified into the following densities: low-density urban areas or areas with 0.70 to 2.29 dwelling units per net residential acre, medium-density urban areas or areas with 2.30 to 6.99 dwelling units per net residential acre, and high-density urban areas or areas with 7.00 to 17.99 dwelling units per net residential acre.*

[f] *For public school sites, which generally provide facilities for intensive nonresource-oriented outdoor recreation activities, the minimum per capita acreage requirements apply to the resident population of the Region residing in urban areas.*

[g] *Type I sites are defined as large outdoor recreation sites having a multicounty service area. Such sites rely heavily for their recreational value and character on natural resource amenities. Type I parks provide opportunities for participation in a wide variety of resource-oriented outdoor recreation pursuits.*

[h] *A passive activity area is defined as an area within an outdoor recreation site which provides an opportunity for such less athletic recreational pursuits as pleasure walking, rest and relaxation, and informal picnicking. Such areas generally are located in all parks or in urban open space sites, and usually consist of a landscaped area with mowed lawn, shade trees, and benches.*

[i] *Type II sites are defined as intermediate size sites having a countywide or multicommunity service area. Like Type I sites, such sites rely for their recreational value and character on natural resource amenities. Type II parks, however, usually provide a smaller variety of recreation facilities and have smaller areas devoted to any given activity.*

[j] *In general, each resident of the Region should reside within 10 miles of a Type I or Type II park. It should be noted, however, that within urban areas having a population of 40,000 or greater, each urban resident should reside within four miles of a Type I or Type II park.*

[k] *Type III sites are defined as intermediate size sites having a multineighborhood service area. Such sites rely more on the development characteristics of the area to be served than on natural resource amenities for location.*

[l] *In urban areas the need for a Type III site is met by the presence of a Type II or Type I site. Thus, within urban areas having a population of 7,500 or greater, each urban resident should be within two miles of a Type III, II, or I park site.*

[m] *The typical service radius of school outdoor recreation facilities is governed by individual facilities within the school site and by population densities in the vicinity of the site. In high-density urban areas each urban resident should reside within 0.5 mile of the facilities commonly located in a Type III or Type IV school outdoor recreation area; in medium-density urban areas each resident should reside within 0.75 mile of facilities commonly located in Type III or Type IV school outdoor recreation areas; and in low-density urban areas each urban resident should reside within one mile of the facilities commonly located in a Type III or Type IV school outdoor recreation area.*

[n] *Type IV sites are defined as small sites which have a neighborhood as the service area. Such sites usually provide facilities for intensive nonresource-oriented outdoor recreation activities and are generally provided in urban areas. Recreation lands at the neighborhood level should most desirably be provided through a joint community-school district venture, with the facilities and recreational land are required to be provided on one site available to serve the recreation demands of both the school student and resident neighborhood population. Using the Type IV park standard of 1.7 acres per thousand residents and the school standard of 1.6 acres per thousand residents, a total of 3.3 acres per thousand residents or approximately 21 acres of recreation lands in a typical medium-density neighborhood would be provided. These acreage standards relate to lands required to provide for recreation facilities typically located in a neighborhood and are exclusive of the school building site and associated parking area and any additional natural areas which may be incorporated into the design of the park site such as drainageways and associated storm water retention basins, areas of poor soils, and floodland areas.*

[o] *The maximum service radius of Type IV parks is governed primarily by the population densities in the vicinity of the park. In high-density urban areas, each urban resident should reside within 0.5 mile of a Type IV park; in medium-density urban areas, each resident should reside within 0.75 mile of a Type IV park; and in low-density urban areas, each urban resident should reside within one mile of a Type IV park. It should be noted that the requirement for a Type IV park also is met by a Type I, II, or III park within 0.5-1.0 mile service radii in high-, medium-, and low-density urban areas, respectively. Further, it should be noted that in the application of the service radius criterion for Type IV sites, only multiuse parks five acres or greater in area should be considered as satisfying the maximum service radius requirement.*

[p] *A recreation corridor is defined as a publicly owned continuous linear expanse of land which is generally located within scenic areas or areas of natural, cultural, or historical interest and which provides opportunities for participation in trail-oriented outdoor recreation activities especially through the provision of trails designated for such activities as biking, hiking, horseback riding, nature study, and ski touring. In the Region in 1973 only Milwaukee County, with an extensive parkway system, and the Wisconsin Department of Natural Resources, with the Kettle Moraine State Forest—Southern Unit, possessed the continuous linear lands required to develop such a recreation corridor.*

Source: SEWRPC.

Table 79

COMPARISON OF WISCONSIN NATURAL RESOURCES BOARD-ADOPTED WATER USE OBJECTIVES TO SEWRPC-RECOMMENDED WATER USE OBJECTIVES FOR THE PIKE RIVER WATERSHED: 1979

Stream Identification	Objectives Adopted by DNR[a]	Objectives Recommended by SEWRPC	Rationale for Recommended Change
Waxdale Creek from CTH H downstream to the Chicago, Milwaukee, St. Paul & Pacific Railroad crossing	Marginal aquatic life, recreational use, and minimum standards	Warmwater fishery and aquatic life, recreational use, and minimum standards	Implementation of the planned water pollution abatement measures is expected to result in a water quality sufficient to permit the assignment of an upgraded water use objective
Waxdale Creek from the Chicago, Milwaukee, St. Paul & Pacific Railroad crossing downstream to the confluence with the Pike River	Intermediate fishery and aquatic life, recreational use, and minimum standards	Warmwater fishery and aquatic life, recreational use, and minimum standards	Implementation of the planned water pollution abatement measures is expected to result in a water quality sufficient to permit the assignment of an upgraded water use objective
Pike River from its headwaters at the confluence with Bartlett Branch downstream to the Kenosha County line	Restricted recreational use and minimum standards	Warmwater fishery and aquatic life, recreational use, and minimum standards	Implementation of the planned water pollution abatement measures is expected to result in a water quality sufficient to permit the assignment of an upgraded water use objective
Pike Creek from its headwaters at the confluence with Airport Branch downstream to the confluence with Somers Branch	Restricted recreational use and minimum standards	Warmwater fishery and aquatic life, recreational use, and minimum standards	Implementation of the planned water pollution abatement measures is expected to result in a water quality sufficient to permit the assignment of an upgraded water use objective
Pike Creek from the confluence with Somers Branch downstream to the confluence with the Pike River	Intermediate fishery and aquatic life, recreational use, and minimum standards	Warmwater fishery and aquatic life, recreational use, and minimum standards	Implementation of the planned water pollution abatement measures is expected to result in a water quality sufficient to permit the assignment of an upgraded water use objective
Somers Branch from east of CTH H downstream to the confluence with Pike Creek	Marginal aquatic life, recreational use, and minimum standards	Warmwater fishery and aquatic, life, recreational use, and minimum standards	Implementation of the planned water pollution abatement measures is expected to result in a water quality sufficient to permit the assignment of an upgraded water use objective
The Pike River estuary	Warmwater fishery and aquatic life, recreational use, and minimum standards	Recommended water use objectives to be determined based on the results of further study	Further study on the hydrologic-hydraulic, water quality, and biological processes and interactions occurring within the estuary is needed before water use objectives can be recommended

NOTE: Stream reaches with identical water use objectives have not been listed.

[a]*DNR objectives were adopted in 1976 and have not been changed.*

Source: SEWRPC.

Table 80

PRELIMINARY RECOMMENDED WATER USE OBJECTIVES AND WATER QUALITY STANDARDS FOR STREAMS IN THE PIKE RIVER WATERSHED: 2000[a]

Water Quality Parameters	Warmwater Fishery and Aquatic Life, Recreational Use, and Minimum Standards[b]
Maximum Temperature (^{o}F)	89[c]
pH Range (standard units)	6.0-9.0[d]
Minimum Dissolved Oxygen (mg/l)	5.0
Maximum Fecal Coliform (counts per 100 ml)	200-400[e]
Maximum Total Residual Chlorine (mg/l)	0.01
Maximum Un-ionized Ammonia Nitrogen (mg/l)	0.02[f]
Maximum Total Phosphorus (mg/l)	0.1
Other	--[g]

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

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

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

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

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

[f] *This level of un-ionized ammonia is estimated to be present at the temperature range of 70-75^{o}F and a pH of 8.0 standard units, which approximate the critical conditions in the Pike River watershed, and at ammonia-nitrogen concentrations of about 0.4 mg/l or greater, and has been recommended by the U. S. EPA as a water quality criterion for the protection of warmwater fish and other aquatic life of the types found in the natural waters of the Pike River watershed.*

[g] *Unauthorized concentrations of substances are not permitted that alone or in combination with other materials present are toxic to fish or other aquatic life. The determination of the toxicity of a substance shall be based upon the available scientific data base. References to be used in determining the toxicity of a substance shall include, but not be limited to, the Federal Register, Part V, Environmental Protection Agency, "Water Quality Criteria Documents, Availability," November 28, 1980; Quality Criteria for Water, EPA-440/9-76-003, U. S. Environmental Protection Agency, Washington, D. C., 1976; and Water Quality Criteria, 1972, EPA-R3-73,003, National Academy of Sciences, National Academy of Engineering, U. S. Government Printing Office, Washington, D. C., 1974. Questions concerning the permissible levels, or changes in the same, of a substance, or combination of substances, of undefined toxicity to fish and other biota shall be resolved in accordance with the methods specified in Water Quality Criteria 1972 and Standard Methods for the Examination of Water and Wastewater, 14th Edition, American Public Health Association, New York, 1975, or other methods approved by the Department of Natural Resources.*

Source: Wisconsin Department of Natural Resources and SEWRPC.

mum, or desirable values. The standards set forth herein should serve as aids not only 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

When applying the watershed development objectives, principles, and standards to 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 through application of these objectives and standards alone, however, to assure such a system integration, since the objectives and 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 the system to the existing and future runoff and waste loadings as derived from the adopted regional land use plan. Second, it must be recognized that it is unlikely that any one plan proposal will meet all the standards completely. Thus, 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 objective which the given standard complements. Third, it must be recognized that certain objectives may be in conflict that will require resolution through compromise; such compromise is an essential part of any design effort. The degree to which the recommended Pike River watershed plan meets the adopted objectives and standards is discussed in Chapter XIV of this report.

ENGINEERING DESIGN CRITERIA AND ANALYTIC PROCEDURE

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 subelements, in the test of the technical feasibility of those subelements, 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 them here.

Rainfall Intensity-Duration-Frequency Relationships

If local storm water control and river flood control measures are to be compatible and function in a coordinated manner, plans for both must be based on consistent 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 control system design using the rational formula with the equations being intended primarily for incorporation into digital computer programs used in storm water control system analysis and design.

The curves in Figure C-2, which relate total rainfall to duration and frequency, are more convenient for use in basinwide hydrologic analysis. The variation of rainfall depth with tributary area and the seasonal variation of rainfall probability are shown in Figures C-3 and C-4, respectively. The relationships presented in Figure C-4 indicate that severe rainfall events, as defined by their duration and recurrence interval, are most likely to occur during

[3] *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.*

the months of July, August, and September. All these rainfall relationships are directly applicable to the Pike River watershed as well as to 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 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.[4] Soils which occur in the watershed and in the Southeastern Wisconsin Region are categorized in hydrologic groups according to their infiltration capabilities as presented 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 combination of floodland and nonfloodland development, 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 Pike River watershed study according to the log Pearson Type III method of analyses as recommended by the U. S. Water Resources Council[5] and as specified by the Wisconsin Department of Natural Resources.[6] In the absence of suitable, long-term flow records, the discharge-frequency analysis was 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. The simulated annual peak discharges were obtained for various combinations of floodland and nonfloodland development using a calibrated hydrologic-hydraulic model as described in Chapter VIII. The resulting discharge-frequency relationships were used to determine the magnitude of the 100-year recurrence interval regulatory flood, and were also used to compute monetary flood damages and to calculate economic benefits associated with alternative floodland management measures.

Design Flood

The design flood adopted for the Pike River watershed is that event having a 100-year recurrence interval peak discharge under year 2000 recommended watershed land use and floodland development conditions. This discharge was determined for locations distributed throughout the watershed stream system and was 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.

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 from 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 regulations, 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

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[4] *Ibid.*

[5] *United States Water Resources Council, "Guidelines for Determining Flood Flow Frequency," Bulletin No. 17 of the Hydrology Committee, Washington, D. C., March 1976.*

[6] *"Wisconsin's Floodplain Management Program," Wisconsin Administrative Code, Chapter NR116, Register, July 1977, No. 259.*

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; 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; and the large flood of April 21, 1973, in the Kinnickinnic River watershed was estimated to have had a recurrence interval of about 60 years as recorded at S. 7th Street in the City of Milwaukee. 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, and 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[7] by the U. S. Water Resources Council, an organization composed of representatives of federal offices and agencies concerned with water resource problems. This U. S. 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 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. The Act 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.

Digital Computer Utilization

Extensive use was made of digital computers in the conduct of the Pike River watershed study 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 was thus able to direct more of its 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 Pike River watershed planning program for the three reasons discussed below.

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. Because successful computer operation requires that all desired operations be completed and correctly programmed, 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, the digital computer can store large amounts of alphanumerical information, facilitate the retrieval and processing of such information, and 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 impossible to manually perform the computations executed by the digital computer hydrologic-hydraulic water quality model 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.

Third, 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.

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 decisionmakers 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 evalua-

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

tion of benefits and costs. This is not to imply that 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 quantifiable 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 considering whether a potential benefit is worth its cost, consideration is 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 decisionmaking 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.

While implying at least subjective consideration of benefits and costs, personal and private decisions, 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. In other words, 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 cost, 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 an understanding of a particular plan element, must be considered in selecting among various plan elements. 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 a comprehensive plan for the Pike River watershed could include benefits of floodland management; recreation; efficient community utilities and facilities; enhancement of property values; and preservation of recreational, scenic, cultural, and ecological values. Costs which could be incurred in implementation of watershed plans include construction and land acquisition costs, and income foregone as a result of the 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 for 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 uneconomical, 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 Pike River watershed plan, 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 Pike River watershed alternative plans.

Using a 6 percent interest rate, 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 $1.00. 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 Pike River watershed planning studies, tangible benefits might 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 1980 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 1980 market prices for land in the Pike 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 receipt 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, and as described above, an economic analysis 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.

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 permits lower initial capital investments, reduces interest costs, and allows for flexibility of continued planning. Staging developments may also allow deferring of an element until increased demands raise its benefit-cost ratio. In planning for staged development, however, consideration must be given to the 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 Pike River watershed planning program. The adopted development objectives for the watershed plan consist of all of the eight adopted regional land use planning objectives, of all of the five adopted water quality management planning objectives, of three of the seven adopted regional park and open space planning objectives, and of two of the four water control facility objectives adopted under previous Commission comprehensive watershed planning studies.

In addition to presenting and discussing the objectives, principles, and standards adopted for the Pike River watershed, this chapter also presents the engineering design criteria and analytic procedures used in the watershed study. These criteria and procedures were used to synthesize a Pike 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 the making of 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.

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Chapter XI

RECOMMENDED LAND USE PLAN AND RECOMMENDED PARK AND OPEN SPACE PLAN FOR THE WATERSHED

INTRODUCTION

The demographic and economic base and the existing land use pattern of the Pike River watershed were described in Chapter III of this report. Forecasts of probable future population and economic activity levels, together with attendant demands for various land uses within the watershed, were set forth in Chapter IV of this report. The resident population of the watershed was forecast to increase from the 1970 level of about 24,200, to a year 2000 level of about 56,300 persons, an increase of about 132 percent over the 30 year period. Employment within the watershed was forecast to increase from the 1970 total of about 8,300 jobs, to a year 2000 total of about 25,200 jobs, an increase of about 204 percent. This growth in population and employment will require an increase in the amount of land devoted to urban uses within the watershed from about 11.8 square miles in 1970 to about 29.3 square miles in 2000, an increase of about 148 percent. The demand for urban land will have to be satisfied primarily through the conversion of some of the remaining agricultural and other open lands of the watershed from rural to urban uses. This conversion, if unplanned or poorly planned and if not properly related to the natural resource base, may be expected to further intensify the developmental and environmental problems of the watershed.

It is accordingly important that new urban development within the watershed be properly related to soil capabilities; to the wetlands and woodlands of the watershed; to the floodlands of the Pike River system; and to established utility systems. If the intensification of developmental and environmental problems is to be avoided and the serious problems of flooding and water pollution already existing within the Pike River watershed are to be abated, new urban development within the watershed must be directed into a more orderly and efficient pattern which is carefully adjusted to the ability of the underlying and sustaining natural resource base to support such development. A land use plan must, therefore, constitute a major element of any comprehensive plan for the development of the Pike River watershed. This land use plan element, although emphasizing the riverine areas of the watershed, must cover the entire watershed, and should represent the basic approach to resolution of the growing developmental and environmental problems of the watershed. The land use plan element and any structural water control facility plan elements for flood control and pollution abatement should be mutually supportive, in that land use development will determine to a considerable extent the loading on the water control facilities, while those facilities will, in turn, influence land use development, particularly in the riverine areas of the watershed.

Regional Land Use Plan

Because in a large urbanizing region, such as southeastern Wisconsin, the socioeconomic factors that determine growth operate on an areawide basis, transcending both political and natural watershed boundaries, a land use plan for a watershed within such an urbanizing region must be set within the framework of an areawide—or regional—land use plan.

The first regional land use plan for southeastern Wisconsin was adopted by the Regional Planning Commission in 1966 and had a design year 1990. In 1977, that plan was refined by the Commission and updated to the design year 2000. The new year 2000 regional land use plan has been formally adopted by the County Boards of Racine and Kenosha Counties. The watershed land use plan recommended herein is accordingly set within the context of, and reflects the concepts contained in, the revised and updated regional land use plan for the design year 2000. The new regional land use plan is fully documented in SEWRPC Planning Report No. 25, A Regional Land Use Plan and a Regional Transportation Plan for Southeastern Wisconsin: 2000, Volume Two, Alternative and Recommended Plans. The new regional land use plan, like the initial regional land use plan, seeks to encourage the centralization of urban development to the greatest degree practicable; to encourage new urban development to occur in locations and at densities consistent with the economical provision of public centralized sanitary sewer, water supply, and mass transit facilities and services; and to encourage new urban development to occur only in areas which are covered by soils well suited to urban use and which are not subject to special hazards such as flooding.

Importantly, the plan seeks to protect and preserve in essentially natural open uses the primary environmental corridors of the Region. These primary environmental corridors, constituting about 20 percent of the total area of the Region, encompass the best remaining woodlands, wetlands, wildlife habitat areas, surface waters and associated undeveloped floodlands and shorelands; areas covered by organic soils; areas of rough topography and/or those which contain significant geological formations; sites having scenic, scientific, and cultural value; areas of ground water recharge and discharge; and the best remaining potential park and related open space sites. Protection and preservation of the primary environmental corridors is considered essential to the protection and wise use of the natural resource base; to the preservation of the cultural heritage and natural beauty of the Region; and to the enrichment of the physical, intellectual, and spiritual development of the resident population; as well as being necessary to the prevention of new and/or the intensification of existing developmental and environmental problems, such as flooding and water pollution. The topography, soils, and flood hazards existing in these corridors, moreover, make these corridors poorly suited to intensive urban development of any kind, but well suited to recreational and conservancy uses. Importantly, the regional land use plan also proposes to preserve to the greatest extent practicable those areas of the Region identified as prime agricultural lands and to convert to urban use only those prime agricultural lands that have already been, in effect, committed to urban development due to the proximity of existing and expanding concentrations of urban uses and to the prior commitment of heavy capital investments in utility extensions.

While the adopted regional land use plan forms the basis for the watershed land use plan as herein presented, it should be noted that in the preparation of the watershed land use plan, the regional land use plan was refined and detailed to reflect the flood hazard in the riverine areas of the watershed as determined under the watershed planning program, to reflect recent local development decisions with respect to major trunk sewer locations, and to reflect the proposals contained in existing community and neighborhood development plans and plan implementation ordinances. The regional land use development objectives, which the regional land use plan is designed to meet, are set forth in SEWRPC Planning Report No. 25 and have been judged to remain valid and attainable within the context of the more detailed watershed development plan. These revised regional land use development objectives and the supporting principles and standards were made on the basis of the watershed land use development objectives, principles, and standards as set forth in Chapter X of this report.

Regional Park and Open Space Plan

Following completion of the new year 2000 regional land use plan in December 1977, the Regional Planning Commission in 1978 completed and adopted a regional park and open space plan. This plan is fully documented in SEWRPC Planning Report No. 27, A Regional Park and Open Space Plan for Southeastern Wisconsin: 2000, and contains recommendations which, while coordinated with the recommendations in the adopted regional land use plan, represent refinements of those recommendations and, as such, should also provide a part of the basic framework for the watershed land use plan.

The regional park and open space plan is composed of two principal elements—an open space preservation plan element and an outdoor recreation plan element. The open space preservation plan element contains specific recommendations for the preservation of the remaining primary environmental corridors of the Region through appropriate combinations of public acquisition and land use regulation. The outdoor recreation element is composed of two components: a resource-oriented outdoor recreation component containing recommendations for the location, size, and development of large parks and recreation corridors within the Region, and an urban-oriented recreation component containing recommendations concerning the location, size, expansion and development of community and neighborhood parks within the urban areas of the Region. In the preparation of the land use plan for the Pike River watershed, the recommendations of the regional park and open space plan were incorporated into the watershed plan, with such refinements as necessary to reflect the most recent public actions concerning the acquisition and development of park and open space sites within the watershed.

WATERSHED LAND USE PLAN

As already noted the regional land use and park and open space plans for the design year 2000 form the basis for the recommended land use plan for the Pike River watershed. This recommended land use plan 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 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 and employment growth within each county through the plan design year 2000. The land use plan 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 the Region and watershed that are covered by soils well suited to such development, that are not subject to special hazards such as flooding, and that can be readily provided with gravity drainage sanitary sewer, public water supply, and urban mass transit services.

The land use plan 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 the intensification of developmental and environmental problems within the Region and the watershed. This land use plan is shown in graphic summary form on Map 44 and in Figure 51 and is more specifically described in the following sections of this chapter.

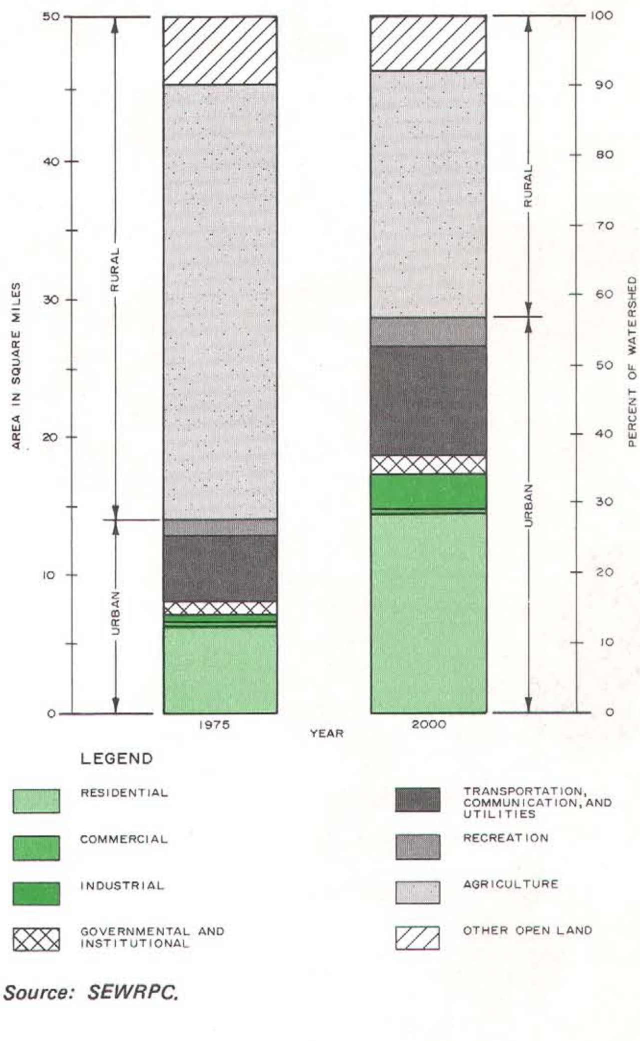
In order to meet the needs of the anticipated growth in population and employment, the amount of land devoted to urban use within the watershed, as indicated in Table 81, was projected to increase from the 1975 total of about 14.3 square miles, or about 28 percent of the total area of the watershed to 29.3 square miles, or about 57 percent of the total area of the watershed, by year 2000. As previously noted, urban land use in the watershed in 1970 totaled about 11.8 square miles, or about 22.9 percent of the total area of the watershed. This demand for urban land will have to be satisfied primarily through the conversion of some of the remaining agricultural and other open lands of the watershed from rural to urban uses. Such rural land uses may be expected to decline collectively from about 37.2 square miles in 1975 to about 22.2 square miles in the year 2000, a decrease of over 40 percent in the 1975-2000 time period.

Residential Land Use

As indicated in Table 81, about 12 percent of the total area of the watershed is presently devoted to residential use. About 8.7 square miles is proposed to be added to the existing stock of residential land

Figure 51

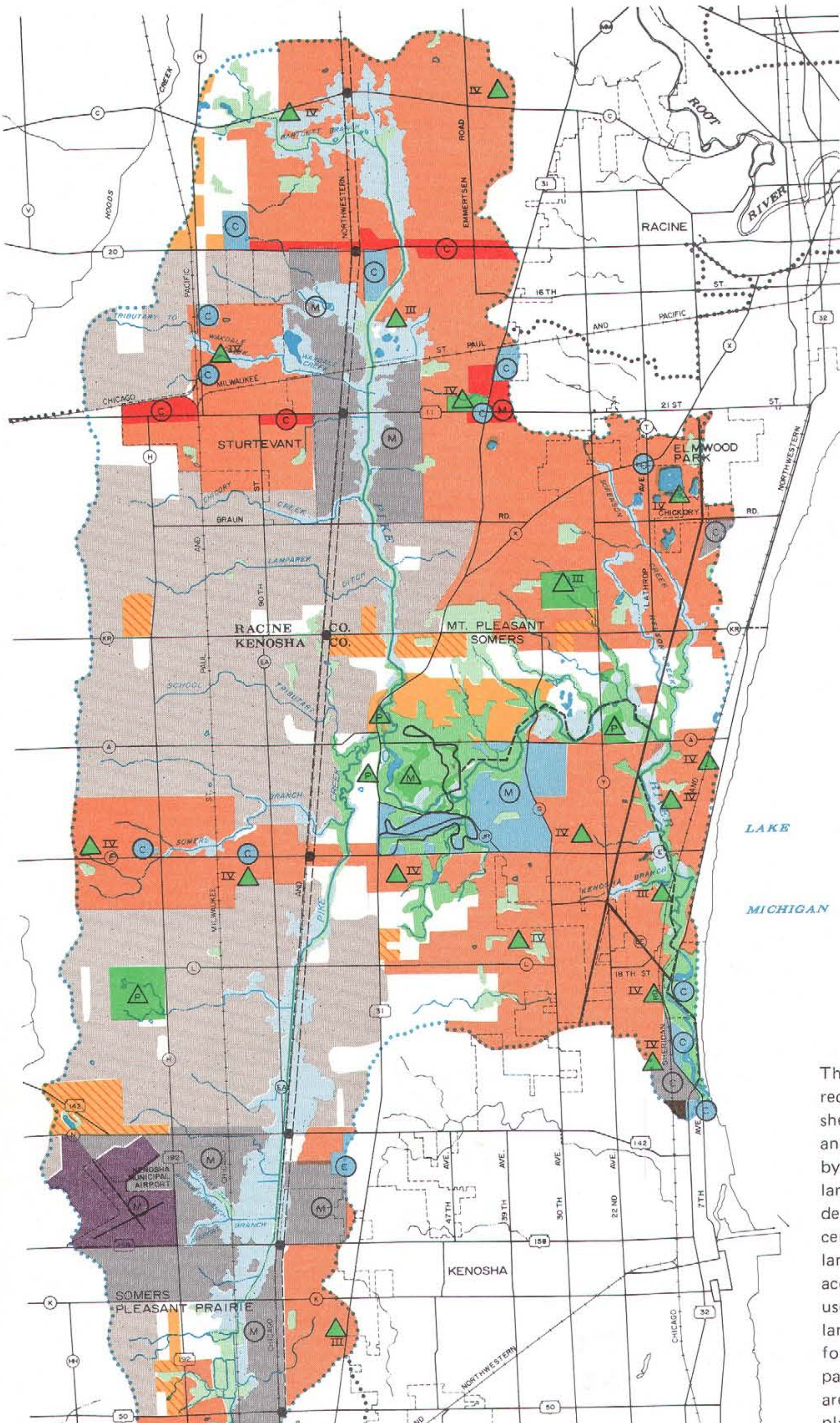
EXISTING AND PROPOSED LAND USE IN THE PIKE RIVER WATERSHED

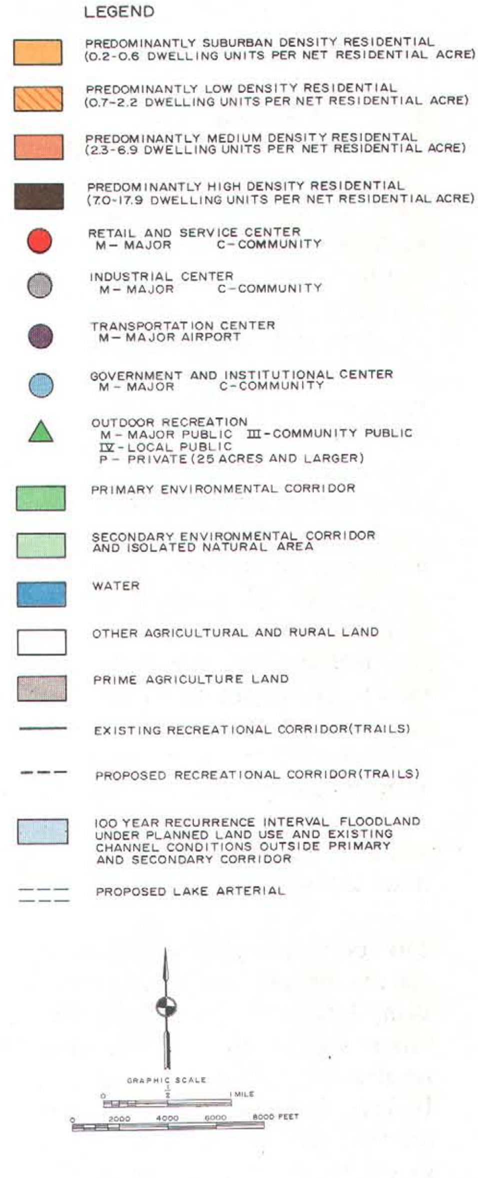


Source: SEWRPC.

Map 44

RECOMMENDED LAND USE AND PARK AND OPEN SPACE PLAN FOR THE PIKE RIVER WATERSHED: 2000





The regional land use plan for the year 2000 forms the recommended land use base for the Pike 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. About 14 square miles, or 28 percent of the watershed, are presently devoted to urban land uses. The recommended land use base would accommodate the anticipated demand for urban land uses through conversion of about 15 square miles of land to urban use by the year 2000. Recommendations for the acquisition, development, and maintenance of park and open space land and facilities in the watershed are related to and represent refinements of the land use plan for the watershed. Included in the recommendations for the Pike River watershed are the protection and preservation of important natural resource features and the provision of additional needed outdoor recreation sites and facilities.

Source: *SEWRPC.*

Table 81

EXISTING AND PROPOSED LAND USE IN THE PIKE RIVER WATERSHED: 1975 AND 2000

Land Use Category	Existing 1975			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								
Residential								
High-Density	0.02	0.1	--[a]	--	--	0.02	0.1	--[a]
Medium-Density	0.33	2.3	0.6	13.18	3,993.9	13.51	46.2	26.3
Suburban and Low-Density	5.94	41.7	11.6	-4.53	-76.3	1.41	4.8	2.8
Subtotal	6.29	44.1	12.2	8.65	137.5	14.94	51.1	29.1
Commercial	0.23	1.6	0.4	0.13	56.5	0.36	1.2	0.7
Industrial	0.70	4.9	1.4	2.27	324.3	2.97	10.2	5.8
Governmental and Institutional	1.02	7.2	2.0	0.25	24.5	1.27	4.3	2.5
Transportation, Communication, and Utilities	4.82	33.8	9.4	3.38	70.1	8.20	28.0	15.9
Recreational	1.20	8.4	2.3	0.32	26.6	1.52	5.2	2.9
Subtotal	7.97	55.9	15.5	6.35	79.7	14.32	48.9	27.8
Urban Total	14.26	100.0	27.7	15.00	105.2	29.26	100.0	56.9
Rural								
Agricultural								
Prime Agricultural	19.27	51.9	37.5	-5.23	-27.1	14.04	72.9	27.3
Other Agricultural	12.99	34.9	25.3	-8.47	-65.2	4.52	20.4	8.8
Other Open Lands	4.90	13.2	9.5	-1.30	-26.5	3.60	16.2	7.0
Rural Total	37.16	100.0	72.3	-15.00	-40.4	22.16	100.0	43.1
Pike River Watershed Total	51.42	--	100.0	--	--	51.42	--	100.0

[a]*Less than 0.05 percent.*

Source: SEWRPC.

in the watershed between the years 1975 and 2000. This new urban development is proposed to occur primarily 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 about 3,300 to 9,200 persons per square mile.

In 1975, about 19 percent of the total area of the watershed and approximately 85 percent of the total resident population of the watershed were served by public sanitary sewerage facilities. By 2000, with the exception of small enclaves of scattered low-density residential developments in rural areas of the watershed, virtually all of the urban areas within the watershed are proposed to be served by public sanitary sewerage facilities.

Retail Service Land Use

In addition to some neighborhood, community and highway-oriented commercial areas, a small portion of one regional commercial center—Elmwood Plaza located in the southern portion of the City of Racine—presently exists within the watershed. By the year 2000 this regional commercial center is proposed to be replaced by a new regional commercial center to be located at the intersection of STH 11 and STH 31. Only a portion of this new site would be located within the watershed.

Industrial Land Use

Land devoted to industrial activity would continue to increase primarily in two regional industrial centers—Mt. Pleasant West, located just east of the Village of Sturtevant in the Town of Mt. Pleasant and Kenosha West, located west of the City of

Kenosha in the Towns of Somers and Pleasant Prairie. Under the Pike River watershed plan, the amount of land used for industrial purposes is proposed to be increased by about 2.3 square miles, from about 0.7 square mile in 1975 to about 3.0 square miles in 2000, an increase of about 324 percent.

Governmental and Institutional Land Use

As indicated in Table 81, the land use plan envisions an increase of approximately 0.3 square mile in governmental and institutional land uses, an increase of about 25 percent over the plan design period. A major university is located in the study area—the University of Wisconsin-Parkside—in the Town of Somers, Kenosha County, about two miles west of Lake Michigan and one and one-half miles south of the Racine-Kenosha County line. In addition, much of the Carthage College campus in the City of Kenosha, Kenosha County, is located within the watershed.

Transportation, Communication, and Utility Facility Land Uses

Transportation and related activities are inherently large consumers of land and along with residential lands represent the most intensive type of urban development in the watershed. As indicated in Table 81, transportation, communication, and utility facility land uses in the watershed may be expected to increase by about 3.4 square miles, or by about 70 percent, over the plan design period. This is due to the expansion of the Kenosha Municipal Airport, as well as the need for additional land access, collector, and arterial streets to serve planned urban development.

Recreational Land Use

As indicated in Table 81, the plan envisions recreational land uses in the watershed to increase by about 0.3 square mile, or by 27 percent, from 1.2 square miles in 1975, to 1.5 square miles in 2000. One major public outdoor recreation center, Petrifying Springs County Park is located in the watershed, just north of the City of Kenosha in the Town of Somers. A description of recommended park and open space reservation and development actions is presented in a later section of this chapter.

Agricultural and Other Open Land Uses

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 land uses. The existing stock of such land within the watershed could, therefore, be expected to decrease from about 37 square miles in 1975, to about 22 square miles in 2000. Thus, by the year 2000, about 43 percent of the total area of the watershed would remain in agricultural and other open land uses. Concurrently with the preparation of the Pike River watershed plan, and subsequent to the preparation of the regional land use and park and open space plans, the Regional Planning Commission in cooperation with the Racine and Kenosha County Boards prepared agricultural land preservation plans for Racine and Kenosha Counties. These plans serve as refinements of the adopted regional land use and park and open space plans and are documented in SEWRPC Community Assistance Planning Report No. 45, A Farmland Preservation Plan for Kenosha County, Wisconsin, and SEWRPC Community Assistance Planning Report No. 46, A Farmland Preservation Plan for Racine County, Wisconsin. Under these agricultural land preservation plans, it was recognized that certain agricultural lands adjacent to the Cities of Racine and Kenosha were committed to ultimate conversion to urban use. It was recommended that the remaining lands identified as prime agricultural lands be maintained in agricultural use and protected through public land use regulation. As indicated in Table 81, there were 19.3 square miles of prime agricultural lands identified in the Pike River watershed in 1980. Of these prime agricultural lands, about 5.2 square miles, or 27 percent, would be converted to urban land uses while the remaining 14.0 square miles, or 73 percent would be maintained in agricultural use and protected through appropriate land use regulations.

Open Space Preservation Plan Element

The proposed land use plan recommends the preservation in essentially natural, open uses of all remaining environmental corridor lands within the watershed. As shown on Map 44, primary environmental corridors within the watershed encompass about 1,189 acres of land along the main stem of the Pike River from the area within and adjacent to Petrifying Springs County Park located in the Town of Somers in Kenosha County to the mouth of the Pike River located in the City of Kenosha. Under the regional park and open space plan, it is recognized that existing private as well as public outdoor recreation and related open space lands comprise a significant part of the primary environmental corridor and, in effect, help to protect the corridor. It is, therefore, recommended that such

Table 82

PRESERVATION OF NATURAL RESOURCE FEATURES IN THE PIKE RIVER WATERSHED: 2000

Civil Division	Primary Environmental Corridors			Secondary Environmental Corridors			Isolated Natural Areas		
	Existing Public Ownership (acres)	Existing Compatible Nonpublic Ownership (acres)	Proposed Public Ownership (acres)	Existing Public Ownership (acres)	Existing Compatible Nonpublic Ownership (acres)	Recommended for Preservation Through Public Land Use Regulation (acres)	Existing Public Ownership (acres)	Existing Compatible Nonpublic Ownership (acres)	Recommended for Preservation Through Public Land Use Regulation (acres)
Kenosha County									
City of Kenosha	70	43	14	0	0	0	0	0	6
Town of Pleasant Prairie . .	0	0	0	0	0	161	0	0	36
Town of Somers	369	95	598	0	8	143	16	0	172
Kenosha Subtotal	439	138	612	0	8	304	16	0	214
Racine County									
City of Racine	0	0	0	0	0	0	0	0	12
Town of Mt. Pleasant	0	0	0	4	0	280	84	0	293
Village of Elmwood Park . .	0	0	0	0	0	0	0	0	18
Village of Sturtevant.	0	0	0	0	0	0	0	0	17
Racine Subtotal	0	0	0	4	0	280	84	0	340
Total	439	138	612	4	8	584	100	0	554

NOTE: 1975 is base year for existing conditions.

Source: SEWRPC.

public and private outdoor recreation and related open space lands be maintained for resource preservation and limited recreation purposes. It is also recommended that the remaining primary environmental corridor lands be acquired through outright purchase using public funds. As shown in Table 82, of the total 1,189 acres of primary environmental corridor lands in the Pike River watershed, 439 acres, or 37 percent, are presently held in public ownership, while 138 acres, or 11 percent, are held in compatible nonpublic outdoor recreation uses. As further shown in Table 82, under the regional park and open space plan and the watershed plan, the remaining 612 acres, or 52 percent, would be acquired over the plan design period at an estimated cost of about $2,056,000, expressed in 1980 dollars. Actual costs for purchase of corridor lands could be expected to range from about $500 per acre, for wetlands located in rural portions of the watershed, to about $14,000 per acre, for upland woodlands located in urbanizing areas of the watershed.

The secondary environmental corridors in the Pike River watershed are located along the main stem of the Pike River through the Town of Mt. Pleasant and upstream from the primary environmental corridors within and adjacent to Petrifying Springs County Park; along Pike Creek, in the Towns of Somers and Pleasant Prairie, also upstream from the primary environmental corridor within and adjacent to Petrifying Springs County Park; and along several intermittent streams tributary to the main stem of the Pike River located in the Towns of Mt. Pleasant and Somers (see Map 44). As in the case of primary environmental corridor lands, it is recommended that the secondary environmental corridor lands which are presently held in public park and open space use, or in compatible private park and related open space use, be maintained in such ownership. Those secondary environmental corridor lands not presently held in public or private park and related open space use are recommended to be considered for preservation and protection through interim land use regulation and ultimate public acquisition as drainageways and other urban open spaces. It is important to note in this respect that, in urban areas, secondary environmental corridor lands may serve as particularly suitable locations for necessary local urban park and open space lands. Thus, public acquisition of secondary environmental corridor lands may be appropriate, particularly when the opportunity is presented to incorporate such corridors into urban storm water detention areas, associated drainageways, and neighborhood parks.

As shown in Table 82, of the 596 acres of secondary environmental corridors in the watershed, only four acres, or less than 1 percent, are presently held in public park and open space uses, while only eight acres, or 1 percent, are held in compatible nonpublic outdoor recreation and related open space uses. The remaining 584 acres, or 98 percent, would be protected through public land use regulation, and, as more detailed drainage and neighborhood unit planning and design proceeded, would be considered for public acquisition through purchase and/or dedication.

In addition to the primary and secondary environmental corridors, other, smaller concentrations of natural resource base elements exist within the watershed area as shown on Map 44. These concentrations are isolated from the remaining environmental corridors by urban development or agricultural uses, and, although separated from the environmental corridor network, such isolated natural features may have important natural values. It is recommended that such areas be preserved in essentially natural, open uses whenever possible. Those isolated natural areas currently held in public or compatible nonpublic outdoor recreation and open space use would be maintained in such uses, while the remaining isolated natural areas would be protected through public land use regulation. As in the case of secondary environmental corridors, it is important to note that in urban areas, isolated natural areas may serve as particularly suitable locations for necessary local urban park and open space lands; and public acquisition of isolated natural areas may be appropriate, particularly when the opportunity is presented to incorporate such areas into urban storm water detention areas or neighborhood parks. As indicated in Table 82, of the 654 acres of isolated natural areas in the watershed, 100 acres, or 15 percent, are held in public ownership. The remaining 554 acres, or 85 percent, would be protected through public land use regulation, and, as more detailed drainage and neighborhood unit planning and design proceeded, would be considered for public acquisition through purchase and/or dedication.

It should be noted that storm water detention areas may, in addition to their primary function as flood control facilities, have multiple use potential. These areas can, for example, be utilized for recreational and other open space uses during most of the year due to the infrequency of major flood events, and the normally short period of inundation. Suitable recreation uses include playfield activities, picnicking, nature study, and other passive recreational pursuits that do not require the construction of facilities for intensive recreational activities which could be damaged during a flood event. As of 1980, for example, the Mt. Pleasant Drainage District No. 1 had reserved about 175 acres of land which, while used for storm water detention, could also be used for recreational purposes. Generally, such sites should be leased or dedicated to an agency with responsibility for the provision of park and outdoor recreation facilities and services such as the county, retaining an easement for storm water retention.

Outdoor Recreation Plan Element

The outdoor recreation plan element for the Pike River watershed is composed of: 1) a resource-oriented outdoor recreation component containing recommendations concerning the number and locations of large parks and recreation corridors; and 2) an urban-oriented outdoor recreation component containing recommendations to guide the public provision of needed local parks within urban areas.

Large Parks and Recreation Corridors: Type I and Type II parks are defined by the Commission as large, public, general-use outdoor recreation sites which provide opportunities for such activities as camping, golfing, picnicking, and swimming; which have a large area; and which contain significant natural resource amenities. Type II parks are defined to range in area from 100 to 249 acres, while Type I parks are defined to range in area from 250 acres up. Type I and Type II parks generally attract users from relatively long distances and serve persons of all age groups residing in both urban and rural areas. Type II parks typically provide a more limited variety of recreational facilities than in Type I parks and have a smaller area devoted to any given activity.

In 1980 there was one existing Type I park within the Pike River watershed—Petrifying Springs County Park. As shown on Map 44, Petrifying Springs County Park is located in the Town of Somers in Kenosha County, and the plan recommends the continued maintenance of this facility. In addition, it is recommended that Sanders Park, an existing 80-acre Type III park owned by Racine County and located in the southern portion of the Town of Mt. Pleasant, be expanded to the size required for a Type II park through the acquisition of 40 additional acres at an estimated cost of $188,000.

A recreation corridor is defined by the Commission as a publicly owned ribbon of land at least 15 miles in length located through areas of scenic, scientific, historic, or natural interest that contains trails marked and maintained for such activities as hiking and biking. As shown on Map 44, a recreation corridor segment is proposed to be located along the main stem of the Pike River from Petrifying Springs County Park to Lake Michigan, where the recreation corridor would traverse the parks along the Lake Michigan shoreline in the City of Kenosha. In addition, this proposed recreation corridor segment would be linked to the Kenosha-Racine County bike trail, which is located on the abandoned Chicago, North Shore & Milwaukee Railway Company right-of-way. This recreation corridor segment would eventually be linked to a recreation corridor proposed to be located along the Root River in Racine County. In urban areas where environmental corridors or separate bike trails may not exist, the corridor would link various larger parks by utilizing existing streets. Recreation corridors through golf courses would not bisect the golf course proper but would most likely follow the perimeter of the course both to minimize disruption of players on the golf course and to maximize safety of hikers and bicyclists utilizing the recreation corridor. The recreation corridor along the Pike River is proposed to be approximately seven miles in length; and, along with the existing five-mile Kenosha-Racine County bike trail along the abandoned Chicago, North Shore & Milwaukee Railway Company right-of-way, a total of approximately 12 miles of recreation corridor providing trails for such activities as hiking and biking would be provided within the Pike River watershed at an estimated development cost of $220,500. Costs for the provision of a hiking and biking trail range from $22,500 per lineal mile for the provision of a compacted limestone surface in rural areas of the watershed, to $53,600 per lineal mile for a paved bituminous surface in urban portions of the watershed. It should be noted that the recreation corridor segments would be located within the primary environmental corridor lands proposed for public acquisition under the open space preservation plan; and, therefore, no additional land acquisition costs would be incurred for the provision of recreation corridor lands.

Urban Parks and Facilities: In contrast to Type I and Type II parks, Type III and Type IV general-use outdoor recreation sites depend more upon the characteristics of the urban area to be served than on the underlying natural resource base amenities. Type III general-use sites, by definition, range in size from 25 to 99 acres, while Type IV general-use sites are under 25 acres in area. Type III and Type IV general-use sites, which typically provide opportunities for intensive, nonresource-oriented outdoor recreation activities such as baseball, basketball, ice skating and tennis, generally attract users from a relatively small service area and are provided primarily to meet the outdoor recreation demand of residents of urban areas.

In 1980 there were two Type III general-use outdoor recreation sites within the Pike River watershed—Sanders Park, with an area of about 80 acres, which is owned by Racine County and located in the Town of Mt. Pleasant, and Poerio Park, with an area of about 70 acres, which is owned by the City of Kenosha. As previously noted, the plan recommends the expansion of Sanders Park to the size required for a Type II park. In addition, the plan element recommends the development of facilities at Poerio Park and the acquisition and development of two additional Type III general-use outdoor recreation sites in the Pike River watershed. As shown on Map 44, one additional Type III site is proposed to be located between the existing Village of Sturtevant and the City of Racine in the Town of Mt. Pleasant in Racine County, and the other Type III site is proposed to be located west of the City of Kenosha in the Town of Pleasant Prairie in Kenosha County.

As shown on Map 44, there were in 1980 four developed Type IV general-use outdoor recreation sites within the Pike River watershed: Petzke Park with an area of about 10 acres, and Petretti Park with an area of about eight acres, which are owned by, and located in, the City of Kenosha; Somers Athletic Field with an area of about seven acres, which is owned by the Town of Somers and located adjacent to the Somers Town Hall; and Stuart McBride Park, with an area of about 15 acres, which is owned by the Town of Mt. Pleasant. The outdoor recreation plan element recommends the continued maintenance of these parks.

The outdoor recreation plan element also recommends the provision of 10 additional Type IV general-use outdoor recreation sites in the Pike River watershed. These 10 additional sites would be located in the areas of the watershed proposed to be converted to urban development by the plan design year 2000. As shown on Map 44, five additional Type IV sites would be located adjacent to the City of Kenosha in the Town of Somers; one additional Type IV site would be located in the general vicinity of CTH E in the proposed urban area in the western portion of the Town of Somers; one additional Type IV site would be located in the northern portion of the Village of Sturtevant; one additional Type IV site would be located in the Village of Elmwood Park; and the remaining two additional Type IV sites would be located west of the City of Racine in the Town of Mt. Pleasant. The 10 Type IV sites and the two Type III sites would have a combined total area of about 206 acres. The total acquisition cost of these parks is estimated at $720,000.[1]

The regional park and open space plan also includes recommendations concerning the type and quantity of urban outdoor recreation facilities which should be provided to meet the existing and probable future recreation needs of residents of urban areas. In comparison to the resource-oriented recreation sites and facilities, nonresource-oriented facilities—including baseball diamonds, basketball courts, ice skating rinks, playfields, playgrounds, softball diamonds, and tennis courts—rely less heavily on natural resource amenities; generally serve a greater need; are provided in urban rather than rural areas; and have a relatively smaller service radius.

[1] *Under the regional park and open space plan, those Type IV parks located in residential areas planned for development between 1975 and the plan design year 2000 would be acquired through the subdivision dedication process, and no public expenditure for such sites would be required. Type III parks and those Type IV parks proposed to be located within or immediately adjacent to existing residential development would be purchased by local units and agencies of government. Two additional Type III parks, each 45 acres in area, would be acquired at an estimated cost of about $396,000, or about $4,400 per acre, and three Type IV parks, each six acres in area, would be acquired at an estimated cost of about $324,000, or about $18,000 per acre. The other seven proposed Type IV parks may be expected to be obtained through dedication so that there should be no acquisition costs associated with the provision of these parks.*

All of the new intensive nonresource-oriented outdoor recreation facilities proposed under this plan element for the Pike River watershed would be developed on existing or proposed additional Type III and Type IV park lands. Although the type and quanitity of these facilities proposed for the watershed would be determined through a joint effort by the school districts and local community recreation agencies based on a more detailed study of community and neighborhood needs, facility development costs were estimated using the regional park and open space plan.[2] The total urban park facility development costs in the urban parks in the Pike River watershed are estimated at $1,815,000, expressed in 1980 dollars. This estimate includes the development costs for intensive nonresource-oriented facilities—for example, softball diamonds, tennis courts, and playfields—as well as the support facilities—for example, restroom facilities and parking spaces—directly related to the recommended facilities for the two Type III and 10 Type IV sites proposed for acquisition and development within the watershed.

SUMMARY

The adopted design year 2000 regional land use and park and open space plans form the basis for the recommended land use and park and open space plans for the Pike River watershed. These plans propose to meet the social, economic, and physical needs of the existing and future resident population of the watershed by allocating sufficient land to each of the various land use categories to satisfy the existing and anticipated demand for each use, meeting both the demands of the urban land market and the land use development objectives and supporting standards developed for the regional land use and park and open space plans. These plans would seek to protect and enhance the natural resource base of the watershed by allocating new urban development only to those areas within the watershed that are covered by soils well-suited to such development that are not sub-

[2] *A description of the methodology for the determination of urban park facility development costs is presented in SEWRPC Planning Report No. 27, A Regional Park and Open Space Plan for Southeastern Wisconsin: 2000, Chapter XIII.*

ject to special hazards such as flooding, and that can be readily and economically provided with sanitary sewer, public water supply, and urban mass transit services.

In order to meet the needs of the anticipated growth in population and employment within the watershed, the amount of land devoted to urban use is projected to increase from a 1975 total of about 14.2 square miles, or about 28 percent of the total area of the watershed, to 29.3 square miles, or about 57 percent of the total area of the watershed. This demand for urban land will have to be satisfied primarily through the conversion of some of the remaining agricultural and other open lands of the watershed from rural to urban uses. Such rural land uses may be expected to decline collectively from about 37.2 square miles in 1975 to about 22.2 square miles in the year 2000, a decrease of about 40 percent over the plan design period.

The open space preservation plan element of the watershed plan recommends the preservation in essentially natural, open uses of all remaining primary environmental corridor lands and preservation of the majority of the prime agricultural lands within the watershed. The primary environmental corridors represent a composite of the best remaining elements of the natural resource base of the watershed, and encompass about 1.9 square miles, or only about 4 percent of the total area of the watershed. These corridor lands are located primarily along the main stem of the Pike River between Petrifying Springs County Park in the Town of Somers and the mouth of the Pike River located in the City of Kenosha. The plan recommends that 612 acres, or about 52 percent, of the corridors not already in public ownership, or in compatible nonpublic ownership, be acquired at an estimated cost of about $2.0 million by the plan design year 2000. The plan also recommends that the majority of the remaining prime agricultural land be maintained in agricultural use. Of the 19.3 square miles of prime agricultural land which existed in the watershed in 1980, 5.2 square miles, or 27 percent, would be converted to urban uses while the remaining 14.0 square miles, or 73 percent, would be maintained in agricultural use and protected through public land use regulation.

The outdoor recreation plan element of the Pike River watershed recommends the provision of a recreation corridor for such activities as hiking and biking within a seven-mile segment of the primary environmental corridor associated with the Pike River and over a five-mile segment of the Kenosha-Racine bike trail. The anticipated cost to provide for these hiking and biking facilities is approximately $220,500. The outdoor recreation plan element also recommends the expansion of Sanders Park at an estimated cost of $188,000, as well as the provision of two new community—25- to 100-acre—parks and 10 new neighborhood—5- to 25-acre—parks to meet the intensive nonresource-oriented outdoor recreation needs for the population residing in urban areas within the watershed. Estimated urban park costs including proposed site acquisition costs and the costs associated with the provision of recreation facilities within these parks, such as baseball diamonds, basketball courts, ice skating rinks, playfields, playgrounds, softball diamonds, and tennis courts total approximately $2,535,000. It should be noted that in order to avoid multiple accounting of implementation costs for regional plan elements, the aforementioned estimated costs for primary environmental corridor acquisition and park and recreation site acquisition and facility development have not been included as implementation costs of the Pike River watershed plan (see Chapter XV) since such costs have been previously included as implementation costs of the Commission-adopted regional park and open space plan.

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Chapter XII

ALTERNATIVE FLOODLAND MANAGEMENT MEASURES

INTRODUCTION

The inventory and analysis phases of the Pike River watershed planning program have identified certain water resource and water resource-related problems, including flooding and water pollution. As stated in Chapter I, the overriding objective of the Pike 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, more attractive, and more economic development pattern, a pattern which is properly related to the underlying and sustaining natural resource base so as to avoid the intensification of existing and the creation of new developmental and environmental problems in the watershed.

The purpose of this chapter is to present alternative floodland management measures from which a recommended floodland management plan for the watershed can be synthesized. The structural and nonstructural floodland management alternatives described herein should be considered as adjuncts to the basic land use development proposals advanced in Chapter XI, and were designed to facilitate the attainment of regional and watershed development objectives. The alternative floodland management measures are thus subordinate to the basinwide land use plan element, and the incremental benefits and costs of these alternatives can be separated from those of the basinwide land use plan element.

The evaluation of a particular alternative relative to other alternatives intended to resolve an identified problem is a sequential process during which the alternative is subjected to several levels of review and evaluation, including technical, economic, financial, legal, and administrative feasibility and political acceptability. To facilitate selection of the best floodland management measures for inclusion in a recommended comprehensive watershed plan, the technical, economic, and environmental aspects of each floodland management alternative 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 planned land use changes. Alternative structural floodland management measures are then described for the various stream reaches of the watershed. Bridge and culvert alteration or replacement for transportation purposes throughout the watershed is discussed, followed by a description of nonstructural floodland management measures also recommended for application throughout the watershed. The chapter concludes with a discussion of accessory floodland management measures.

AVAILABLE FLOODLAND MANAGEMENT MEASURES

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 the resident population of a watershed. The 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 the 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 elements, a comparative evaluation of those elements, and the synthesis of the most effective elements into an integrated plan. The floodland management plan for the Pike River watershed is specifically intended to achieve the land use development objectives, sanitary sewerage system development objectives, and water control facility development objectives and their supporting standards as set forth in Chapter X.

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, diversion facilities such as dikes and channels, 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 conservation, recreation, and other open space uses; floodland use regulations; land use controls outside of the floodlands; structure floodproofing; structure removal; channel maintenance; flood insurance; lending institution policies; realtor policies; community utility policies; and emergency programs. Table 83 lists structural and nonstructural floodland management measures which may apply, individually or in combinations, to the stream network of the Pike 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, being preventative, are generally more effective in riverine areas that have not yet been converted to flood-damage-prone development even though they have the potential for such development.

Structural Measures

Each of the five structural floodland management measures set forth in Table 83 is discussed briefly below. Emphasis is placed on the function of each measure; on the 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 either detain floodwaters upstream of flood-prone areas for subsequent gradual release—as is the case with a detention pond—or to retain floodwaters for a combination of gradual release and evaporation or groundwater recharge—in the case of a retention pond—thereby substantially decreasing downstream discharges and flood stages, and associated flood damages. A key factor in the potential application of this alternative is the existence of sites having sufficient floodwater storage volume that are positioned upstream of all, or a significant portion of, the flood-prone riverine areas and which can thereby 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 reaches, 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, potentially adverse water quality conditions within the impoundment, and the false sense of security with respect to 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 along a completely new alignment in order to bypass the flood-prone reach. Diverted flood flows are sometimes discharged to receiving watercourses outside the subwatershed and, despite the legal problems that may be involved, outside the 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 alterna-

Table 83

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

Alternative		Function	Comment
Major Category	Name		
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, or to divert floodwaters around a flood-prone area on a completely new alignment	- -
	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 by use 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, or, to control selected practices by which existing urban or rural lands are managed	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	- -
	Community education programs	To inform and educate citizens regarding personal and private actions by property owners and residents which 1) may adversely affect flood flows and stages or 2) could favorably affect or prevent changes in flood flows and stages in the watershed	May have relationship to aesthetic, recreational, urban utility, or water quality aspects of water resources management in the watershed
	Flood insurance	To minimize monetary loss or reduce monetary impact on structure owner	Premiums may be subsidized or actuarially determined

Table 83 (continued)

Alternative		Function	Comment
Major Category	Name		
Nonstructural (continued)	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	- -
	Channel maintenance	To maintain integrity of flood stage profiles; to permit unobstructed flow from storm sewers, drainage ditches, and drainage tiles; and to remove potentially troublesome buoyant material	Will not significantly reduce stages of major floods except as those stages might be influenced by accumulation of buoyant material on the upstream side of bridge waterway openings

Source: SEWRPC.

tive is the availability of a suitable diversion route or alignment and an adequate receiving watercourse or other point of discharge.

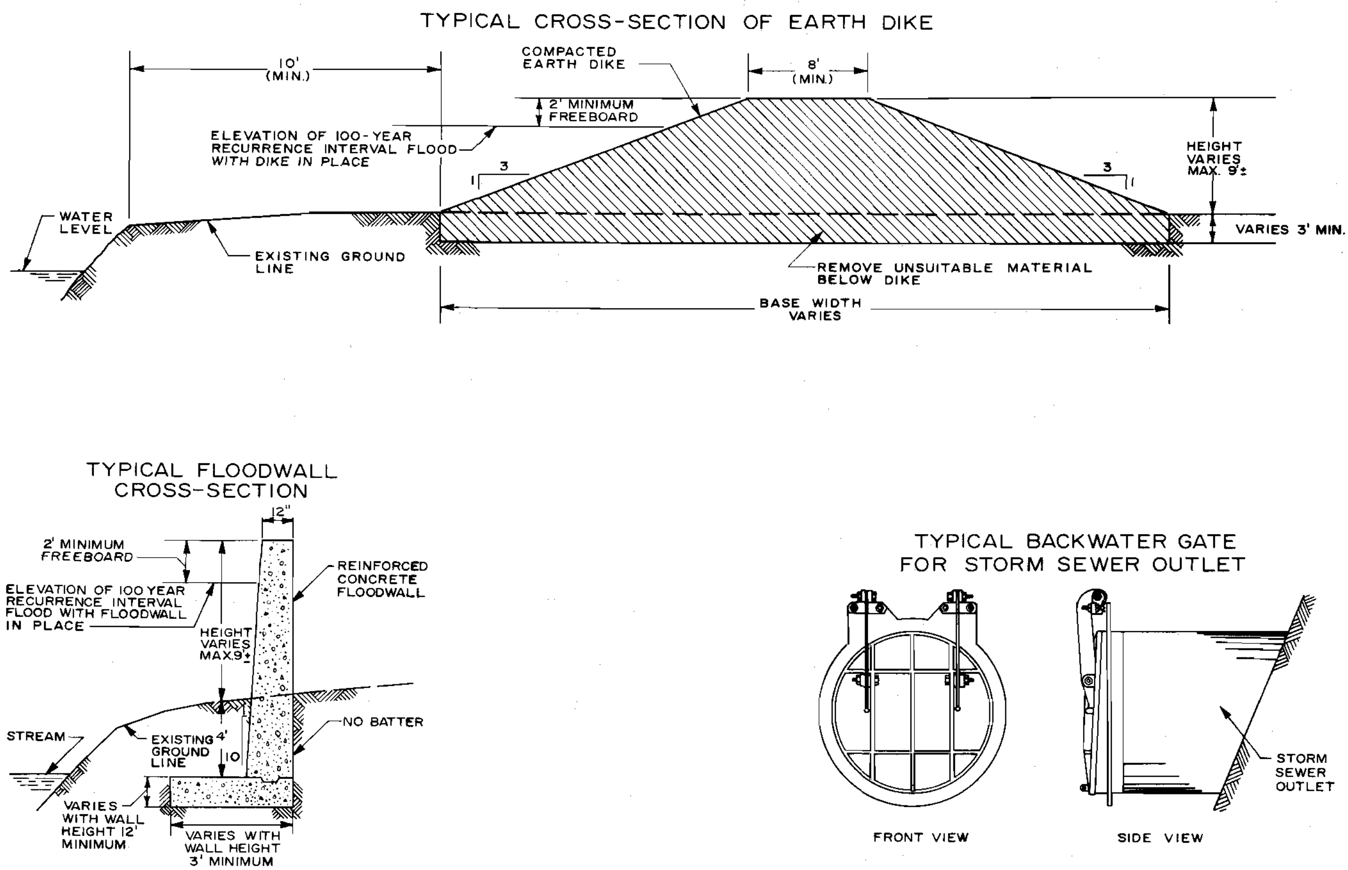
A favorable feature of the diversion technique, shared with the reservoir alternative, is the potential which a single major upstream facility may have to mitigate flood problems in several downstream reaches. A negative aspect, also shared with impoundments, is the false sense of security with respect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

Dikes and Floodwalls: Earthen dikes and concrete or sheet steel floodwalls, like those shown in Figure 52, 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 occurence 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 than the former.

In order to be effective in reducing flooding, dikes and floodwalls must normally be supplemented by the installation of backwater gates on those

Figure 52

TYPICAL EARTH DIKE, CONCRETE FLOODWALL, AND BACKWATER GATE



Source: SEWRPC.

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 recurrence interval river flood stage. A storm water drainage system, which typically includes street storm water inlets and storm sewer outfalls, normally provides for the conveyance of storm water runoff from developed urban areas to a recovery stream. During major flood events, however, high river levels may in some areas 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 may be protected 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 higher than the "natural" condition stage as a result of the lateral constriction imposed on the stream by the dikes and floodwalls, and this design-condition stage 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 existing development can be protected from flood inundation by local action. It must be recognized, however, that the serious negative aspects of dikes and floodwalls include the potential for increasing upstream flood stages as a result of the hydraulic constriction imposed on the stream, and the possibility that a series of successive dike-floodwall projects along a stream may substantially reduce the natural floodwater storage capability of the river reach and thereby increase downstream discharges and associated stages. Other significant negative characteristics of dikes and floodwalls include the potentially high capital costs; the potentially high aesthetic cost, or penalty, normally associated with the placement of these high, long structures in the riverine areas, particularly if the areas protected are devoted primarily to residential land use; and the false sense of security engendered by the presence of the dikes or floodwalls that may develop with respect to flood dangers.

Channel Enclosure and Modification: 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. Channel modifications—more commonly called channelization—may include one or more of the following major changes to the natural stream channel, all designed to increase the capacity of the stream system channel: 1) straightening, deepening, and widening; 2) placement of a concrete invert and partial sidewalls; and 3) reconstruction of selected bridges and culverts as needed. In some instances, a portion of the channelized reach may be constructed so as to bypass a segment—such as a series of meandering loops—of the existing channel. However, such a bypass is not as extreme in terms of new alignment and total length as the diversion approach discussed above. 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.

The function of channel modifications or enclosure is 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 effect 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 floodwalls—provides a means whereby action can be taken locally to effectively provide 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, maintenance, and the possibility of aggravating downstream discharges and stages resulting from the loss of floodwater storage capacity in a long channelized or enclosed reach.

Bridge and Culvert Alteration or Replacement: Existing or new highway and railway bridges and culverts, or modifications to existing bridges and culverts, may, by virtue of the conveyance provided, significantly affect upstream and downstream flood stages and aggravate existing, or create new, flood hazards. Futhermore, increased regulatory flood stages attendant to bridge and culvert construction or reconstruction must be 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 transportation system by inundating highways or railway bridges or their approaches, thereby rendering the related transportation facilities impassable during major floods.

The purpose of bridge and culvert removal, alteration, or replacement 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 related transportation facilities. 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 Hydraulic Submodel 2 as described in Chapter VIII of this report.

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

Nonstructural Measures

Each of the 12 nonstructural floodland management measures presented in Table 83 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 Conservation, Recreation, and Other 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 may 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 such recreational uses as cross country hiking and skiing trails. 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 to dedicate the land in the environmental corridor portions of those tracts to a local governmental 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 limiting soils, difficulties in supplying and maintaining utilities, 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 governmental 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 proximity to the riverine-area parkways. A study was conducted by the Commission under its regional park and open space planning program to investigate the effects of public open space land on residential values.[1] 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

[1] *SEWRPC Planning Report No. 27, A Regional Park and Open Space Plan for Southeastern Wisconsin: 2000, Chapter X, "Impact of Public Open Space Lands on Residential Property Values Based Upon an Analysis in Milwaukee County," November 1977.*

and collation of census housing value data; analysis of residential land sales information; analysis of locally assessed property values; and a survey of occupants of riverine-area residential property.

The study indicated 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. Futhermore, 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 Petrifying Springs Park in the Town of Somers, 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 indicated 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.

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 the police powers granted them by state legislatures. Such regulations are ordinarily intended for 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 IX 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 advantages of floodland regulations are that they control the manner in which new development occurs in riverine areas, and also control selected practices by which existing urban or rural lands are managed. 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.

Floodland use regulations in Wisconsin generally employ the two-district floodway-floodplain fringe approach as incorporated in the State of Wisconsin Floodplain Management Program. That program was modified in 1977 to require that floodways be delineated so as to cause no increase in the regulatory or 100-year recurrence interval flood stage.[2]

Although stipulation of a "no-stage increase" floodway eliminates or reduces some of the potential problems associated with the two-district floodway-floodplain fringe approach to floodland regulations, one significant negative aspect remains. The two-district floodway-floodplain fringe approach to floodland regulations may lead to the destruction of the environmental corridors of a watershed, since it encourages floodland fill with development outside 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 as well as for flood damage mitigation. Such more comprehensive floodland regulations may in rural areas simply designate a floodland district for which all flood-prone development is excluded, or may, with more complexity, incorporate a floodway, a developable floodplain fringe, and an undevelopable conservancy district.

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, recent studies of the hydrologic-hydraulic interdependence between the land surface and the streams of the watershed system suggest that land use planning may indeed be an effective floodland management measure.[3] It is vital that land use planning consider

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[2] *Wisconsin Administrative Code, "Wisconsin's Flood Plain Management Program," Chapter NR116, July 1977.*

[3] *For a graphic demonstration of the potential impact of land use changes outside of floodland areas on flood discharges, stage, and damage, refer to SEWRPC Planning Report No. 26, A Comprehensive Plan for the Menomonee River Watershed, Volume Two, Alternative Plans and Recommended Plan, October 1976, pp. 72-97.*

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.

Community Education Programs: It is important that the public be fully aware of how the actions of property owners may affect flood flows and stages. Personal and private actions, such as dumping of debris in a stream channel by property owners and residents, may adversely affect flood flows and stages, or localized channelization or removal of obstructions to flow may increase the flood flows and stages downstream. Proper actions, however—taken within the framework of a water resources management plan for the watershed—by property owners and residents may serve to reduce an existing flooding problem or prevent a future flooding problem which would, in turn, reduce the degree of action necessary by local units of government, and thus minimize the public financial burden.

Structure Floodproofing: As discussed in Chapter IV 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 in 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 physical 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 three categories:[4] 1) techniques for preventing entry of floodwaters; 2) techniques for ensuring 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; and 3) the techniques of raising—that is, elevating—the structure such that the first—or other—most damage-prone floor is above the design flood stage, supplemented with measures to protect the basement and other portions of the structure below the design flood stage from damage.

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 it causes will continue to occur.

Prevention of Floodwater Entry: A variety of floodproofing measures and techniques is available to prevent the entry of floodwaters. Sanitary

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[4] *For more detailed descriptions of floodproofing measures and estimate of costs see:*

- *John R. Sheaffer, et al., Introduction to Floodproofing: An Outline of Principles and Methods, University of Chicago Center for Urban Studies, April 1967.*
- *U. S. Army Corps of Engineers, Floodproofing Regulations, Washington, D. C., June 1972.*
- *Shelton R. McKeever, Floodproofing: An Example of Raising a Private Residence, U. S. Army Corps of Engineers, South Atlantic Division, Atlanta, Georgia, March 1977.*
- *William K. Johnson, Physical and Economic Feasibility of Nonstructural Flood Plain Management Measures, U. S. Army Corps of Engineers—Hydrologic Engineering Center and Institute for Water Resources, May 1977.*
- *William D. Carson, Estimating Costs and Benefits for Nonstructural Flood Control Measures, U. S. Army Corps of Engineers—Hydrologic Engineering Center, October 1975.*

sewer backup through basement floor 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, preferably provided with standby gasoline powered electrical generators, 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. 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 blocks[5] may be placed in basement window openings, and flood shields have been designed for quick installation over doorways, windows, and other structural openings.

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 intended to prevent water from entering the basement of such structures. Generally speaking, the concrete block basements widely used in residential construction in southeastern Wisconsin are not capable of withstanding hydrostatic forces associated with complete saturation of the soil surrounding the buildings.[6] A possible alternative, therefore, to the attempt 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 the structural integrity of the basement while minimizing the entry of sanitary sewage, sediment, and other objectionable materials normally associated with basement flooding and, as discussed below, incorporating measures to maintain utilities and services and protect structure contents.

Maintain Utilities and Services and Protect Contents: The second category of floodproofing measures applicable to existing residential, commercial, industrial, and other structures consists of techniques designed to ensure 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 considered 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 serving 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 and electrical equipment may be protected by removal of critical water-vulnerable components—for example, the blower motor on a forced air heating unit—prior to entry of the floodwaters.

If there is a high probability that 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 be moved to higher floors, or be temporarily elevated on supports or shelves.

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[5] *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.*

[6] *For example, see: Investigation of Basement Construction in Fargo, North Dakota and Moorhead, Minnesota Area, prepared for the Federal Insurance Administration by the National Association of Home Builders Research Foundation, Inc., Rockville, Maryland, June 1975.*

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 small, heavily urbanized basins, such as the Sorensen Creek subwatershed, that are characterized by a rapid response of peak flood flows to a major rainfall event.

Elevating the Structure: The third category of floodproofing measures is raising the structure—that is, elevating it—on its present site such that the first floor or other most damage-prone floor is above the design flood stage. Structure raising is supplemented with basic floodproofing measures like those described above to protect the basement and other portions of the elevated structure that remain below the design flood stage.

While basic floodproofing measures like those discussed above are generally considered feasible for most nonresidential structures—such as business, commercial buildings, and schools—even if the design flood stage is above the first floor elevation, such measures are not generally technically feasible or practical for single-family residences when the design flood stage is above the elevation of the first floor. This is the condition for which structure elevation is often the most appropriate floodproofing measure.

The total capital cost of elevating a structure is composed of costs that are directly dependent on and increase with the extent to which the structure is elevated, and fixed costs that are independent of the height to which the structure is raised. Examples of the latter, or fixed, costs include placing beams or other supports beneath the structure, disconnecting utilities, and replacing shrubs, whereas examples of the former, or variable, costs include vertical extensions to the basement walls, and the fill required to raise the yard grade. While the average cost of applying basic floodproofing techniques to a single-family residential structure—that is, floodproofing the structure without elevating it—so as to prevent the entry of floodwaters or to at least maintain utilities and services and protect contents is estimated to be $3,800 in 1980 dollars, the cost of elevating the residential structure—which would probably be required if the design flood stage were above the first floor elevation—is estimated to be $33,000 in 1980 dollars, assuming that the building is raised four feet, and increases by about $3,000 for each additional foot that the structure is raised. While the costs of floodproofing by structure elevation may be expected to greatly exceed the cost of basic floodproofing, the structure elevation alternative may be expected to be considerably less costly than the structure acquisition and removal alternative described below.

Principal 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 focus 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: As discussed above, it is generally technically and economically feasible to apply basic floodproofing measures to well-constructed brick and masonry structures used for commercial or industrial purposes and to floodproof private residences, sometimes by elevating them. There are, however, situations in which structure floodproofing is not technically practicable or economically sound, such as when the structures are dilapidated and do not meet building code standards or when the cost of elevating them would be prohibitively high because of a large difference between the first floor elevation and the design flood stage.

Therefore, floodproofing measures considered in the design of alternative flood damage abatement plans are sometimes supplemented with proposals to remove those structures, usually private residences, having first floor elevations below the 100-year recurrence interval flood stage—the stage used to design floodproofing and removal alternatives. The cost of removing a residential structure from a flood-prone area is computed as the sum of the structure and site acquisition cost, structure demolition or moving cost, site restoration costs, and occupant relocation cost, the last of which is provided to the displaced homeowner or tenant 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 can 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. 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 they are 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 the 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 lost taxes because of the likely compensating effect of several factors, including: the reduced cost of municipal services such as schools, water supply, and sewerage; the reduced cost of flood-related emergency service; and the likelihood that some of the evacuated residents will construct new residences within the civil division on previously undeveloped land, thereby restoring some of the lost tax base.

Channel Maintenance: Channel maintenance consists of the periodic removal of silt, sand, and gravel deposits; heavy vegetation; and the wide variety of debris found in all streams but most commonly in streams flowing through urban areas. Examples of debris commonly found in stream channels are: brush, tree limbs, scrap lumber, oil drums, wooden crates, cardboard boxes, rubble from demolition activities, tires, bicycles, shopping carts, and appliances.

Channel maintenance may be expected to yield three positive results with respect to flooding and related stormwater inundation problems. First, periodic stream channel cleaning and maintenance are important to maintain the integrity of the flood stage profiles developed under the watershed planning program. As noted in Chapter VIII 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. Second, periodic cleaning and maintenance of the stream channels is needed to maintain the channel bottom profile at an elevation below the invert of existing or planned storm sewer and storm water channel 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 or storm water inundation of urban areas and of cropland. Third, 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 in areas of inundation.

While it is important for civil divisions and governmental agencies within the watershed affected by or having jurisdiction over the stream system to carry out channel maintenance, it is important to recognize that such maintenance will have no significant effect on the peak stage of major flood events as calculated and presented in this report. It should be noted, however, that if such maintenance is not performed, the probability of debris accumulating on the upstream side of bridge waterway openings is much greater and thus could result in flood stages higher, as a result of such accumulations, than those calculated and presented in this report. The intensive relationship of peak flood stages to minor channel cleaning and alteration has been quantified and documented in Commission studies of flood problems in the City of West Allis in the Root River watershed,[7] the Village of Elm Grove in the Menomonee River watershed,[8] and the Village of Pewaukee in the Fox River watershed.[9] These studies have all indicated that channel cleaning and maintenance will not, in itself, have any significant effect on reducing peak flood stages.

Flood Insurance: The overriding objective of the National Flood Insurance Program is to encourage the purchase of flood insurance by individual landowners 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.

As of December 31, 1980, all of the communities in the Pike River watershed except the Village of Elmwood Park were participating in the federal Flood Insurance Program. Such participation can provide relief in the event that a serious flood occurs prior to implementation of committed or planned flood control measures. 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 management measures—the 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 floodland areas. The interest of lending institutions in the possible flood-prone status of 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 a 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 federal flood insurance is secured by the owner of the property.

Realtor Policies: As a result of an executive order by former Governor Patrick J. Lucey of Wisconsin on November 26, 1973, real estate brokers, salesmen, or their agents are strongly urged to properly inform potential purchasers of property about 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 and utilities such 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 sew-

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[7] *January 23, 1974 letter report to Milwaukee County Executive and Milwaukee County Board of Supervisors from SEWRPC concerning revaluation of Root River watershed plan as it relates to flood problems in the City of West Allis, p. 17.*

[8] *SEWRPC Planning Report No. 26, A Comprehensive Plan for the Menomonee River Watershed, Volume Two, Alternative Plans and Recommended Plan, Chapter IV, "Alternative Floodland Management Measures," October 1976, pp. 116-117.*

[9] *SEWRPC Community Assistance Planning Report No. 14, A Floodland Management Plan for the Village of Pewaukee, Chapter III, "Alternative Floodland Management Measures and Recommended Floodland Management Plan," September 1977, pp. 100-101.*

erage system development objectives and standards which have been incorporated into the overall development objectives and standards for the Pike 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 Pike 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 facilities and services constructed in nonflood-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 the installation of remote upstream stage sensors and alarms, patrolling of riverine areas to note when bankful conditions are imminent, monitoring of National Weather Service flash flood watch and warning bulletins during periods when rainfall or snowmelt are occurring or are anticipated, broadcasting emergency messages to community residents over radio and television, using police patrol cars or other vehicles equipped with public address systems, utilizing a siren warning system employing a special pattern to indicate that flooding is occurring, preplanning road closures and evacuation of residents, and the mobilization of portable pumping equipment to relieve the surcharge of sanitary sewers.

[10] *William K. Johnson, Physical and Economic Feasibility of Nonstructural Flood Plain Management Measures, U. S. Army Corps of Engineers—Hydrologic Engineering Center and Institute for Water Resources, May 1977.*

HYDROLOGIC-HYDRAULIC CONSEQUENCES OF PLAN YEAR 2000 LAND USE

The purpose of developing and calibrating a water resource simulation model under the Pike River watershed planning program, as described in Chapter VIII of this report, was to provide a tool for quantifying watershed hydrologic, hydraulic, and water quality characteristics under existing and future land use conditions within the watershed. The results of applying the model to the stream system of the Pike River watershed for existing land use with existing channel and floodplain conditions and for plan year 2000 land use with existing channel and floodplain 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 Chapter VIII and in subsequent sections of this chapter.

Procedure

Watershedwide applications of the simulation model were made for the two combinations of land use-channel/floodplain conditions noted above in order to quantify the probable impact of future urban development on flood flows and stages in the Pike River watershed. In 1975, about 28 percent of the total area of the watershed was in urban land use, whereas the year 2000 land use plan for the watershed as described in Chapter XI envisions that about 57 percent of the watershed area will be devoted to urban land use. The hydrologic and hydraulic submodels were applied to each of the two combinations of land use-channel/floodplain conditions according to the procedure described in Chapter VIII. The simulation analyses resulted in corresponding flood flows at 38 selected points on the stream system of the watershed—eight on the Pike River, four on Pike Creek, and 26 on various major tributaries as shown on Map 37 in Chapter VIII. Twenty-four locations were selected for comparison of flood flows under the two land use-channel/floodplain conditions, as shown on Map 45.

Discharge-frequency relationships at selected locations were chosen as an effective means for comparing and contrasting the hydrologic-hydraulic response of the watershed to the two combinations of land use-channel/floodplain conditions, inasmuch as discharge-frequency relationships are concise representations of the watershed or subwatershed flood flow characteristics.

The hydraulic response of the watershed to the two combinations of land use-channel/floodplain conditions was determined by computing and contrasting the 100-year recurrence interval flood stages for each condition. The impact of the two combinations of land use-channel/floodplain conditions was also quantified by computing and comparing the average annual monetary flood risks for selected flood-prone reaches under existing (1975) and plan year 2000 development conditions as presented in subsequent sections of this chapter which discuss alternative floodland management plan elements.

Discussion of the Hydrologic-Hydraulic Response of the Watershed to Plan Year 2000 Land Use

The 10-, 50-, and 100-year recurrence interval discharge-frequency data for the existing and planned land use and existing channel conditions in the watershed are presented in Table 84. The discharge-frequency relationships, shown graphically in Figures 53 through 56, demonstrate and quantify the expected hydrologic-hydraulic impact of land use changes. The following discussion draws on the results of the watershedwide simulation modeling to identify the locations at which significant flood discharge and stage changes may be expected to occur, and to indicate the magnitude and significance of those impacts.

Discharge-Frequency Relationships: Figures 53 through 56, which present discharge-frequency relationships for four watershed locations under each of the two land use-channel/floodplain conditions, are typical of the discharge-frequency relationships that exist or may be expected to exist within the watershed under the two land use development conditions investigated. It may be noted that the two discharge-frequency curves at each location are approximately parallel, with a tendency, however, for the curves to converge as the severity of flood events increases. If the discharge-frequency relationships for any two land use-channel/floodplain conditions at a given location on the stream system were exactly parallel, then a constant ratio of flood flows would exist between the two conditions. A slight convergence of discharge-frequency relationships for increasing recurrence intervals indicates that the ratio of flood flows for the two conditions decreases slightly for more infrequent flood events. Therefore, the relative impact of land use tends to be somewhat less for the more severe flood events—as indicated by a slight decrease in ratios of flood flows shown in Table 84. This is to be expected because the volume and intensity of rainfall and rainfall-snowmelt which is associated with the more severe flood events saturate the pervious portions of the watershed, causing those areas to behave in a manner similar to impervious areas.

SELECTION OF FLOOD-PRONE REACHES

Development of the floodland management element of the comprehensive plan for the Pike River watershed requires that the existing and probable future flood-prone reaches within the watershed be identified, and alternative floodland management measures developed and evaluated for those reaches which have or may be expected to have severe flood problems. A two-step approach was used to determine the stream reaches for which alternative floodland management measures were to be developed. The first step involved the hydrologic-hydraulic simulation of flood flows and stages under existing land use and existing channel and floodplain conditions to identify existing flood-prone reaches and areas. The results of this step were checked against the findings of the historic flood damage survey conducted under the watershed study. The second step involved the hydrologic-hydraulic simulation of flood flows and stages under plan year 2000 land use and existing channel and floodplain conditions, including in the latter, however, any locally committed flood control measures to identify those areas in the watershed which may be expected to be flood damage prone under the plan year 2000 land use conditions without implementation of any further floodland management measures. The results of this two step approach to the identification of the flood-prone areas of the watershed, and the subsequent design and evaluation of alternative flood damage abatement measures are described in the following sections of this chapter on a reach-by-reach basis.

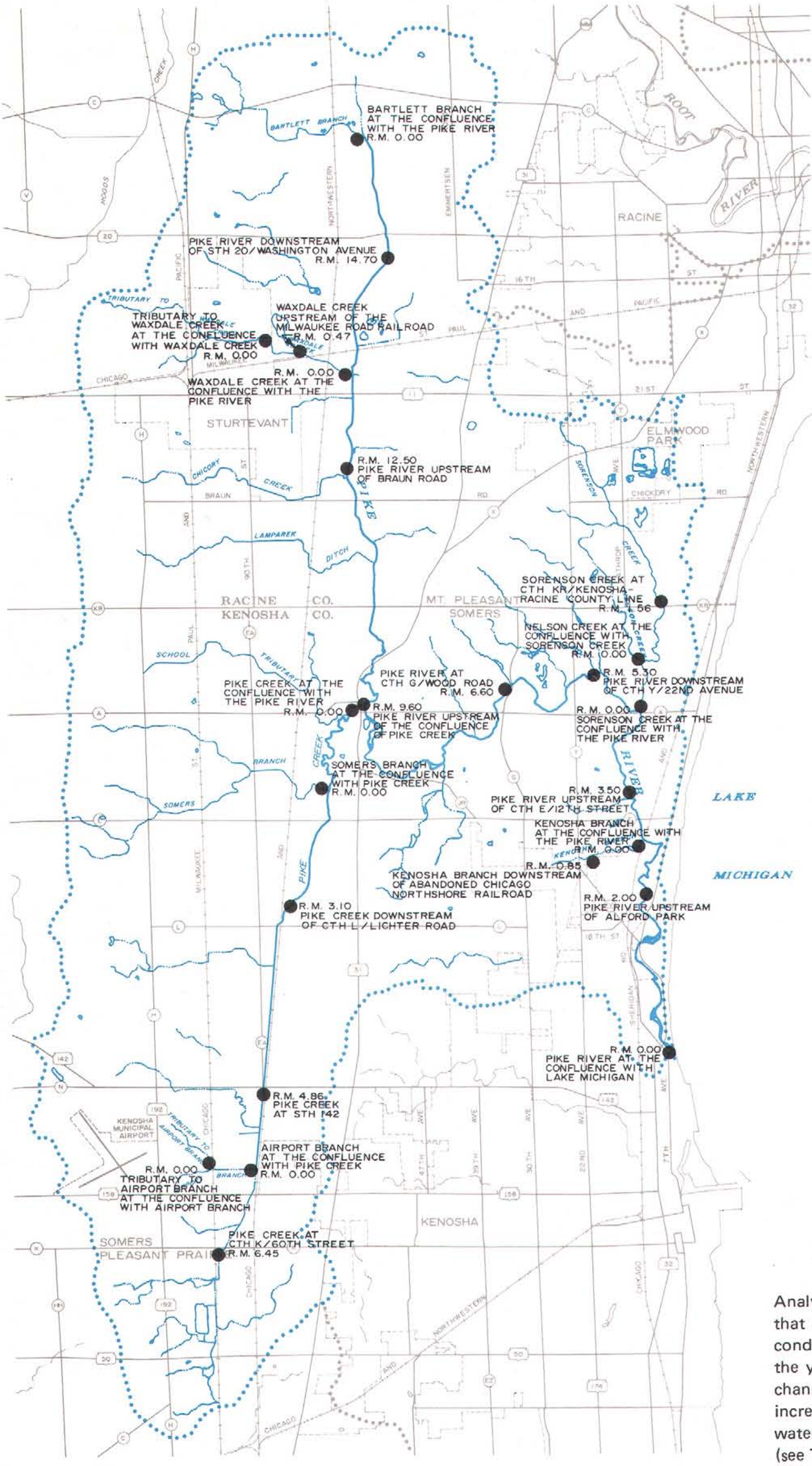
ALTERNATIVE FLOODLAND MANAGEMENT PLAN ELEMENTS FOR BARTLETT BRANCH

The Flood Problem

The hydrologic-hydraulic simulation of Bartlett Branch under existing land use and existing channel and floodplain conditions indicated that for the reach beginning 0.24 mile upstream from the confluence with the Pike River and extending upstream about 1.2 miles to CTH C, there exists the potential for significant flood damage to homes and minor flood damage to crops, with most of the flood damage to homes occurring upstream of Spring Street. Average annual monetary flood

Map 45

EFFECTS OF CHANGING LAND USE ON 100-YEAR FLOOD FLOWS IN THE PIKE RIVER WATERSHED



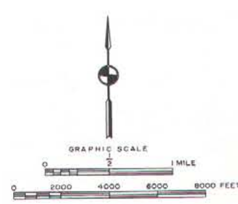
LEGEND

● LOCATION SELECTED FOR COMPARISON OF FLOOD FLOWS UNDER EXISTING AND YEAR 2000 PLANNED LAND USE CONDITIONS

LAND USE CONDITIONS

1 EXISTING 1975

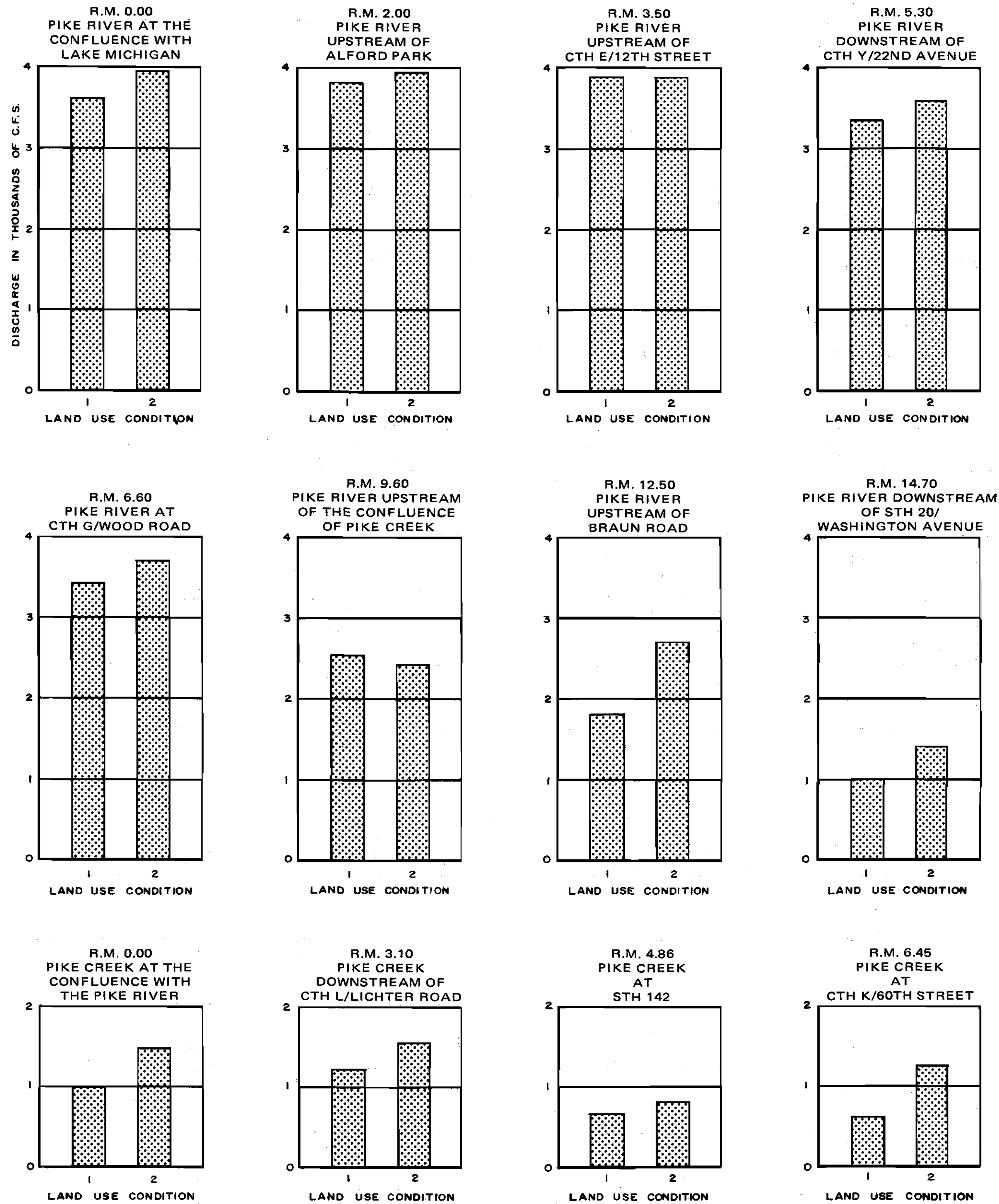
2 PLANNED YEAR 2000



Analysis conducted under the watershed study indicates that relative to existing and year 2000 planned land use conditions, 100-year flood flows in the watershed under the year 2000 planned land use conditions and existing channel and floodplain condition may be expected to increase by up to 90 percent at 26 locations in the watershed, with an average increase of about 30 percent (see Table 84).

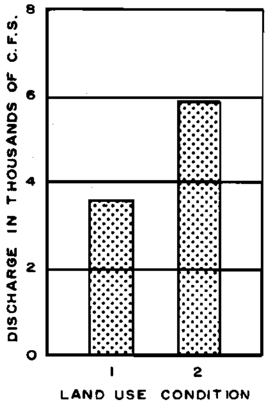
Source: SEWRPC.

Map 45 (continued)

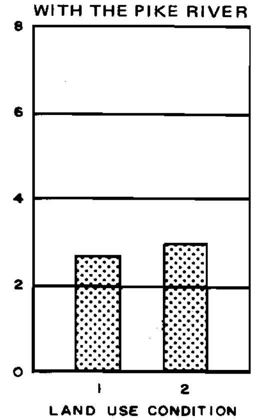


Map 45 (continued)

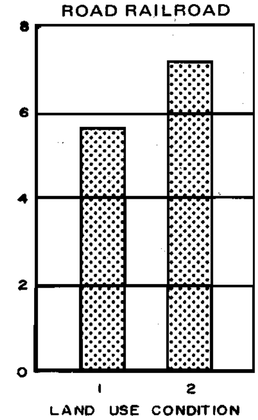
R.M. 0.00
BARTLETT BRANCH
AT THE CONFLUENCE
WITH THE PIKE RIVER



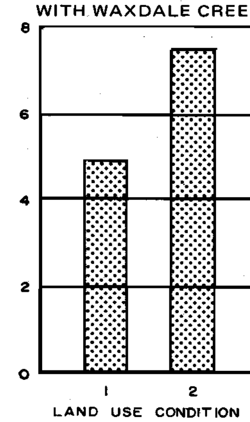
R.M. 0.00
WAXDALE CREEK AT
THE CONFLUENCE
WITH THE PIKE RIVER



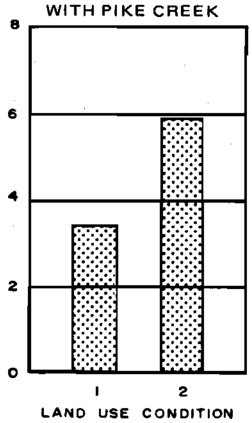
R.M. 0.47
WAXDALE CREEK UPSTREAM
OF THE MILWAUKEE
ROAD RAILROAD



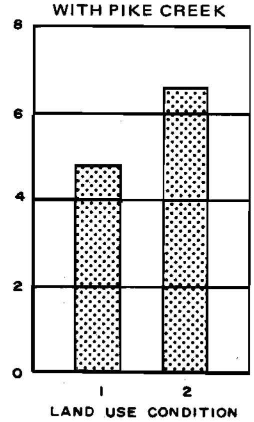
R.M. 0.00
TRIBUTARY TO WAXDALE CREEK
AT THE CONFLUENCE
WITH WAXDALE CREEK



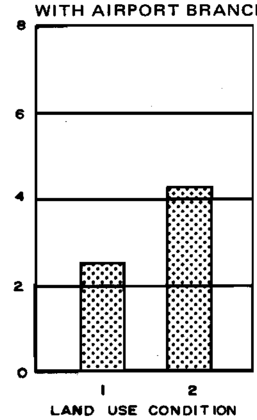
R.M. 0.00
SOMERS BRANCH
AT THE CONFLUENCE
WITH PIKE CREEK



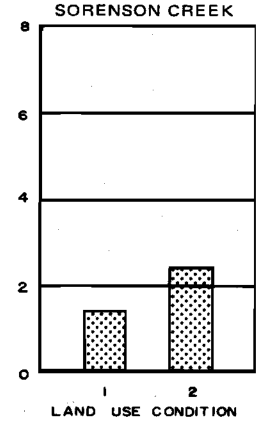
R.M. 0.00
AIRPORT BRANCH
AT THE CONFLUENCE
WITH PIKE CREEK



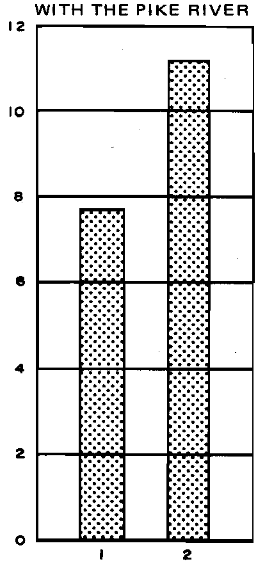
R.M. 0.00
TRIBUTARY TO AIRPORT
BRANCH AT THE CONFLUENCE
WITH AIRPORT BRANCH



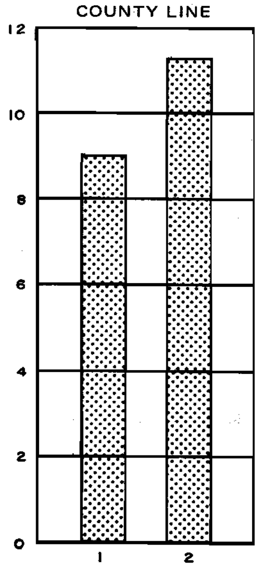
R.M. 0.00
NELSON CREEK AT THE
CONFLUENCE WITH
SORENSON CREEK



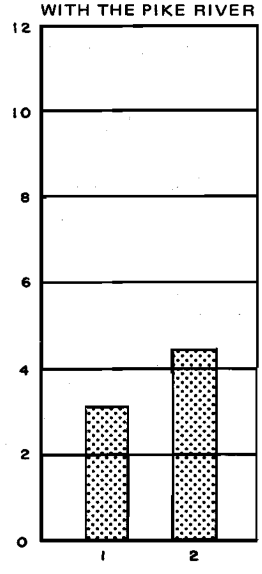
R.M. 0.00
SORENSON CREEK AT
THE CONFLUENCE
WITH THE PIKE RIVER



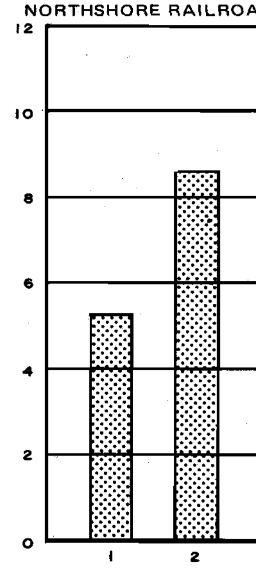
R. M. 1.56
SORENSON CREEK AT
CTH KR/KENOSHA-RACINE
COUNTY LINE



R.M. 0.00
KENOSHA BRANCH
AT THE CONFLUENCE
WITH THE PIKE RIVER



R.M. 0.85
KENOSHA BRANCH DOWNSTREAM
OF ABANDONED CHICAGO
NORTHSHORE RAILROAD



damages attributable to primary and secondary structural flooding and flooding of crops were estimated, by application of the economic submodel described in Chapter VIII, at $800 under existing conditions, and $26,300 under plan year 2000 land use and existing channel conditions assuming that no new flood-prone structures would be constructed in the subwatershed. The increase in damages would be caused solely by increases in flood flows and stages caused by the conversion of land from rural to urban use in the tributary drainage area. If additional flood-prone development were permitted, even higher monetary damages could be expected to be incurred. Under existing conditions, flood damages of about $27,000 may be expected to be incurred during a 100-year recurrence interval flood event; however, no damages should be incurred from a flood event having a recurrence interval of 25 years or less. Under plan year 2000 land use and existing channel conditions, flood damages of about $50,000 and $481,200 may be expected to be incurred, respectively, during the 10- and 100-year flood events.

As noted above, only minor flood damage to crops is expected to be incurred along Bartlett Branch, amounting to about $700 on an average annual basis under plan year 2000 land use conditions, and less than $200 under existing conditions. Analyses of alternative flood control measures such as dikes, detention ponds, or major channelization for other stream reaches as described elsewhere herein indicated that the cost of any technically feasible flood control measures which would alleviate these minor crop damages would greatly exceed the benefits received. Accordingly, the alternative flood control measures were designed to abate urban damages only.

Structure Floodproofing and Elevation Alternative

A structure floodproofing, elevation, and removal alternative flood control plan was prepared and evaluated to determine if such a structure-by-structure approach would be a technically feasible and economically sound solution to the urban flood damage problems along Bartlett Branch. For analytical purposes, the 100-year recurrence interval flood stage under plan year 2000 land use and existing channel and floodplain conditions was used to estimate the number of existing floodprone structures to be floodproofed, elevated, or removed and the approximate costs involved.

In the case of residential structures in the primary flood hazard area, floodproofing was assumed to be feasible if the design flood stage was below the first floor elevation. Structure elevation was considered feasible for residential structures with basements if the estimated cost of elevating the structure was less than the estimated structure removal cost. Structures to be elevated were assumed to have the first floor raised to an elevation two feet higher than the 100-year recurrence interval flood stage to provide adequate freeboard. For aesthetic reasons, structure elevation was limited to a maximum of four feet. Structures which would have to be elevated more than four feet were considered for removal.

Floodproofing was assumed to be feasible for all nonresidential structures within the primary flood hazard area provided the flood stage was not more than seven feet above the first floor elevation. The floodproofing costs were assumed to be a function of the depth of water over the first floor. With respect to structures located in the secondary flood hazard area, that is, outside of but immediately adjacent to the 100-year recurrence interval flood hazard area, and where the analyses indicated the 100-year recurrence interval flood stage could be expected to occur for a sufficient duration to create the potential for such secondary flooding, it was assumed that floodproofing would be applied to all structures with basement floors below the elevation of the design flood stage.

As shown on Map 46, the analysis indicated that 41 structures may be expected to be located in the primary flood hazard area, and nine may be expected to be located in the secondary flood hazard area along Bartlett Branch. Of the 41 structures located in the primary flood hazard area, 13 would have to be elevated, 28 would have to be floodproofed, and none would have to be removed under this alternative. All nine structures in the secondary flood hazard area would have to be floodproofed. Future flood damage to the existing private residences along this reach would be virtually eliminated by these floodproofing and elevation measures. Table 85 sets forth the number and type of structures to be floodproofed and elevated and also summarizes the estimated costs and benefits.

Assuming that these structure floodproofing measures would be fully implemented, and utilizing an annual interest rate of 6 percent[11] and a pro-

[11] *This interest rate is discussed on page 31 of Chapter X.*

Table 84

HYDROLOGIC EFFECT OF CHANGING LAND USE IN THE PIKE RIVER WATERSHED

Location			Recurrence Interval (years)	Discharge (cubic feet per second)		Ratio of Year 2000 Planned Land Use Flow to Existing Land Use Flow
Stream	River Mile	Description		Existing (1975) Land Use	Plan Year 2000 Land Use	
Pike River	0.00	Confluence with Lake Michigan	10 50 100	1,920 3,060 3,720	2,500 3,500 3,950	1.1 1.1 1.1
	2.00	Upstream of Alford Park	10 50 100	1,880 3,060 3,820	2,500 3,490 3,930	1.4 1.0 1.0
	3.50	Upstream of CTH E/12th Street	10 50 100	1,920 3,200 3,880	2,510 3,450 3,870	1.3 1.1 1.0
	5.30	Downstream of CTH Y/22nd Avenue	10 50 100	1,660 2,830 3,400	2,280 3,260 3,660	1.4 1.2 1.1
	6.60	At CTH G/Wood Road	10 50 100	1,600 2,780 3,420	2,270 3,250 3,700	1.4 1.2 1.1
	9.60	Upstream of Confluence of Pike Creek	10 50 100	1,150 2,050 2,550	1,560 2,160 2,430	1.4 1.1 1.0
	12.50	Upstream of Braun Road	10 50 100	760 1,550 1,800	1,500 2,410 2,680	2.0 1.6 1.5
	14.70	Downstream of STH 20/Washington Avenue	10 50 100	320 830 980	780 1,250 1,390	2.4 1.5 1.4
Pike Creek	0.00	Confluence with Pike River	10 50 100	600 1,000 1,150	880 1,340 1,650	1.5 1.3 1.4
	3.10	Downstream of CTH L/Lichter Road	10 50 100	600 1,040 1,250	880 1,290 1,530	1.4 1.2 1.2
	4.86	At STH 142	10 50 100	360 600 740	780 1,220 1,400	2.2 2.0 1.9
	6.45	At CTH K/60th Street	10 50 100	250 510 610	390 700 810	1.6 1.4 1.3
Bartlett Branch	0.00	Confluence with Pike River	10 50 100	200 310 360	300 520 590	1.5 1.7 1.6
Waxdale Creek	0.00	Confluence with Pike River	10 50 100	130 230 250	170 250 280	1.3 1.1 1.1
	0.47	Upstream of the Milwaukee Road Railroad	10 50 100	270 510 570	400 650 720	1.5 1.3 1.3

Table 84 (continued)

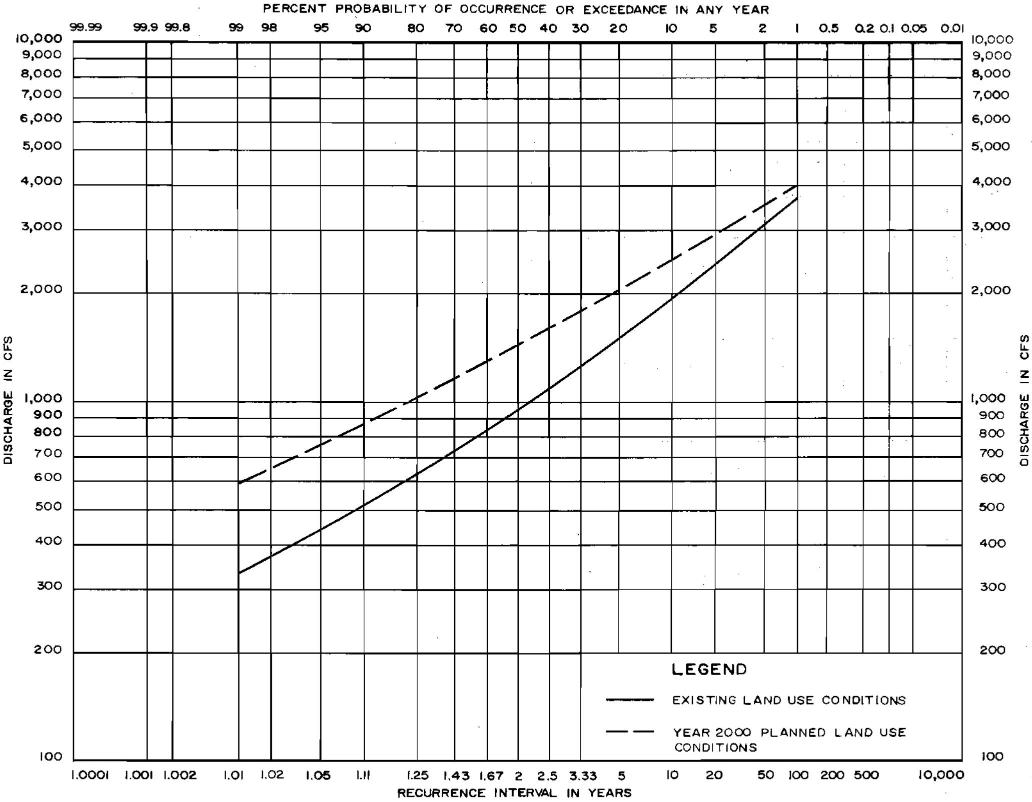
Location			Recurrence Interval (years)	Discharge (cubic feet per second)		Ratio of Year 2000 Planned Land Use Flow to Existing Land Use Flow
Stream	River Mile	Description		Existing (1975) Land Use	Plan Year 2000 Land Use	
Tributary to Waxdale Creek	0.00	Confluence with Waxdale Creek	10	230	370	1.6
			50	430	650	1.5
			100	490	750	1.5
Chicory Creek	0.00	Confluence with Pike River	10	30	--[a]	1.0
			50	90	--[a]	1.0
			100	140	--[a]	1.0
Lamparek Ditch	0.00	Confluence with Pike River	10	30	--[a]	1.0
			50	150	--[a]	1.0
			100	220	--[a]	1.0
Somers Branch	0.00	Confluence with Pike Creek	10	100	110	1.1
			50	180	260	1.4
			100	220	320	1.5
Airport Branch	0.00	Confluence with Pike Creek	10	190	330	1.7
			50	320	420	1.3
			100	360	440	1.2
Tributary to Airport Branch	0.00	Confluence with Airport Branch	10	110	240	2.2
			50	210	360	1.7
			100	250	410	1.6
Nelson Creek	0.00	Confluence with Sorenson Creek	10	70	120	1.7
			50	120	210	1.7
			100	140	240	1.7
Sorenson Creek	0.00	Confluence with Pike River	10	360	630	1.7
			50	740	1,010	1.4
			100	860	1,080	1.3
	1.56	At CTH KR/Kenosha-Racine County Line	10	400	720	1.8
			50	790	1,150	1.5
			100	940	1,240	1.3
Kenosha Branch	0.00	Confluence with Pike River	10	250	490	2.0
			50	460	790	1.7
			100	530	870	1.6
	0.85	Downstream of Abandoned North Shore Railroad	10	240	480	2.0
			50	450	780	1.7
			100	530	860	1.6
		Maximum ratio of 10-year discharges				3.0
		Minimum ratio of 10-year discharges				1.0
		Median ratio of 10-year discharges				1.6
		Maximum ratio of 100-year discharges				1.9
		Minimum ratio of 100-year discharges				1.0
		Median ratio of 100-year discharges				1.4

[a]*No change in land use.*

Source: SEWRPC.

Figure 53

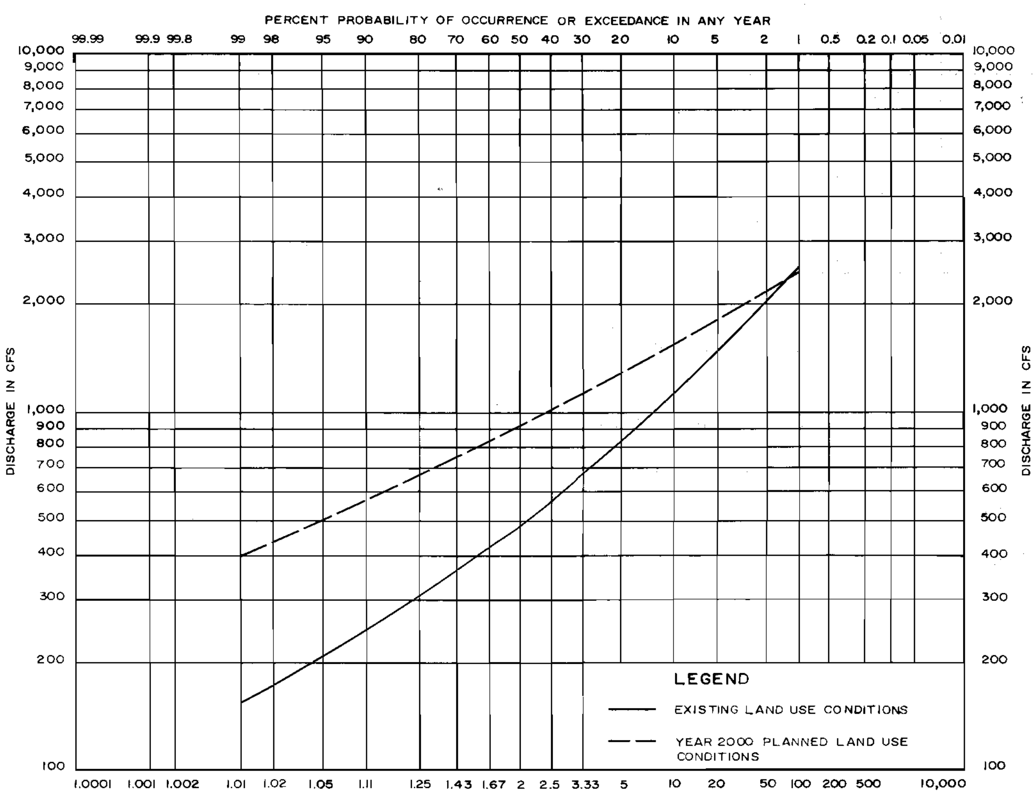
SIMULATED DISCHARGE-FREQUENCY RELATIONSHIPS FOR THE PIKE RIVER AT THE CONFLUENCE WITH LAKE MICHIGAN UNDER EXISTING AND PLAN YEAR 2000 LAND USE CONDITIONS



Source: SEWRPC.

Figure 54

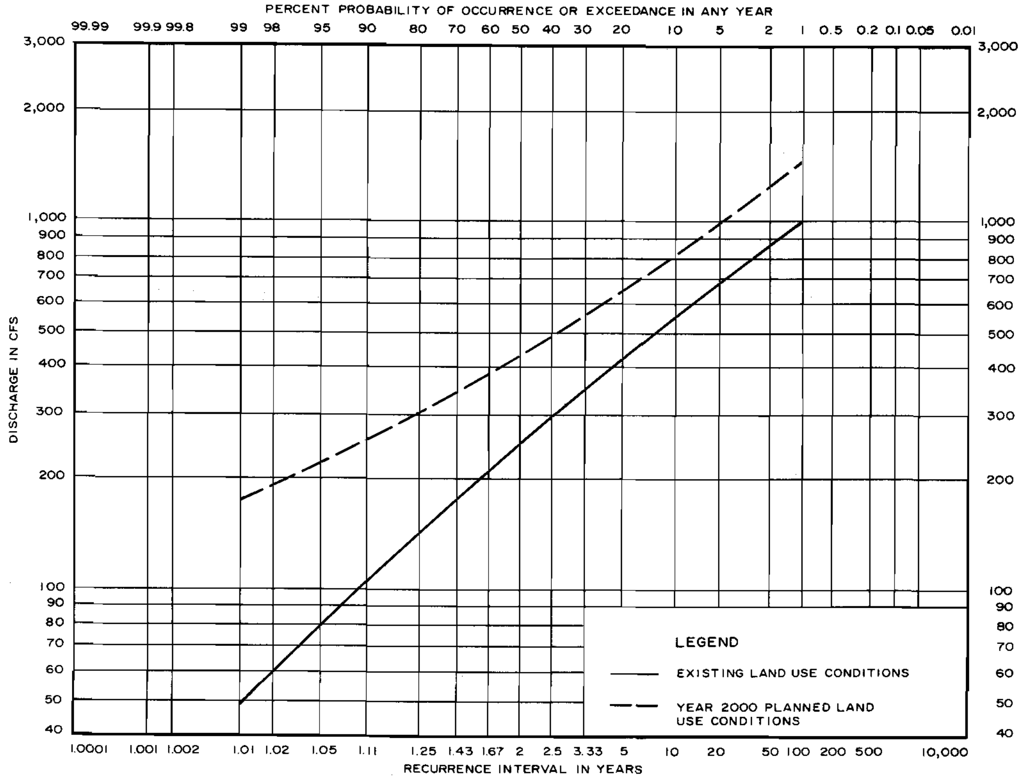
SIMULATED DISCHARGE-FREQUENCY RELATIONSHIPS FOR THE PIKE RIVER UPSTREAM OF THE CONFLUENCE OF PIKE CREEK UNDER EXISTING AND PLAN YEAR 2000 LAND USE CONDITIONS



Source: SEWRPC.

Figure 55

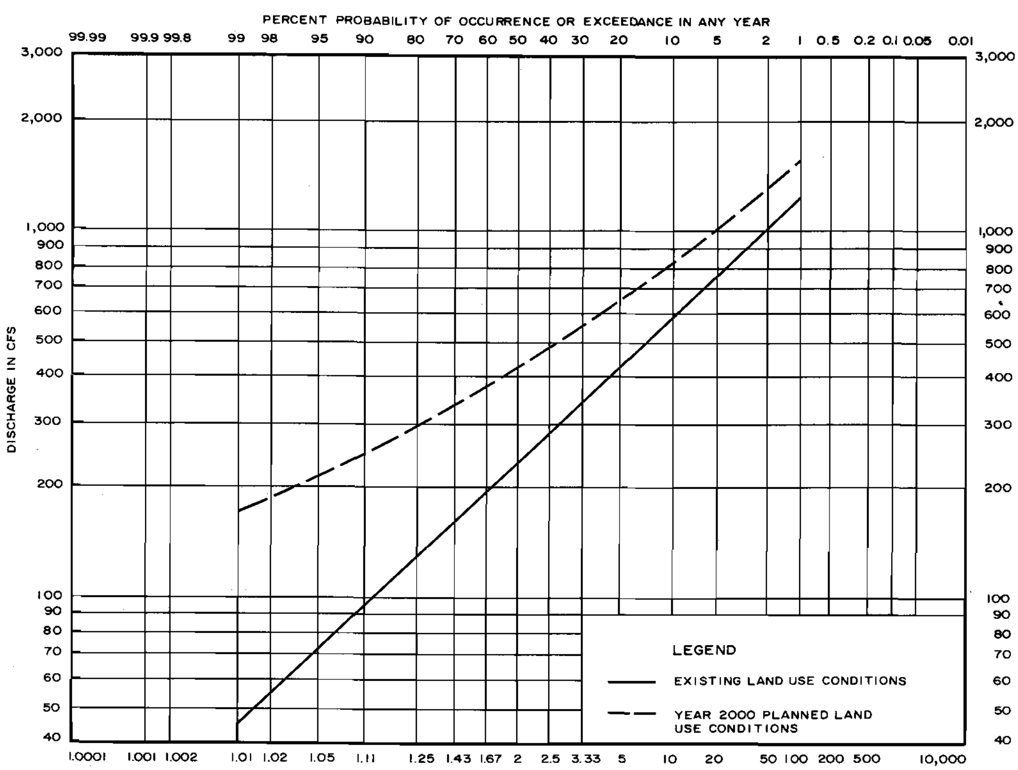
SIMULATED DISCHARGE-FREQUENCY RELATIONSIP FOR PIKE CREEK AT THE CONFLUENCE WITH THE PIKE RIVER UNDER EXISTING AND PLAN YEAR 2000 LAND USE CONDITIONS



Source: SEWRPC.

Figure 56

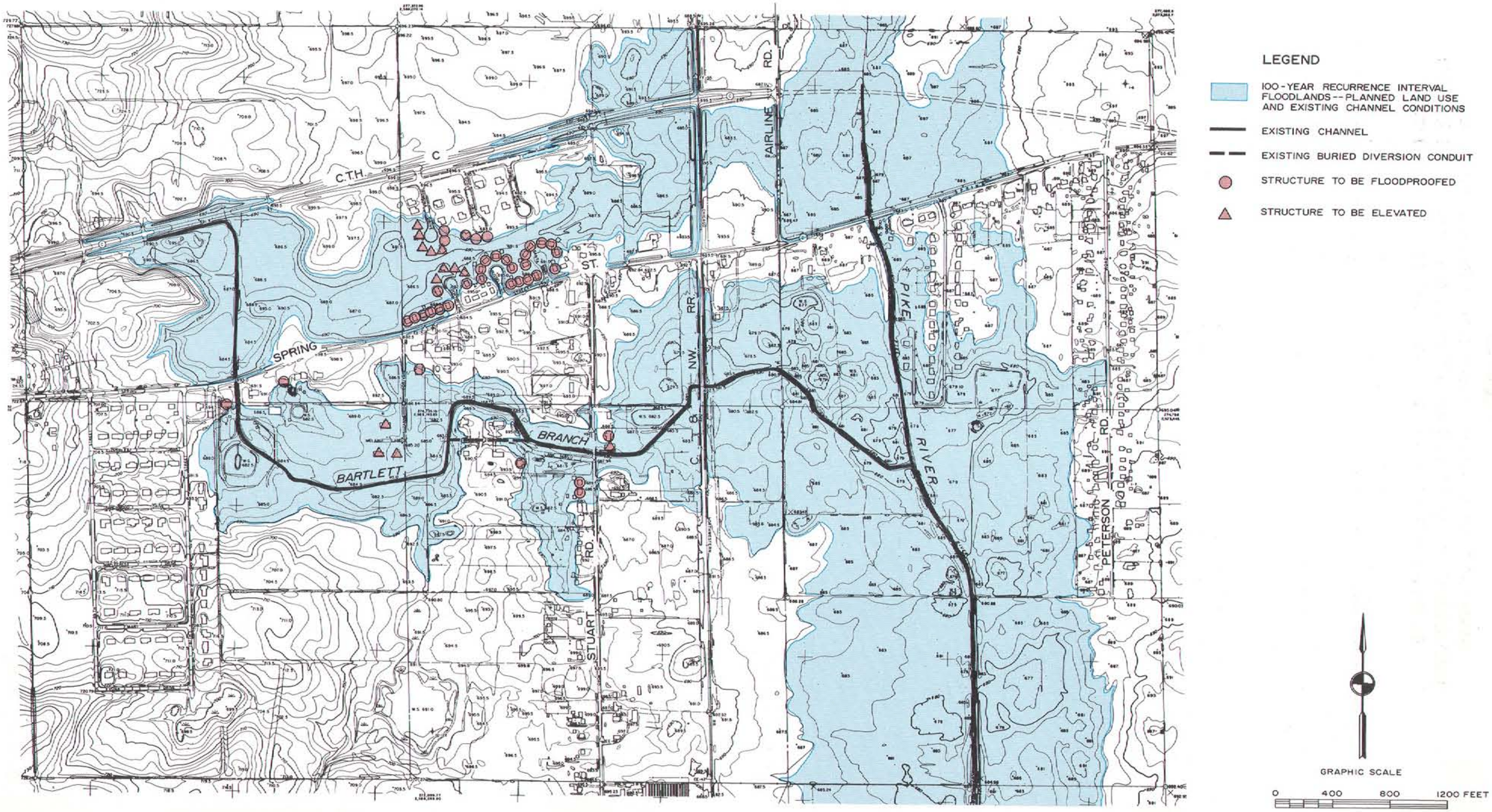
SIMULATED DISCHARGE-FREQUENCY RELATIONSHIPS FOR PIKE CREEK DOWNSTREAM OF CTH L/LITCHER ROAD UNDER EXISTING AND PLAN YEAR 2000 LAND USE CONDITIONS



Source: SEWRPC.

Map 46

STRUCTURE FLOODPROOFING AND ELEVATION ALTERNATIVE FOR BARTLETT BRANCH



A structure floodproofing and elevation alternative flood control plan was prepared and evaluated to determine if such a measure would provide a technically feasible and economically sound solution to the urban flood damage problem along Bartlett Branch. Under this alternative, 37 structures would have to be floodproofed and 13 structures would have to be elevated. While technically feasible, this alternative was found to be economically unsound.

Source: SEWRPC.

Table 85

PRINCIPAL FEATURES, COSTS, AND BENEFITS OF FLOODLAND MANAGEMENT ALTERNATIVES FOR BARTLETT BRANCH

Alternative			Economic Analysis[a]											Nontechnical and Noneconomic Considerations	
Number	Name	Description	Technically Feasible	Capital Cost Item	Capital Cost (thousands)	Annual Amortized Capital Cost (thousands)	Annual Operation and Maintenance Cost (thousands)	Total Annual Cost (thousands)	Annual Benefits (thousands)	Excess of Annual Benefits Over Cost (thousands)	Benefit-Cost Ratio	Benefit-Cost Ratio Greater Than 1.0		Positive	Negative
1	No action	--	Yes	--	$ --	$ --	$ --	$ 25.6[b]	$ --	$ --	--	No		--	--
2	Structure floodproofing and elevation	a. Floodproof up to 37 residential structures b. Elevate 13 residential structures	Yes	Floodproofing Elevating Subtotal	161.0 259.0 420.0	22.5	--	27.5	25.6	- 1.9	0.93	No		Immediate partial flood relief at discretion of property owners Most of the costs would be borne by beneficiaries	Complete, voluntary implementation unlikely and therefore left with a significant residual flood problem Some floodproofing is likely to be applied without adequate professional advice and, as a result, structure damage may occur
3	Dike-structure floodproofing and elevation composite	a. 900 feet of earthen dike b. Drainage culvert c. Floodproof seven residential structures d. Elevate four residential structures	Yes	Dike Culvert and backwater gate Floodproofing Elevating Subtotal	57.3 0.5 26.6 88.9 173.3	11.0	0.5	11.5	25.6	14.1	2.49	Yes		See structure floodproofing and elevation above	Aesthetic impact of visual barrier See structure floodproofing and elevation above
4	Culvert replacement-channel enlargement composite	a. Replace four stream crossings b. 1.08 miles of channel enlargement[c]	Yes	Bridges Channel Subtotal	1,380.0 210 1,590.0	100.0	1.0	101.0	25.6	- 74.5	0.25	No		--	--
5	Detention storage	Detention storage reservoir upstream of CTH C	No	--[d]	--[d]	--[d]	--[d]	--[d]	--[d]	--[d]	--[d]	--[d]		Potential to retain public open space	--[e]
6	Onsite detention storage, and structure floodproofing and elevation composite[e]	a. Floodproof two residential structures b. Elevate one residential structure c. Provide onsite detention storage facilities	Yes	Floodproofing Elevating Onsite detention storage facilities Subtotal	7.6 20.8 280.8 309.2	19.6	6.2	25.8	25.6	- 0.2	0.99[c]	No		See Alternative 2 above	--
7	Onsite detention storage and bridge modification composite[e]	a. Culvert addition at Stuart Road b. Provide onsite detention storage facilities	Yes	Culvert Onsite detention storage facilities Subtotal	32.4 280.8 313.2	19.7	6.2	25.9	25.6	- 0.3	0.99[h]	No		Potential to retain public open space	--

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

[b]*The total annual cost for this alternative consists of the average annual monetary flood damages.*

[c]*The cost of the enlarged channel is based on a bottom width of 20 feet, a top width of 100 feet and an average depth of 11 feet, with side slopes of three horizontal to one vertical.*

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

Source: SEWRPC.

[e]*The economic analyses included costs for onsite storage. It should not be concluded that onsite storage is uneconomical based upon these data, since the use of onsite storage may permit the size and length of local storm water drainage facilities to be reduced with attendant cost reductions. The viability of onsite storage in this respect should be evaluated on a site specific basis.*

[f]*Excluding the cost for onsite sotrage and the benefits attendant thereto, the ratio of total average annual benefits to public costs is 0.49.*

[g]*Excluding the cost for onsite storage and the benefits attendant thereto, the ratio of total average annual benefits to public costs is 0.55.*

[h]*Excluding the cost for onsite storage and the benefits attendant thereto, the ratio of total average annual benefits to public costs is 0.88.*

ject life and amortization period of 50 years, the average annual cost is estimated at $27,500, consisting entirely of the amortization of the $420,000 capital cost—$161,000 for floodproofing and $259,000 for structure elevation. The average annual flood damage abatement benefit was estimated at $25,600 per year, yielding a benefit-cost ratio of 0.93. Therefore, the structure floodproofing and elevation alternative plan as described herein, while technically feasible, was not found to be economically sound.

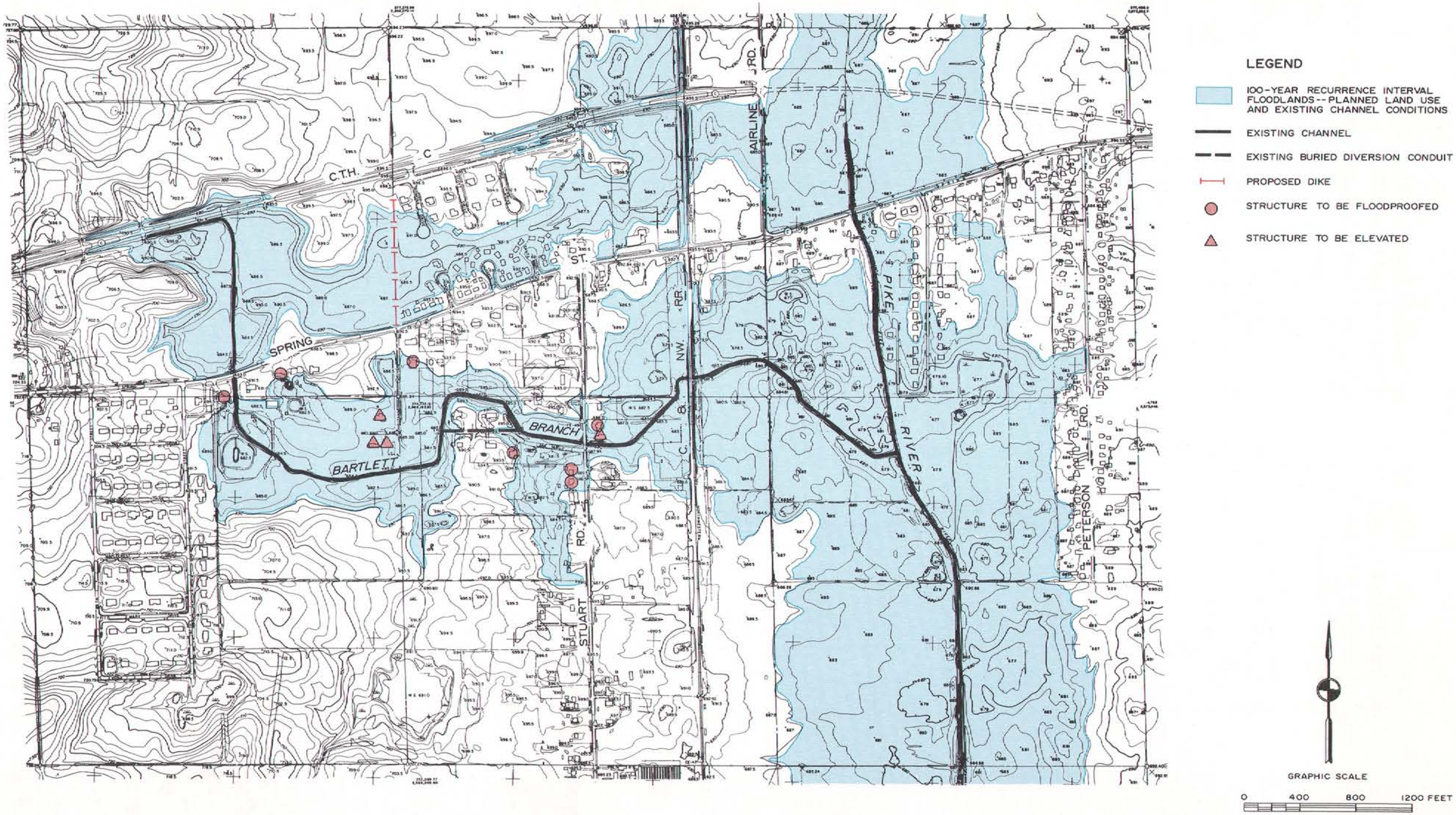
Combination Dike and Structure Floodproofing and Elevation Alternative

A combination dike and structure floodproofing, elevation, and removal alternative flood control plan was also prepared and evaluated in order to determine if such a combination measure would provide a technically feasible and economically sound solution to the urban flood damage problems along Bartlett Branch. The 100-year recurrence interval flood discharge under plan year 2000 land use and existing channel conditions was used as the basis for the design of this alternative.

The dike and structure floodproofing and elevation alternative flood control plan for Bartlett Branch, is shown on Map 47 and the costs and benefits attendant to this alternative are set forth in Table 85. The assumed dike design is shown in Figure 52. Under this alternative, a total of about 900 feet of earthen dike with an average height of

Map 47

COMBINATION DIKE AND STRUCTURE FLOODPROOFING AND ELEVATION ALTERNATIVE FOR BARTLETT BRANCH



A combination dike and structure floodproofing and elevation alternative flood control plan was prepared and evaluated to determine if such a measure would provide a technically feasible and economically sound solution to the urban flood damage problem along Bartlett Branch. Under this alternative, about 900 feet of earthen dike would be constructed about 1,100 feet east of, and approximately parallel to, Bartlett Branch between CTH C and Spring Street. In addition, seven structures would have to be floodproofed and four structures would have to be elevated. This alternative was found to be both technically feasible and economically sound.

Source: SEWRPC.

about five feet and a maximum height of about nine feet, would be constructed about 1,100 feet east of, and approximately parallel to, Bartlett Branch between CTH C and Spring Street, thus eliminating the potential flooding of the existing structures located upstream of Spring Street. In addition, this alternative would have to include provisions for the construction of a drainage system consisting of a 12-inch diameter corrugated metal pipe culvert through the dike, the culvert being equipped with a backwater gate to prevent the accumulation of lateral runoff behind the dike, the backup of flood waters through the culvert, and the attendant creation of local drainge problems. Under this alternative, structure floodproofing and elevation would also be required downstream of Spring Street.

As shown on Map 47, the analysis indicated that a total of seven residential structures may be expected to be located in the primary flood hazard area along this reach of Bartlett Branch and four residential structures may be expected to be located in the secondary flood hazard area. Of the seven structures located in the primary flood hazard area, four structures would have to be elevated, three structures would have to be floodproofed, and none would have to be removed under this alternative. The four structures located in the secondary flood hazard area would have to be floodproofed. Future flood damage to residential structures along this reach would be virtually eliminated by these floodproofing and elevation measures. Table 85 sets forth the number and type of structures to be floodproofed and elevated and also summarizes the estimated costs and benefits.

Assuming that the dike project and structure floodproofing and elevation 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 average annual cost is estimated at about $11,500, consisting of the amortization of the $173,300 capital cost—$26,600 for floodproofing, $88,900 for structure elevation, and $57,800 for the dike and appurtenant culvert—and $500 per year for operation and maintenance of the dike. The average annual flood damage abatement benefit is estimated at $25,600, resulting in an excess of $14,100 in annual benefits over costs and a benefit-cost ratio of 2.23. Therefore, the combination dike and structure floodproofing and elevation alternative plan, as described herein, was found to be both technically feasible and economically sound along Bartlett Branch.

The cost of this alternative plan was also computed utilizing an annual interest rate of 10 percent to determine the effect on the economic viability of this project. Assuming this interest rate, the average annual cost was estimated at about $17,800, resulting in an excess of $7,800 in annual benefits over costs, and a benefit-cost ratio of 1.44. Therefore, the combination dike and structure floodproofing and elevation alternative was found to also be economically sound using a 10 percent annual interest rate.

Culvert Replacement and Channel Enlargement Alternative

An alternative flood control plan consisting of culvert replacement and channel enlargement was prepared and evaluated for Bartlett Branch upstream of the Chicago & North Western Transportation Company crossing. Under this alternative, the Chicago & North Western Transportation Company, Stuart Road, Clinton Lane extended, and Spring Street crossings would be replaced with clear span bridges, and the existing channel from the railroad crossing upstream to CTH C, a distance of about 1.1 miles, would be enlarged, as shown on Map 48. The physical characteristics and estimated costs of this alternative flood control plan element are set forth in Table 85.

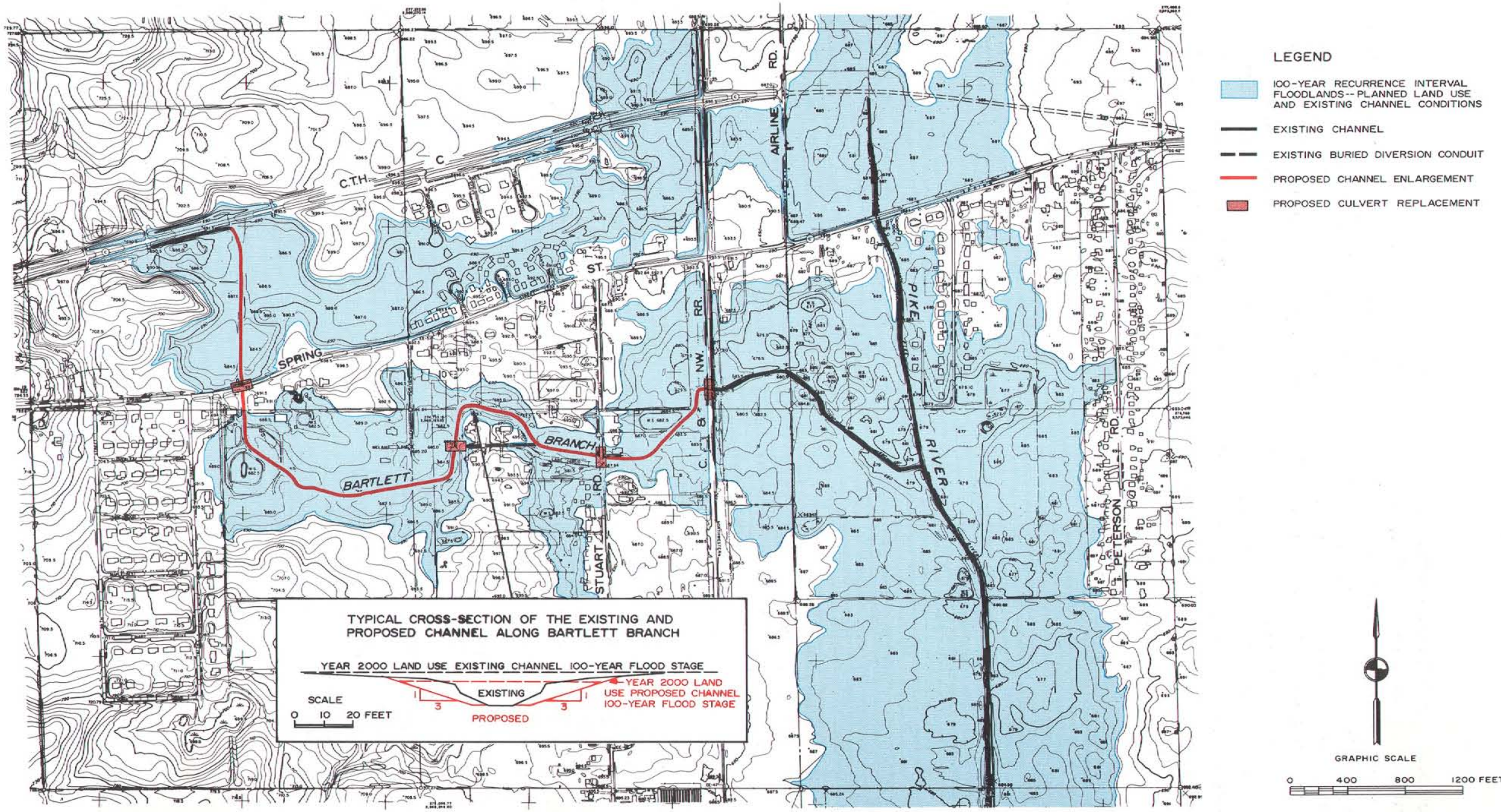
Assuming that the culvert replacement and channel enlargement alternative would be fully implemented, and utilizing an annual interest rate of 6 percent and a project life and amortization period of 50 years, the average annual cost is estimated at $101,000, consisting of amortization of the $1,590,000 capital cost of the bridge replacement and channelization, and $800 in annual operation and maintenance costs for the channelized reach. The average annual flood abatement benefit was estimated at about $25,600, yielding a benefit-cost ratio of 0.25. Therefore, the culvert replacement and channel enlargement alternative, as described herein, while technically feasible was not found to be economically sound.

Combination Onsite Storage, and Structure Floodproofing and Elevation Alternative

A combination onsite storage, and structure floodproofing, elevation, and removal alternative flood control plan, as shown on Map 49, was prepared and evaluated for Bartlett Branch. This alternative assumes the continued application of the Town of Mt. Pleasant policy requiring that onsite storm water detention facilities be provided as land is converted from rural to urban use to prevent

Map 48

CULVERT REPLACEMENT AND CHANNEL ENLARGEMENT ALTERNATIVE FOR BARTLETT BRANCH

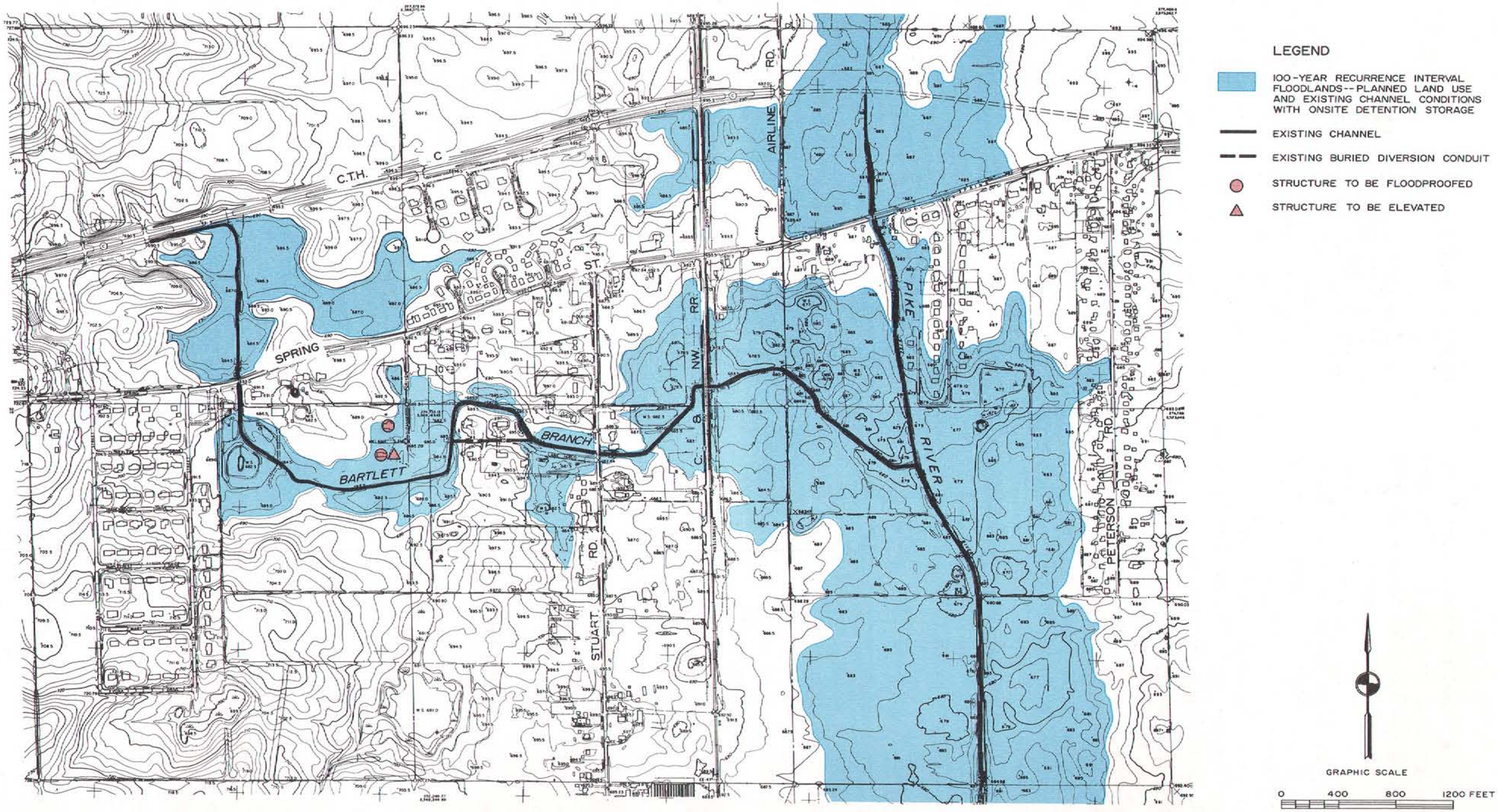


A culvert replacement and channel enlargement alternative flood control plan was prepared and evaluated to determine if such a measure would provide a technically feasible and economically sound solution to the urban flood damage problem along Bartlett Branch. Under this alternative, four crossings of Bartlett Branch would be replaced with clear span bridges, and about 1.1 miles of existing channel would be enlarged. While technically feasible, this alternative was found to be economically unsound.

Source: SEWRPC.

Map 49

COMBINATION ONSITE STORAGE AND STRUCTURE FLOODPROOFING AND ELEVATION ALTERNATIVE FOR BARTLETT BRANCH



A combination onsite storage and structure floodproofing and elevation alternative flood control plan was prepared and evaluated to determine if such a measure would provide a technically feasible and economically sound solution to the urban flood damage problem along Bartlett Branch. Under this alternative, onsite detention storage facilities would be provided by developers as land is converted from rural to urban uses. In addition, two structures would have to be floodproofed and one structure would have to be elevated. While technically feasible, this alternative was found to be economically unsound.

Source: SEWRPC.

any increase in peak flood discharges and corresponding stages resulting from such urbanization up to and including the 100-year recurrence interval event.

The analysis, as set forth in Table 85, indicated that three structures may be expected to be located in the primary flood hazard area, and no structures may be expected to be located in the secondary flood hazard area. Of the three structures located in the primary flood hazard area, one structure would have to be elevated, and two structures would have to be floodproofed. None of the structures would have to be removed under this alternative. Future flood damage to private residences and commercial structures along this reach would be virtually eliminated by these floodproofing measures and the assumed onsite storage. Table 85 sets forth the number and type of structures to be floodproofed and elevated and also summarizes the estimated costs and benefits.

Assuming that the onsite storage and 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 average annual cost is estimated at about $25,800, consisting of the amortization of the $309,200 capital cost—$280,800 for onsite detention storage, $7,600 for floodproofing, and $20,800 for structure elevation—and $6,200 in annual operation and maintenance cost of the storage facilities. Although the onsite detention storage facilities could be provided by the land developer at no cost to the Town of Mt. Pleasant, the estimated capital cost of these facilities of $280,000 and the estimated annual operation and maintenance cost of $6,200 are properly included in any economic analysis of this alternative when evaluating major flood control alternatives on an areawide basis. The average annual flood damage abatement benefit is estimated at $25,600, resulting in a benefit-cost ratio of 0.99. On the basis of these findings, it should not be concluded that onsite storage is uneconomical in every case. In this respect it should be recognized that onsite storage may permit the size and length of local stormwater drainage facilities to be reduced with attendant cost reductions. The viability of onsite storage in this respect should be evaluated on a site specific basis. Excluding the cost for onsite storage and the benefits attendant thereto, the ratio of total average annual benefits to public costs is only 0.49.

Therefore, the onsite storage and structure floodproofing and elevation plan element as described herein, while technically feasible, was not found to be economically sound.

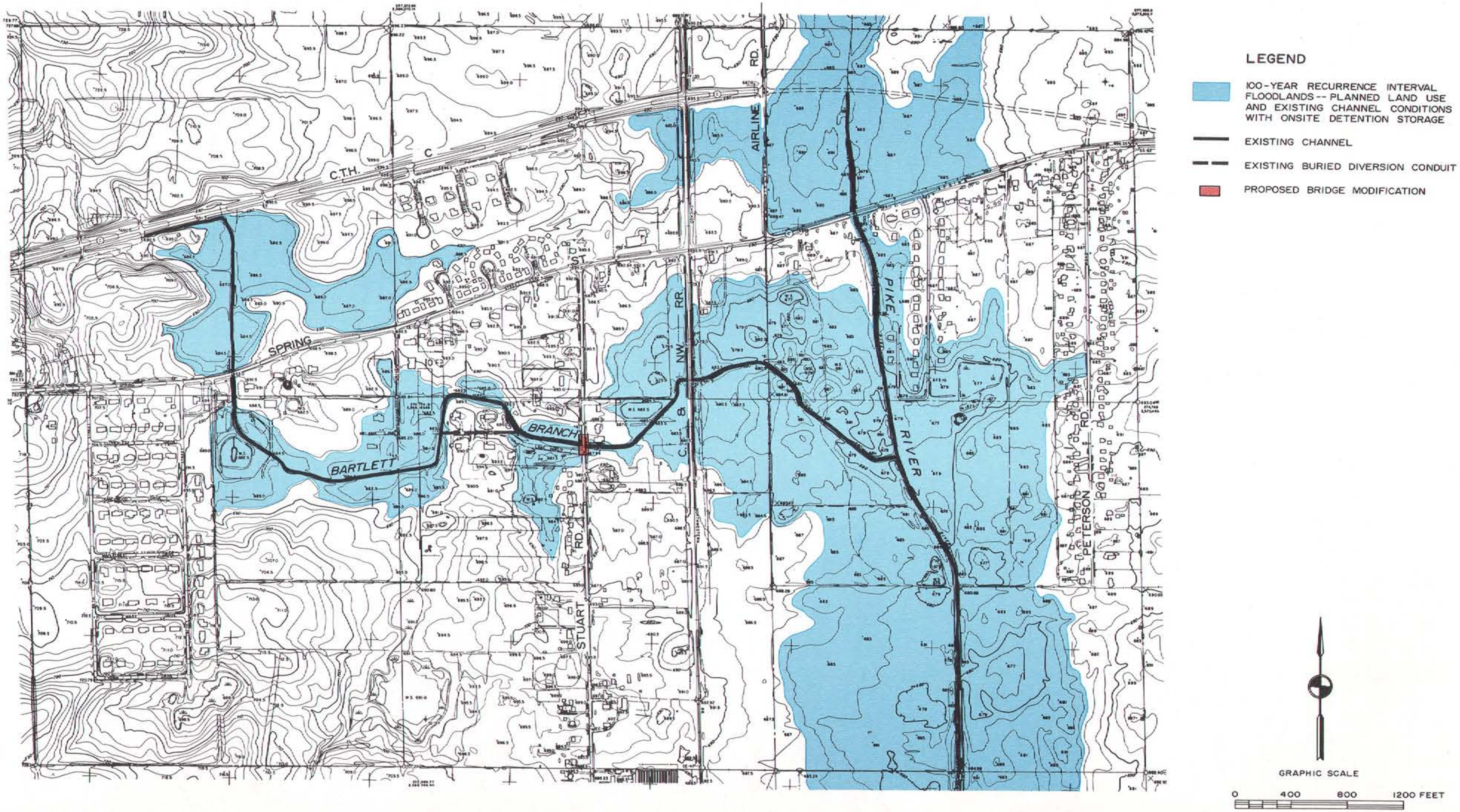
Combination Onsite Storage and Bridge Modification Alternative

An alternative flood control plan consisting of a combination of onsite storage and bridge modification was prepared and evaluated for Bartlett Branch upstream of the Chicago & North Western Transportation Company crossing. This alternative also assumes the continued application of the Town of Mt. Pleasant policy requiring that onsite storm water detention facilities be provided as land is converted from rural to urban use to prevent any increase in peak flood discharges and corresponding stages resulting from such urbanization up to and including the 100-year recurrence interval event. Under this plan element, an additional six-foot diameter concrete culvert would be added to the two existing six-foot diameter concrete culverts under Stuart Road. The physical characteristics and estimated costs of this alternative flood control plan element are shown on Map 50 and are set forth in Table 85.

Assuming that the onsite storage and bridge modification 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 $25,900, consisting of amortization of the $313,200 capital cost of the onsite detention storage and the culvert addition, and $6,200 in annual operation and maintenance cost of the storage facilities. Although the onsite detention storage facilities could be provided by the land developers at no cost to the Town of Mt. Pleasant, the estimated capital cost of these facilities of $280,800, and the estimated annual operation and maintenance cost of $6,200, are all properly included in any economic analysis of this alternative when evaluating major flood control alternatives on an areawide basis. The average annual flood damage abatement benefit is estimated at $25,600, resulting in a benefit-cost ratio of 0.99. In this respect it should be recognized that onsite storage may permit the size and length of local storm water drainage facilities to be reduced with attendant cost reductions. The viability of onsite storage in this respect should be evaluated on a site specific basis. Excluding the costs for onsite storage and the benefits attendant thereto, the ratio of the total average annual benefit to public costs is still only 0.88. The onsite storage and bridge modification plan element, as described herein, while technically feasible was not found to be economically sound.

Map 50

COMBINATION ONSITE STORAGE AND BRIDGE MODIFICATION ALTERNATIVE FOR BARTLETT BRANCH



A combination onsite storage and bridge modification alternative flood control plan was prepared and evaluated to determine if such a measure would provide a technically feasible and economically sound solution to the urban flood damage problem along Bartlett Branch. Under this alternative, onsite detention storage facilities would be provided by developers as land is converted from rural to urban uses. In addition, one bridge would have to be modified. While technically feasible, the alternative was found to be economically unsound.

Source: SEWRPC.

ALTERNATIVE FLOODLAND MANAGEMENT PLAN ELEMENTS FOR WAXDALE CREEK AND THE TRIBUTARY TO WAXDALE CREEK

The Flood Problem

The hydrologic-hydraulic simulation of Waxdale Creek and the tributary to Waxdale Creek under existing land use, channel, and floodplain conditions indicated that for the reach upstream of the Chicago, Milwaukee, St. Paul & Pacific Railroad Company (The Milwaukee Road) crossing, there exists the potential for only minor flood damage to crops and no damage to any residential structures. Under existing conditions, flood damages of about $1,000 during a 100-year recurrence interval flood event, and about $400 during a 10-year recurrence interval flood event may be expected to be incurred. Under plan year 2000 land use and existing channel and floodplain conditions, flood damages of about $1,000 and $600 would be expected to be incurred, respectively, during 100- and 10-year events.

The potential also exists for the flooding of certain areas of the S. C. Johnson & Sons plant located immediately upstream of the Milwaukee Road crossing. Precise estimates of damage to such a major industrial facility requires intimate knowledge of the plant operations, materials handling equipment, production schedules, and structural data on the individual buildings themselves. Review of the available site development plans, however, indicated that the first floor elevations of all of the existing buildings within the plant site should be above the elevation of the design flood, thus eliminating the potential for any significant flood damage. The review of the available site development plans also indicated that few buildings have basements, and those basements that do exist do not have any means whereby floodwaters can readily enter and cause damage. Accordingly, the only problems resulting from flooding of certain areas of the plant site would be related to interference with vehicle movements through the plant site vehicle loading and unloading operations and vehicle parking. The hydrologic-hydraulic simulation, moreover, indicated that flooding would be experienced during only relatively short durations, not more than about three hours for a major flood event. Therefore, any indirect flood damages due to flooding of the S. C. Johnson & Sons plant were not considered to be severe enough to warrant a specific flood control measure to alleviate such damages.

No Action Alternative

As noted above, only minor flood damages to crops are expected to be incurred on an average annual basis along this reach of Waxdale Creek and the tributary to Waxdale Creek, amounting to about $400 under plan year 2000 conditions, and about $100 under existing conditions. As shown below, these damages would be relatively insignificant when compared to even the least costly of the action alternative plan elements such as the construction of dikes, detention ponds, or major channelization. Accordingly, the cost of any project implemented to prevent these minor flood damages may be expected to greatly exceed the benefits received. Therefore, a no-action plan element would be practicable for this reach of Waxdale Creek and the tributary to Waxdale Creek.

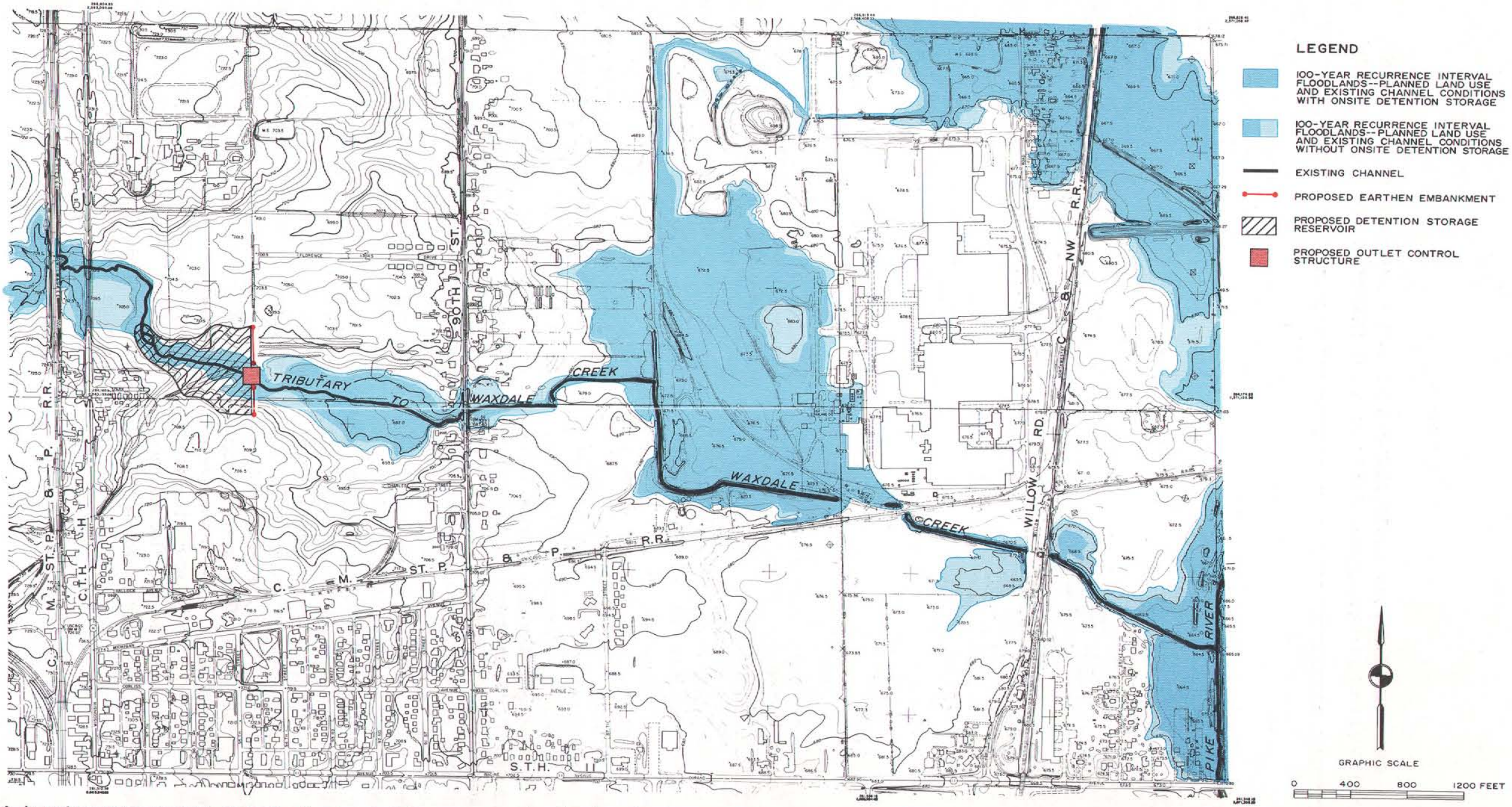
Detention Storage Reservoir Alternative

A detention storage reservoir alternative flood control plan, as shown on Map 51, was prepared and evaluated for Waxdale Creek and the tributary to Waxdale Creek as the most practical and least costly of the action alternatives. The reservoir would be located just downstream of CTH H and would provide 71 acre-feet of storage with two feet of freeboard in an area of about nine acres—sufficient to eliminate downstream flooding potential attendant to floods up to and including the 100-year recurrence interval event. The physical characteristics and economic costs of this alternative flood control plan element are set forth in Table 86. The assumed reservoir outlet control structure design is shown in Figure 57.

The total capital cost of a detention reservoir at this site is estimated to be about $639,000, consisting of $607,000 for excavation and construction of an outlet control structure, and $32,000 for land acquisition. The equivalent average annual cost assuming an economic life of 50 years and an annual interest rate of 6 percent, would be about $40,300, consisting entirely of the amortization of the $639,000 capital cost. The average annual flood abatement benefits are estimated at about $400 and, as already noted, are relatively insignificant when compared to the average annual cost of this project. Therefore, the detention storage reservoir plan element, as described herein, as well as any of the other action alternatives such as dikes or major channelization, while technically feasible, are not economically sound.

Map 51

DETENTION STORAGE RESERVOIR ALTERNATIVES FOR WAXDALE CREEK AND THE TRIBUTARY TO WAXDALE CREEK



A detention storage reservoir alternative flood control plan was prepared and evaluated to determine if such a measure would be a technically feasible and economically sound solution to the flood problem along Waxdale Creek and the tributary to Waxdale Creek. Under this alternative, a detention storage reservoir would be constructed just downstream of CTH H and would provide 71 acre-feet of storage with two feet of freeboard in an area of about nine acres. If onsite detention storage is provided upstream of the reservoir site as land is converted from rural to urban use, 63 acre-feet of storage would have to be provided, requiring an area of about eight acres.

Source: SEWRPC.

Table 86

PRINCIPAL FEATURES, COSTS, AND BENEFITS OF FLOODLAND MANAGEMENT ALTERNATIVES FOR WAXDALE CREEK AND THE TRIBUTARY TO WAXDALE CREEK

Alternative			Economic Analysis[a]											
			Technically Feasible	Capital Cost		Annual Amortized Capital Cost (thousands)	Annual Operation and Maintenance Cost (thousands)	Total Annual Cost (thousands)	Annual Cost (thousands)	Excess of Annual Benefits Over Cost (thousands)	Benefit-Cost Ratio	Benefit-Cost Ratio Greater Than 1.0	Nontechnical and Noneconomic Considerations	
Number	Name	Description		Item	(thousands)								Positive	Negative
1	No action	- -	Yes	- -	$ - -	$ - -	$ - -	$ 0.4[b]	$ - -	$ - -	- -	No	- -	- -
2	Detention storage	71 acre-foot detention storage reservoir	Yes	Reservoir and outlet culvert Earthen embankment Land acquisition Subtotal	533.0 74.0 32.0 639.0	40.3	- -	40.3	0.4	-39.9	0.01	No	Potential to retain public open space	- -
3	Combination onsite detention storage and detention storage reservoir[c]	a. 63 acre-foot detention storage reservoir b. Provide onsite detention storage facilities	Yes	Reservoir and outlet culvert Earthen embankment Land acquisition Onsite detention storage facilities Subtotal	473.0 66.0 29.0 309.0 877.0	55.3	7.0	62.3	0.4	-61.9	0.006	No	See Alternative 2	- -

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

[b] *The total annual cost of this alternative consists of the average annual monetary flood damages.*

[c] *The economic analyses included costs for onsite storage. It should not be concluded that onsite sotrage is uneconomical based upon these data, since the use of onsite storage may permit the size and length of local storm water drainage facilities to be reduced with attendant cost reductions. The viability of onsite storage in this respect should be evaluated on a site specific basis.*

Source: SEWRPC.

Combination Onsite Storage and Detention Reservoir Alternative

A combination onsite storage and detention reservoir alternative flood control plan was also prepared and evaluated for Waxdale Creek and the tributary to Waxdale Creek, as described in Table 86. This alternative assumes the continued application of the Town of Mt. Pleasant policy requiring that onsite storm water detention facilities be provided as land is converted from rural to urban use to prevent any increase in peak flood discharges and corresponding stages resulting from such urbanization up to and including the 100-year recurrence interval event. This alternative plan element is similar to Alternative 2, as shown on Map 51, except that provision of onsite storage would require less land and excavation for the reservoir. The detention storage reservoir would be located just downstream of CTH H and would provide 63 acre-feet of storage with two feet of freeboard in an area of about eight acres—sufficient to eliminate downstream flooding attendant to floods up to and including the 100-year recurrence interval event. The physical characteristics and economic costs of this alternative flood control plan element are set forth in Table 86. The assumed reservoir outlet control structure design is shown in Figure 57.

The total capital cost of onsite storage and a detention reservoir at this site is estimated to be about $877,200, consisting of $313,200 for onsite detention storage, $535,000 for excavation and construction of an outlet control structure, and $29,000 for land acquisition. The equivalent average annual cost assuming an economic life of 50 years and an annual interest rate of 6 percent, would be about $62,300, consisting of the amortization of the $877,200 capital cost, and $7,000 in annual operation and maintenance costs of the storage facilities. Although the onsite storage facilities could be provided by the land developer at no cost to the Town of Mt. Pleasant, the estimated capital cost of these facilities of $313,200, and the estimated annual operation and maintenance costs of $7,000, are properly included in any economic analysis of this alternative when evaluating major flood control alternatives on an areawide basis. The average annual flood damage abatement benefit is estimated at $400 and, as noted above, is relatively insignificant when compared to the average annual cost of this project. On the basis of these findings, it should not be concluded that onsite storage is uneconomical in every case. In this respect it should be recognized that onsite storage may permit the size and length of local storm water drainage facilities to be reduced with attendant cost reductions. The viability of onsite storage in this respect should be evaluated on a site specific basis. Therefore, the onsite storage and detention storage reservoir alternative plan, as described herein, while technically feasible, is economically unsound.

ALTERNATIVE FLOODLAND MANAGEMENT PLAN ELEMENTS FOR CHICORY CREEK

The Flood Problem

The hydrologic-hydraulic simulation of Chicory Creek under existing land use, channel, and floodplain conditions indicated that for the reach beginning at the Chicago & North Western Transportation Company crossing and extending upstream of the Chicago, Milwaukee, St. Paul & Pacific Railroad Company (The Milwaukee Road) crossing, there exists the potential for only minor flood damage to crops and residential structures. Average annual monetary flood risks attributable to flood damage to crops and residential structures are estimated, by application of the economic submodel described in Chapter VIII, at less than $200 under existing conditions. These damages should not increase under plan year 2000 land use and existing channel and floodplain conditions, as no significant land use changes are envisioned in the tributary drainage area. During a 100-year recurrence interval flood event flood damages of about $10,000 may be expected to be incurred, however no damages should be incurred from a flood event having a recurrence interval of 50 years or less.

No Action Alternative

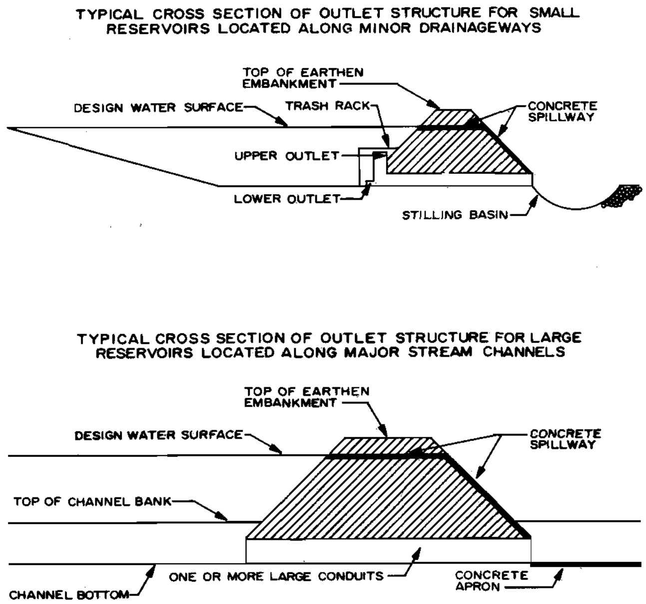
As noted above, only minor flood damages to crops and structures are expected to be incurred on an average annual basis along this reach of Chicory Creek. These damages are relatively insignificant when compared to even the least costly of the action alternative plan elements such as the construction of dikes, detention ponds, or major channelization. Accordingly, the cost of any project implemented to prevent these minor flood damages may be expected to greatly exceed the benefits received. Therefore, a no-action plan element would be practicable for this reach of Chicory Creek.

Detention Storage Reservoir Alternative

A detention storage reservoir alternative flood control plan, as shown on Map 52, was prepared and evaluated for Chicory Creek as the most practical and least costly of the action alternatives. The reservoir would be located just upstream of 90th Street and would provide 21 acre-feet of storage with two-feet of freeboard in an area of about five acres, sufficient to eliminate downstream flooding attendant to floods up to and including the 100-year recurrence interval event. The physical characteristics and estimated costs of this alternative floodland management plan element are set forth in Table 87. The assumed reservoir outlet control structure design is shown in Figure 57.

Figure 57

TYPICAL DETENTION STORAGE RESERVOIR OUTLET CONTROL STRUCTURES



Source: SEWRPC.

The total capital cost of a detention reservoir as at this site was estimated to be about $228,000, consisting of $210,000 for excavation and construction of an outlet control structure, and $18,000 for land acquisition. The equivalent average annual cost assuming an economic life of 50 years and an annual interest rate of 6 percent, would be about $14,300, consisting entirely of the amortization of the $228,000 capital cost. The average annual flood abatement benefits are estimated at less than $200 and, as already noted, are relatively insignificant when compared to the average annual cost of this project. Therefore, the detention storage reservoir alternative plan, as described herein, as well as any of the other action alternatives such as dikes or major channelization, while technically feasible, is not economically sound.

Table 87

PRINCIPAL FEATURES, COSTS, AND BENEFITS FOR FLOODLAND MANAGEMENT ALTERNATIVES FOR CHICORY CREEK

Alternative				Economic Analysis[a]										
			Technically Feasible	Capital Cost		Annual Amortized Capital Cost (thousands)	Annual Operation and Maintenance Cost (thousands)	Total Annual Cost (thousands)	Annual Benefits (thousands)	Excess of Annual Benefits Over Cost (thousands)	Benefit-Cost Ratio	Economically Feasible	Nontechnical and Noneconomic Considerations	
Number	Name	Description		Item	(thousands)								Positive	Negative
1	No action	--	Yes	--	$--	$ --	$ --	$ 0.2[b]	$ --	$ --	--	No	--	--
2	Detention storage	21 acre-foot detention reservoir	Yes	Reservoir and outlet culvert Earthen embankment Land acquisition Subtotal	139 71 18 228	14.3	--	14.3	0.2	- 14.1	0.01	No	Potential to retain public open space	--

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

[b]The total annual cost of this alternative consists of the average annual monetary flood damage.

Source: SEWRPC.

NO ACTION FLOODLAND MANAGEMENT PLAN ELEMENT FOR LAMPAREK DITCH

The hydrologic-hydraulic simulation of Lamparek Ditch under existing land use, channel, and floodplain conditions indicated that for the reach beginning 0.19 mile upstream from its confluence with the Pike River and extending upstream to CTH H there is no potential for flood damage to crops or to structures. This situation should not change under plan year 2000 land use and existing channel and floodplain conditions, as no land use changes are envisioned in the tributary drainage area. The analyses indicated that the 100-year recurrence interval flood event may be expected to be contained within the channel of this reach of Lamparek Ditch. Accordingly, a no-action plan element would be appropriate for this reach of Lamparek Ditch.

ALTERNATIVE FLOODLAND MANAGEMENT PLAN ELEMENTS FOR SOMERS BRANCH

The Flood Problem

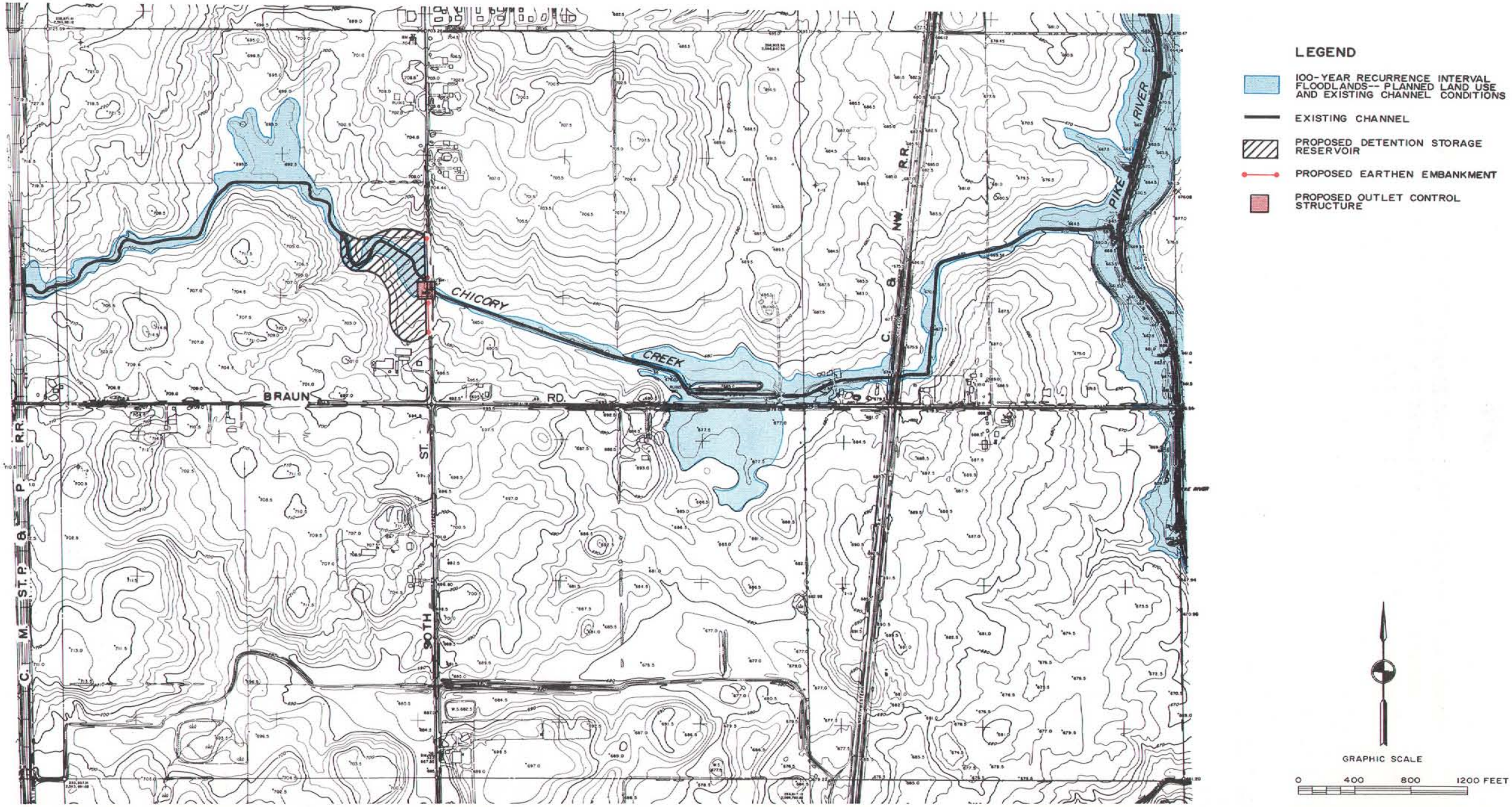
The hydrologic-hydraulic simulation of Somers Branch under existing land use and existing channel and floodplain conditions indicated that two flood-prone reaches exist on this tributary of Pike Creek. The first such reach begins at the Chicago, Milwaukee, St. Paul & Pacific Railroad Company (The Milwaukee Road) crossing and extends upstream a distance of 0.43 mile. The potential for major flood damages to structures, along with the potential for minor flood damage to crops, exists along this reach. The second such flood-prone reach begins 0.32 mile upstream from the confluence with Pike Creek and extends further upstream a distance of 0.79 mile to CTH EA. The potential for only minor flood damage to crops exists along this reach.

For the flood-prone reach upstream of the Milwaukee Road crossing, average annual monetary flood risks attributable to primary and secondary residential flooding and flooding of crops were estimated, by application of the economic submodel described in Chapter VIII, at $1,400 under existing conditions, and $4,200 under plan year 2000 land use and existing channel and floodplain conditions. If additional flood-prone development were permitted in the flood hazard area along this reach of Somers Branch, even higher monetary risks could be expected to be incurred. Under existing conditions, flood damages of about $10,900 during a 100-year recurrence interval flood event, and about $5,300 during a 10-year recurrence interval event may be expected to be incurred. Under the plan year 2000 land use and existing channel and floodplain conditions, flood damages of about $27,000 and $17,800 may be expected to be incurred, respectively, during 100- and 10-year events.

It should be noted that crop damages incurred along this reach are less than $100 on an average annual basis under both existing and plan year 2000 land use conditions. Analyses indicated that there would be no economically feasible means of alleviating these minor flood damages. Accordingly, the alternative flood control measures were designed to abate structural damages only.

Map 52

DETENTION STORAGE RESERVOIR ALTERNATIVE FOR CHICORY CREEK



A detention storage reservoir alternative flood control plan was prepared and evaluated to determine if such a measure would be a technically feasible and economically sound solution to the flood problem along Chicory Creek. Under this alternative, a detention storage reservoir would be constructed immediately upstream of 90th Street and would provide 21 acre-feet of storage with two feet of freeboard in an area of about five acres. While technically feasible, this alternative was found to be economically unsound.

Source: SEWRPC.

Table 88

PRINCIPAL FEATURES, COSTS, AND BENEFITS OF FLOODLAND MANAGEMENT ALTERNATIVES FOR SOMERS BRANCH

Reach	Alternative: Number	Alternative: Name	Alternative: Description	Technically Feasible	Economic Analysis[a]: Capital Cost: Item	Capital Cost (thousands)	Annual Amortized Capital Cost (thousands)	Annual Operation and Maintenance Cost (thousands)	Total Annual Cost (thousands)	Annual Benefits (thousands)	Excess of Annual Benefits Over Cost (thousands)	Benefit-Cost Ratio	Benefit-Cost Ratio Greater Than 1.0	Nontechnical and Noneconomic Considerations: Positive	Nontechnical and Noneconomic Considerations: Negative
Downstream of CTH EA	1	No action	--	Yes	--	$ --	$ --	$ --	$ 0.3[b]	$ --	$ --	--	No	--	--
	2	Combination culvert modification and major channelization	a. Modify one stream crossing b. 0.8 mile of major channelization[c]	Yes	Culvert Channelization Subtotal	55.0 104.0 159.0	10.0	0.5	10.5	0.3	- 10.2	0.03	No	--	--
Upstream of the Milwaukee Road	3	No action	--	Yes	--	--	--	--	4.2[b]	--	--	--	No	--	--
	4	Structure floodproofing and elevating	a. Floodproof up to three residential structures b. Elevate up to two residential structures	Yes	Floodproofing Elevating Subtotal	11.4 42.1 53.5	3.4	--	3.4	4.2	0.8	1.24	Yes	Immediate partial flood relief at discretion of property owners Most of the costs would be borne by beneficiaries	Complete, voluntary implementation unlikely and therefore left with a significant residual flood problem Overland flooding and some attendant problems remain Some floodproofing is likely to be applied without adequate professional advice and, as a result, structure damage may occur
	5	Dike	a. 1,600 feet of earthen dike b. Drainage culvert	Yes	Dike Culvert and backwater gate Subtotal	278.0 0.5 278.5	17.6	1.7	19.3	4.2	- 15.1	0.22	No	--	Aesthetic impact of visual barrier
	6	Detention storage	a. 40 acre-foot detention reservoir b. Diversion ditch and three culverts	Yes	Reservoir and outlet control Diversion ditch and three culverts Land acquisition Subtotal	218.0 25.0 23.0 266.0	16.8	0.7	17.5	4.2	- 13.3	0.24	No	Potential to retain public open space	--
	7	Combination culvert replacement and major channelization	a. Replace one stream crossing b. One mile of major channelization[d]	Yes	Bridge Channelization Subtotal	253.0 142.0 395.0	24.9	0.8	25.7	4.2	- 21.5	0.16	No	--	--
	8	Combination onsite detention storage and detention storage reservoir[e]	a. 25 acre-foot detention reservoir b. Provide onsite detention storage facilities	Yes	Reservoir and outlet control Diversion ditch and three culverts Land acquisition Onsite detention storage facilities Subtotal	161.0 13.0 16.8 702.0 892.8	56.2	16.3	72.5	4.2	- 68.3	0.06[f]	No	See Alternative 6 above	--

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

[b] *The total annual cost of this alternative consists of the average annual monetary flood damages.*

[c] *The cost of the channel is based on a bottom width of 20 feet and side slopes of one on three.*

Source: SEWRPC.

[d] *The cost of the channel is based on a bottom width of 10 feet and side slopes of one on three.*

[e] *The economic analysis included costs for onsite storage. It should not be concluded that onsite storage is uneconomical based upon these data, since the use of onsite storage may permit the size and length of local storm water drainage facilities to be reduced with attendant cost reductions. The viability of onsite storage in this respect should be evaluated on a site specific basis.*

[f] *Excluding the costs for onsite storage and the benefits attendant thereto, the ratio of total average annual benefits to public costs is 0.02.*

For the other flood-prone reach downstream of CTH EA, average annual monetary flood damages attributable to flooding of crops are estimated at less than $100 under existing conditions, and about $300 under plan year 2000 land use and existing channel and floodplain conditions. Under existing conditions, flood damages of about $4,000 during a 100-year recurrence interval flood may be expected to be incurred; however, no damages should be incurred from a flood event having a recurrence interval of 10 years or less. Under plan year 2000 land use conditions, flood damages of about $8,000 and $2,000 could be expected to be incurred, respectively, during 100-year and 10-year events.

River Mile 0.32 to CTH EA

As noted above, on an average annual basis, only minor flood damages to crops are expected to be incurred along this reach of Somers Branch downstream of CTH EA. These damages would be relatively insignificant when compared to even the least costly of the "action" alternative plan elements such as dikes, detention ponds, or major channelization. Accordingly, the cost of any project implemented to prevent these minor flood damages could be expected to greatly exceed the benefits received. Therefore, a no-action plan element would be practicable for this reach of Somers Branch.

Combination Culvert Modification and Major Channelization Alternative: A culvert replacement and major channelization alternative flood control plan was developed for this reach of Somers Branch. This alternative was considered to be the most practical and least costly of the action alternatives. Under this plan element, 0.8 mile of major channelization would be completed, as shown on Map 53, and the conveyance capacity of the Chicago & North Western Transportation Company crossing would be increased by the addition of a six-foot diameter concrete culvert to the three existing four-foot diameter concrete culverts. The physical characteristics and estimated costs of this alternative flood control plan element are set forth in Table 88.

Utilizing an annual interest rate of 6 percent, and an amortization period and project life of 50 years, the average annual cost is estimated at $10,500, consisting of amortization of the $159,000 capital cost of the additional culvert and major channelization, and $500 in annual operation and maintenance cost of the channelized reaches. The average annual flood abatement benefits are about $300 and, as noted above, are relatively insignificant when compared to the average annual cost of this project. Therefore, the culvert modification and major channelization plan element, as described herein, as well as any of the other action alternatives such as dikes or detention ponds, while technically feasible, may be concluded to be not economically sound.

The Milwaukee Road Crossing to River Mile 2.38 Structure Floodproofing and Elevation Alternative A structure floodproofing, elevation, and removal alternative flood control plan was prepared and evaluated to determine if such a structure-by-structure approach would be a technically and economically acceptable solution to the flood problem along this reach of Somers Branch upstream of the Milwaukee Road crossing. For the purpose of this analysis, the 100-year recurrence interval flood stage under plan year 2000 land use and existing channel conditions was used to estimate the number of flood-prone structures to be floodproofed, elevated, or removed, and the approximate costs involved.

As shown on Map 54, the analysis indicated that a total of two structures may be expected to be located in the primary flood hazard area, and three structures may be expected to be located in the secondary flood hazard area. The two structures located in the primary flood hazard area would have to be elevated and the three structures located in the secondary flood hazard area would have to be floodproofed. Future flood damages to private residences and commercial structures along this reach would be virtually eliminated by floodproofing and elevation measures. Table 88 sets forth the number and type of structures to be floodproofed and elevated, and also summarizes the estimated costs and benefits.

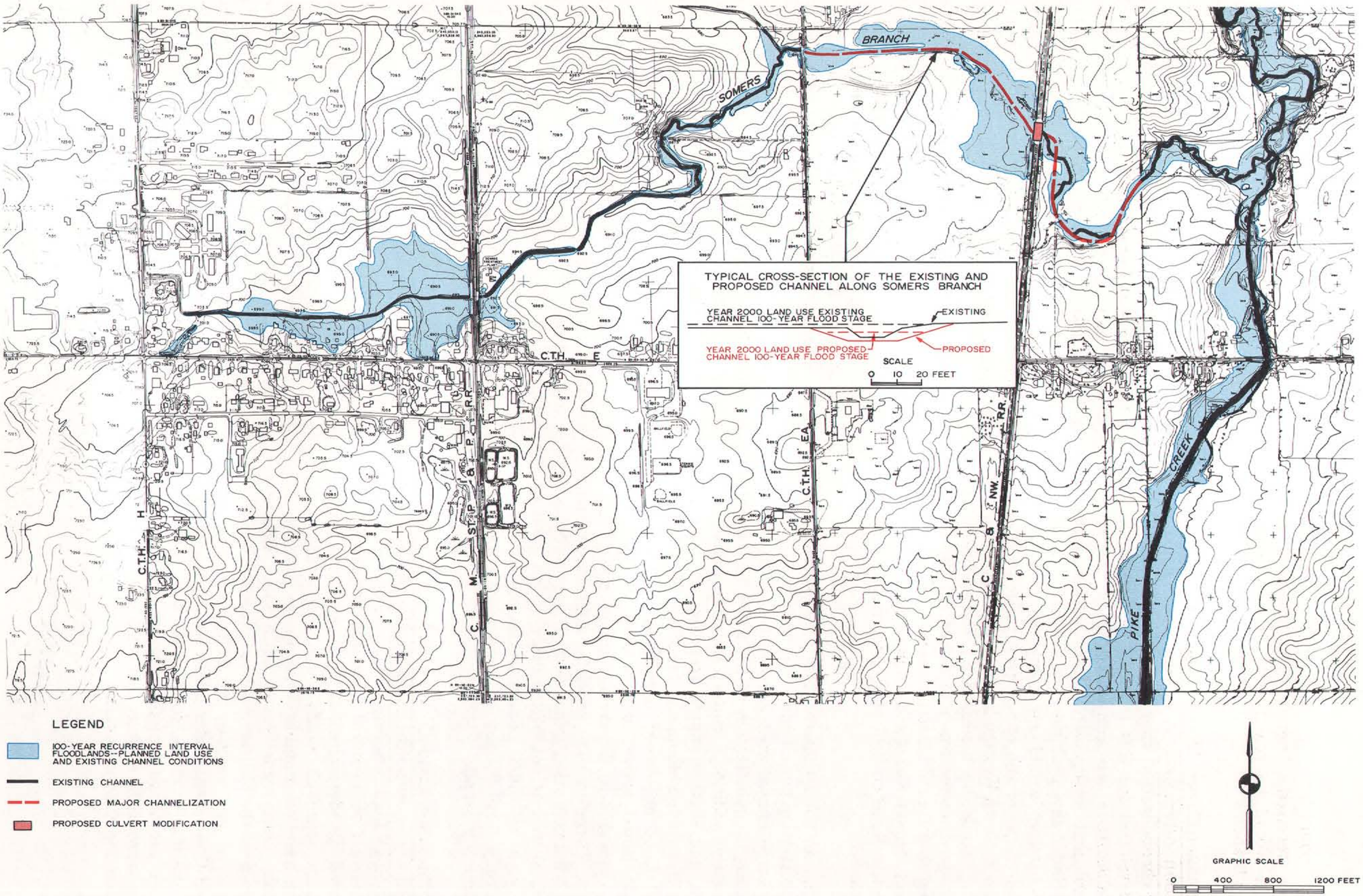
Assuming that these structure floodproofing and elevation measures would be fully implemented, and utilizing an annual interest rate of 6 percent and a project life and amortization period of 50 years, the equivalent average annual cost is estimated at about $3,400 per year, consisting entirely of the amortization of the $53,500 capital cost—$11,400 for floodproofing and $42,100 for structure elevation. The average annual flood damage abatement benefit is estimated at $4,200 per year, yielding a benefit-cost ratio of 1.24. Therefore, the structure floodproofing and elevation alternative plan, as described herein, would be technically feasible and economically sound.

Dike Alternative: A dike alternative flood control plan was prepared and evaluated for the lands subjected to flooding by Somers Branch in order to determine if such a structural measure would provide a technically and economically sound solution to the existing and anticipated flood problem. The 100-year recurrence interval flood event under plan year 2000 land use and existing channel and floodplain conditions was used as the basis for the design of this alternative.

The dike alternative flood control plan element for Somers Branch is shown on Map 55, while the costs and benefits attendant to construction of the dike are set forth in Table 88. The assumed dike design is shown in Figure 52. Under this alternative plan element, a total of about 1,600 feet of earthen dike with an average height of about four feet, and a maximum height of eight feet, would be constructed as far from the main channel as possible, so as to not significantly reduce the floodwater storage potential that exists upstream of the Milwaukee Road crossing. In addition, the dike

Map 53

COMBINATION CULVERT MODIFICATION AND MAJOR CHANNELIZATION ALTERNATIVE FOR SOMERS BRANCH

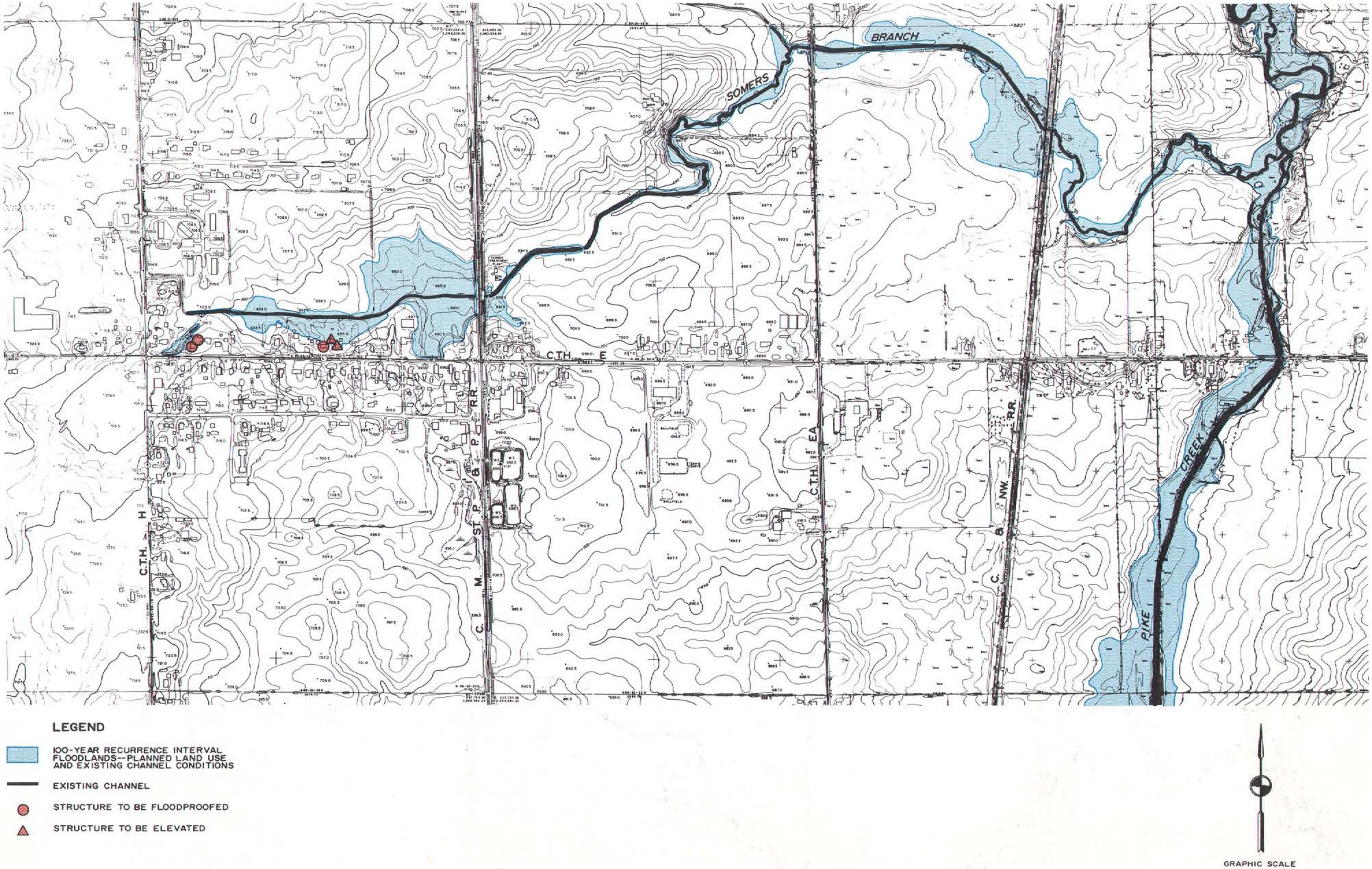


A combination culvert modification and major channelization alternative flood control plan was prepared and evaluated to determine if such a measure would provide a technically feasible and economically sound solution to the flood problem along Somers Branch between river mile 0.32 and CTH EA at river mile 1.11. Under this alternative, about 0.8 mile of major channelization would be carried out and the conveyance capacity of the Chicago & North Western Transportation Company crossing would be increased. While technically feasible, this alternative was found to be economically unsound.

Source: SEWRPC.

Map 54

STRUCTURE FLOODPROOFING AND ELEVATION ALTERNATIVE FOR SOMERS BRANCH

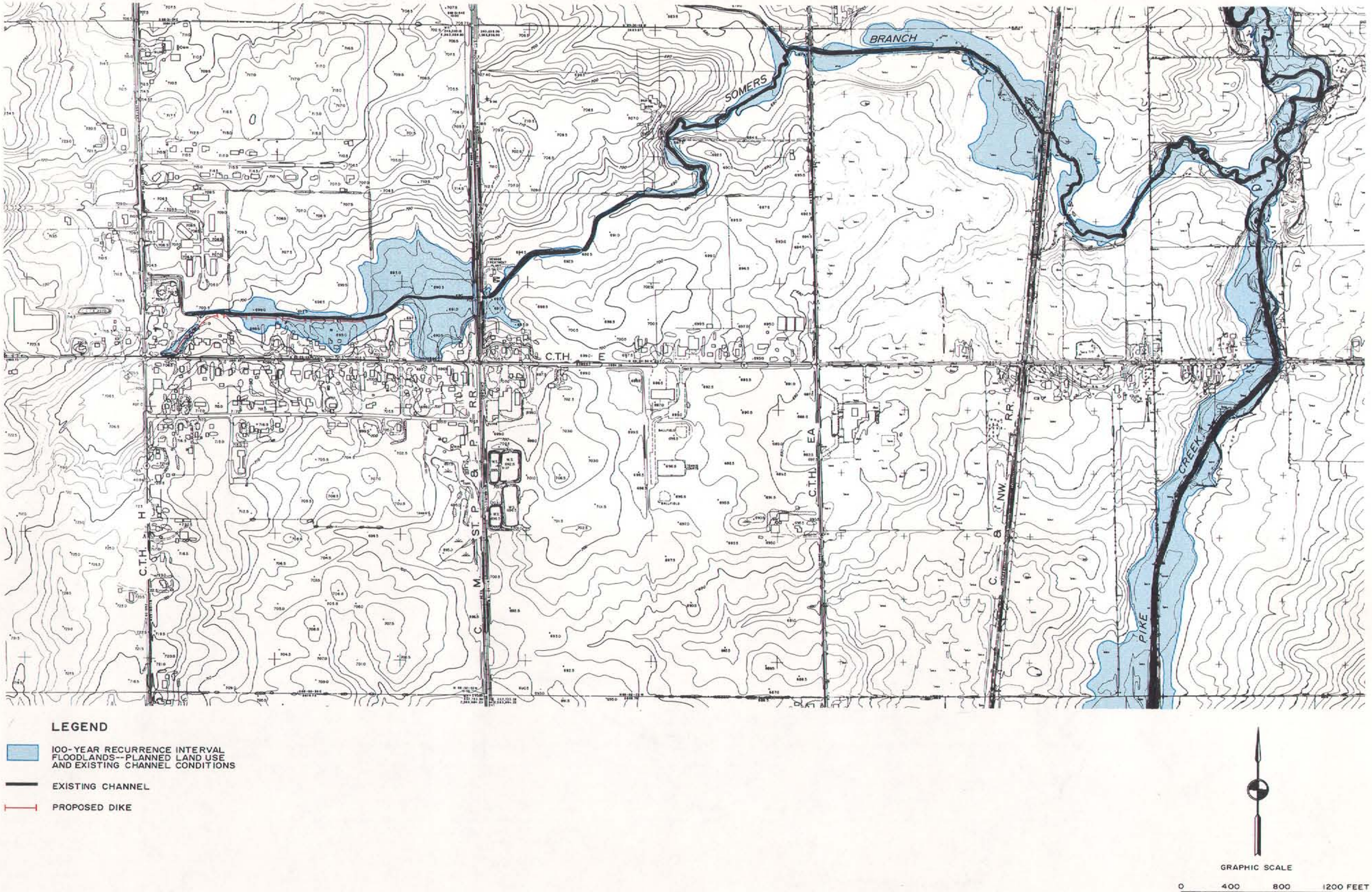


A structure floodproofing and elevation alternative flood control plan was prepared and evaluated to determine if such a measure would provide a technically feasible and economically sound solution to the urban flood problem along Somers Branch upstream of the Milwaukee Road crossing. Under this alternative, three structures would be floodproofed and two structures would be elevated. This alternative was found to be both technically feasible and economically sound.

Source: SEWRPC.

Map 55

DIKE ALTERNATIVE FOR SOMERS BRANCH



A dike alternative flood control plan was prepared and evaluated to determine if such a measure would provide a technically feasible and economically sound solution to the urban flood problem along Somers Branch upstream of the Milwaukee Road crossing. Under this alternative, about 1,600 feet of earthen dike would be constructed. While technically feasible, this alternative was found to be economically unsound.

Source: SEWRPC.

plan element would have to include provisions for the construction of a drainage system consisting of a 12-inch diameter corrugated metal pipe culvert through the dike equipped with a backwater gate to prevent the accumulation of lateral runoff behind the dike, the backup of floodwaters through the culvert, and the attendant creation of local drainage problems.

Assuming that the dike 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 $19,300. This cost consists of the amortization of the $278,000 capital cost of the dike, including land acquisition costs, amortization of the $500 capital cost of the required local drainage culvert, and $1,700 in annual operation and maintenance cost of the dike. The average annual flood abatement benefit is estimated at about $4,200, yielding a benefit-cost ratio of 0.22. Therefore, the dike plan element, as described herein, while technically feasible, is not economically sound.

Detention Storage Reservoir Alternative: A detention reservoir alternative flood control plan was also prepared and evaluated for this reach of Somers Branch. The reservoir would be located at the intersection of CTH E and CTH H and designed to abate the potential for flooding of structures located upstream of the Milwaukee Road crossing of Somers Branch shown on Map 56. The reservoir would provide approximately 40 acre-feet of storage, sufficient to contain the 100-year recurrence interval flood event with generally about two feet of freeboard in an area of about eight acres. The reservoir would be confined by the CTH E road embankment on the north, and the CTH H road embankment on the east, as shown on Map 56, and would require excavation to an average depth of about six feet. In addition, a ditch would be constructed along CTH H to divert the runoff from the tributary area north of CTH E and west of CTH H to the reservoir. The physical characteristics and estimated costs of this alternative floodland management plan element are set forth in Table 88. The assumed reservoir outlet control structure design is shown in Figure 57.

The total capital cost of a detention reservoir at this site was estimated to be about $266,000, consisting of $230,000 for construction of the reservoir and outlet control structure, and $23,000 for land acquisition, and $13,000 for construction of the diversion ditch. The equivalent average annual cost assuming an economic life of 50 years and an annual interest rate of 6 percent, would be about $17,500, consisting of $16,800 for the annual amortized capital costs and $700 annual operation and maintenance cost. The average annual flood abatement benefits are estimated at about $4,200, resulting in an excess of about $13,300 in annual costs over benefits and a benefit-cost ratio of 0.24. Therefore, the detention storage reservoir plan element, as described herein, may be considered technically feasible but not economically sound.

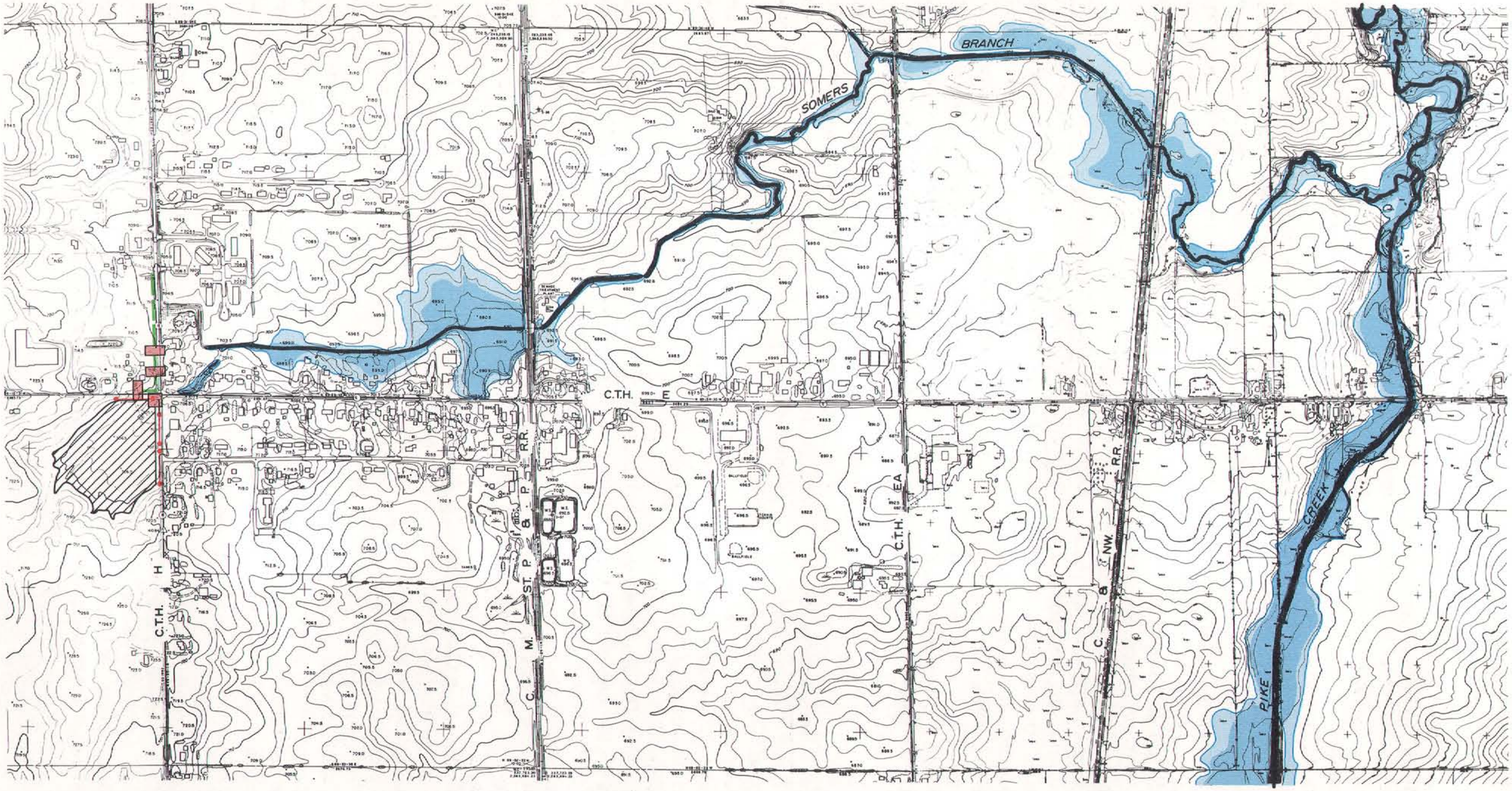
Combination Culvert Replacement and Major Channelization Alternative: A culvert replacement and major channelization alternative flood control plan was developed for this reach of Somers Branch. Under this plan element, major channelization would occur between River Mile 1.45 and River Mile 2.38 as shown on Map 57, and the conveyance capacity of the Milwaukee Road crossing would be increased by replacing the existing four-foot diameter concrete culvert with a clear span bridge. The proposed channel would have a bottom width of 10 feet with side slopes of one on three, and would be designed to provide two feet of freeboard during the design flood event. The physical characteristics and estimated costs of this alternative flood control plan element are set forth in Table 88.

Utilizing an annual interest rate of 6 percent and an amortization period and project life of 50 years, the average annual cost is estimated at $25,700, consisting of amortization of the $395,000 capital cost of the bridge and major channelization, and $800 in annual operation and maintenance cost of the channelized reaches. The average annual flood abatement benefit is estimated at $4,200, yielding a benefit-cost ratio of 0.16. Therefore, the culvert modification and major channelization plan element, as described herein, would be technically feasible but not economically sound. It should also be noted that this flood control measure would result in a two-fold increase in peak flood discharges downstream; however, the minor flood damages to crops under plan year 2000 land use conditions would not increase significantly.

Combination Onsite Storage and Detention Storage Reservoir Alternative: A combination onsite storage and detention storage reservoir alternative flood control plan was also developed for this reach of Somers Branch to abate the potential for

Map 56

DETENTION STORAGE RESERVOIR ALTERNATIVES FOR SOMERS BRANCH



LEGEND

- 100-YEAR RECURRENCE INTERVAL FLOODLANDS--PLANNED LAND USE AND EXISTING CHANNEL CONDITIONS WITH ONSITE DETENTION STORAGE
- 100-YEAR RECURRENCE INTERVAL FLOODLANDS--PLANNED LAND USE AND EXISTING CHANNEL CONDITIONS WITHOUT ONSITE DETENTION STORAGE
- EXISTING CHANNEL
- PROPOSED EARTHEN EMBANKMENT
- PROPOSED DIVERSION DITCH
- PROPOSED DETENTION STORAGE RESERVOIR
- PROPOSED OUTLET CONTROL STRUCTURE
- PROPOSED CULVERT

GRAPHIC SCALE

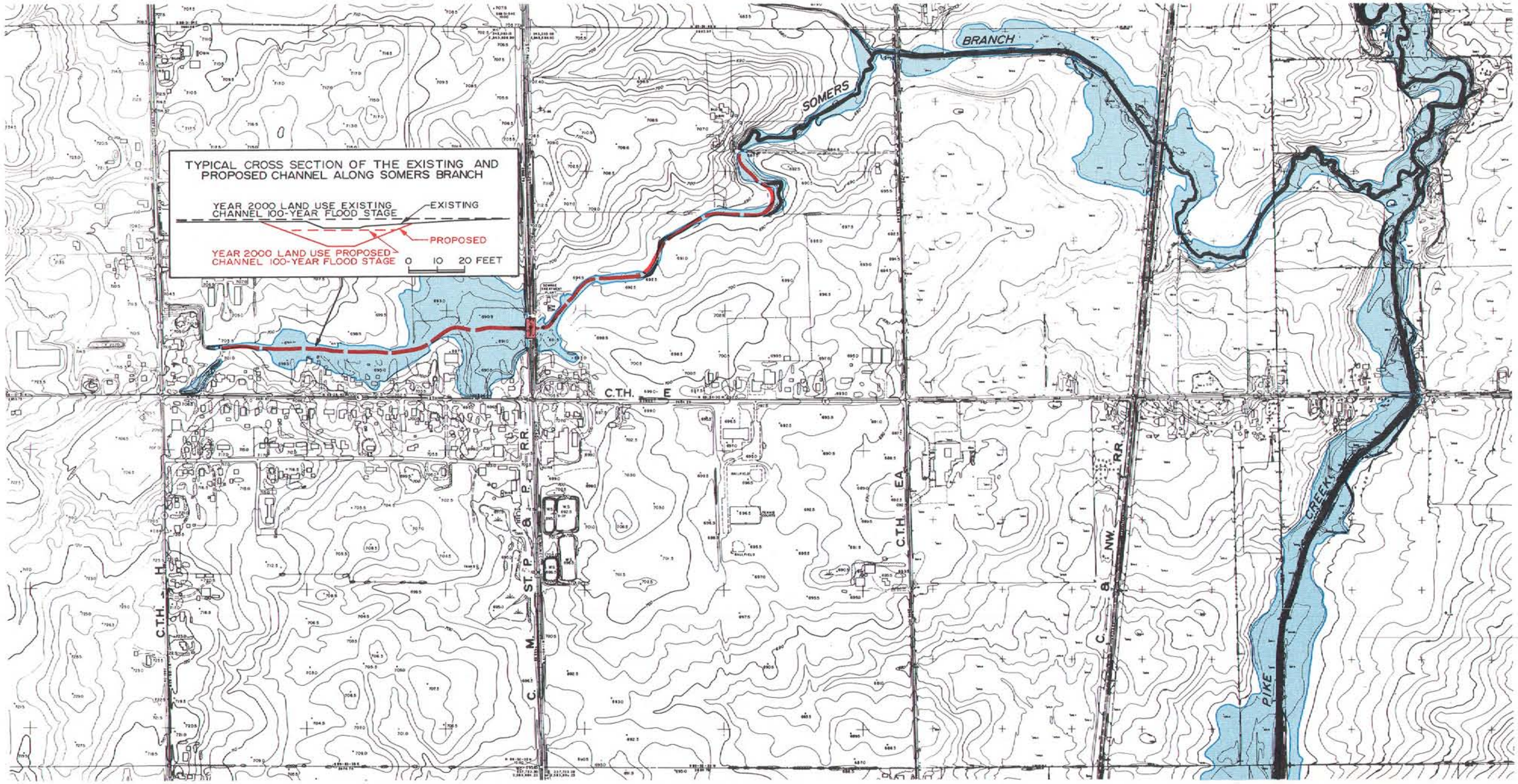
0 400 800 1200 FEET

A detention storage reservoir alternative flood control plan was prepared and evaluated to determine if such a measure would provide a technically feasible and economically sound solution to the urban flood problem along Somers Branch upstream of the Milwaukee Road Crossing. Under this alternative, a detention storage reservoir would be constructed at the intersection of CTH E and CTH H and would provide 40 acre-feet of storage with two feet of freeboard in an area of about eight acres. In addition, a ditch would be constructed along CTH H to divert the runoff from the tributary area north of CTH E and west of CTH H to the reservoir. If onsite storage is provided upstream of the reservoir site as land is converted from rural to urban use, 25 acre-feet of storage would have to be provided requiring about six acres. While technically feasible, this alternative was found to be economically unsound.

Source: SEWRPC.

Map 57

COMBINATION CULVERT REPLACEMENT AND MAJOR CHANNELIZATION ALTERNATIVE FOR SOMERS BRANCH



LEGEND

100-YEAR RECURRENCE INTERVAL FLOODLANDS--PLANNED LAND USE AND EXISTING CHANNEL CONDITIONS

EXISTING CHANNEL

PROPOSED CULVERT REPLACEMENT

PROPOSED MAJOR CHANNELIZATION

GRAPHIC SCALE

0 400 800 1200 FEET

A combination culvert replacement and major channelization alternative flood control plan was prepared and evaluated to determine if such a measure would provide a technically feasible and economically sound solution to the flood problem along Somers Branch upstream of the Milwaukee Road crossing. Under this alternative, 1.0 mile of major channelization would be carried out and the Milwaukee Road culvert would be replaced with a clear span bridge. While technically feasible, this alternative was found to be economically unsound.

Source: SEWRPC.

flood damage to structures located upstream of the Milwaukee Road crossing. This alternative assumes the adoption of a policy similar to that adopted by the Town of Mt. Pleasant requiring that onsite storm water detention facilities be provided as land is converted from rural to urban use to prevent any increase in peak flood discharges and corresponding stages resulting from such urbanization up to and including the 100-year recurrence interval event. The physical characteristics and estimated costs of this alternative floodland management plan element are set forth in Table 88. The assumed reservoir outlet control structure design is shown in Figure 57. This alternative plan element is similar to Alternative 6 as shown on Map 56, except that the provision of onsite storage would reduce the size of the reservoir and, thus reduce the cost of excavation and land acquisition. The reservoir would provide approximately 25 acre-feet of storage sufficient to detain floods up to and including the 100-year recurrence interval event under existing channel and planned land use conditions with generally about two feet of freeboard in an area of about six acres.

The total capital cost of onsite storage and a detention reservoir at this site was estimated to be about \$892,800—consisting of \$702,000 for onsite storage, \$161,000 for construction of the reservoir and outlet control structure, \$16,800 for land acquisition, and \$13,000 for construction of the diversion ditch. The equivalent average annual cost, assuming an economic life of 50 years and an annual interest rate of 6 percent, would be about \$72,500—consisting of \$56,200 for the annual amortized capital costs, and \$16,300 annual operation and maintenance cost. Although the onsite detention storage facilities could be provided by the land developer at no cost to the Town of Somers, the estimated capital cost of these facilities of \$702,000, and the estimated annual operation and maintenance cost of \$15,600, are properly included in any economic analysis of this alternative when evaluating major flood control alternatives on an areawide basis. The average annual flood damage abatement benefit is estimated at \$4,200, resulting in a benefit-cost ratio of 0.06. On the basis of these findings, it should not be concluded that onsite storage is uneconomical in every case. In this respect it should be recognized that onsite storage may permit the size and length of local storm water drainage facilities to be reduced with attendant cost reductions. The viability of onsite storage in this respect should be evaluated on a site specific basis. Excluding the costs for onsite storage and the benefits attendant thereto, the ratio of total average annual benefits to public costs is still only 0.35. The onsite storage and the offsite detention storage reservoir plan element, as described herein, while technically feasible, is not economically sound.

ALTERNATIVE FLOODLAND MANAGEMENT PLAN ELEMENTS FOR AIRPORT BRANCH AND THE TRIBUTARY TO AIRPORT BRANCH

The Flood Problem

The hydrologic-hydraulic simulation of Airport Branch and the tributary to Airport Branch under existing land use, channel, and floodplain conditions indicated that for the reaches upstream of the Chicago, Milwaukee, St. Paul, & Pacific Railroad Company (The Milwaukee Road) there exists the potential for only minor flood damage to crops.

Average annual monetary flood risks associated with flood damage to crops are estimated, by application of the economic submodel, at less than \$100 under existing conditions. During a 100-year recurrence interval flood event, flood damages to crops of about \$1,200 may be expected to be incurred; however, no damages would be expected to be incurred during a flood event with a recurrence interval of about 10 years or less.

Under plan year 2000 land use conditions, the predominantly agricultural land uses of the drainage area tributary to this reach would be converted to a major industrial center, thus increasing flood flows and stages significantly. Under this locally committed land use design there could be industrial development located in the flood hazard area. Thus it will be necessary to implement a flood control system to accommodate such development and to prevent flood damage in the newly developed areas. The least costly, technically feasible flood control system for this area is described below.

Combination Culvert Modification and Major Channelization Alternative

An alternative flood control plan consisting of culvert modification and major channelization was prepared and evaluated for Airport Branch and the tributary to Airport Branch upstream of the Milwaukee Road crossing. This alternative was considered to be the only technically feasible plan element for these stream reaches. Under this plan element, the conveyance capacity of the existing Milwaukee Road crossing which consists of two

Table 89

PRINCIPAL FEATURES, COSTS, AND BENEFITS OF FLOODLAND MANAGEMENT ALTERNATIVES FOR AIRPORT BRANCH AND THE TRIBUTARY TO AIRPORT BRANCH

Alternative			Economic Analysis[a]											
			Technically Feasible	Capital Cost		Annual Amortized Capital Cost (thousands)	Annual Operation and Maintenance Cost (thousands)	Total Annual Cost (thousands)	Annual Benefits (thousands)	Excess of Annual Benefits Over Cost (thousands)	Benefit-Cost Ratio	Benefit-Cost Ratio Greater Than 1.0	Nontechnical and Noneconomic Considerations	
Number	Name	Description		Item	(thousands)								Positive	Negative
1	No action	- -	Yes	- -	$- -	$ - -	$ - -	$ 0.1	- -[b]	$- -	- -	No	- -	- -
2	Combination culvert modification and major channelization	a. Modify one stream crossing b. 0.9 mile of major channelization[c]	Yes	Culverts Channelization Subtotal	64 141 205	12.9	0.7	13.6	- -[b]	- -	- -	- -	- -	- -
3	Combination onsite detention storage and major channelization[d]	a. 0.9 mile of major channelization[e] b. Provide onsite detention storage facilities	Yes	Channelization Onsite detention storage facilities Subtotal	132 666 798	50.3	15.5	65.8	- -[b]	- -	- -	- -	Potential to retain public open space	- -

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

[b]*In the absence of a precise development plan these benefits cannot be estimated at this time.*

[c]*The cost is based on bottom widths of five and 10 feet, respectively, for Airport Branch and the tributary to Airport Branch, and side slopes of one on three.*

[d]*The economic analyses included costs for onsite storage. It should not be concluded that onsite storage is uneconomical based upon these data, since the use of onsite storage may permit the size and length of local storm water drainage facilities to be reduced with attendant cost reductions. The viability of onsite storage in this respect should be evaluated on a site specific basis.*

[e]*The cost is based on a bottom width of five feet and side slopes of one on three.*

Source: SEWRPC.

four-foot diameter culverts and one three-foot diameter culvert, would be increased by the addition of two four-foot diameter culverts, and major channelization of Airport Branch and the tributary to Airport Branch would be carried out for a distance of approximately 0.5 mile and 0.4 mile, respectively, upstream of the Milwaukee Road crossing, as shown on Map 58. The physical characteristics and estimated costs of this alternative flood control plan element are set forth in Table 89.

Assuming that the culvert replacement and major channelization 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 $13,600, consisting of amortization of the $205,000 capital cost of the additional culverts and channelization, and $700 in annual operation and maintenance cost of the channelized reaches. Any benefits received would be directly attributable to the ability to develop the flood hazard area for industrial purposes. In the absence of a precise development plan these benefits cannot be estimated at this time.

The cost of this floodland management plan element was also computed utilizing an annual interest rate of 10 percent to determine the effect on the average annual cost of this project. Assuming this interest rate the average annual cost is estimated at about $21,200.

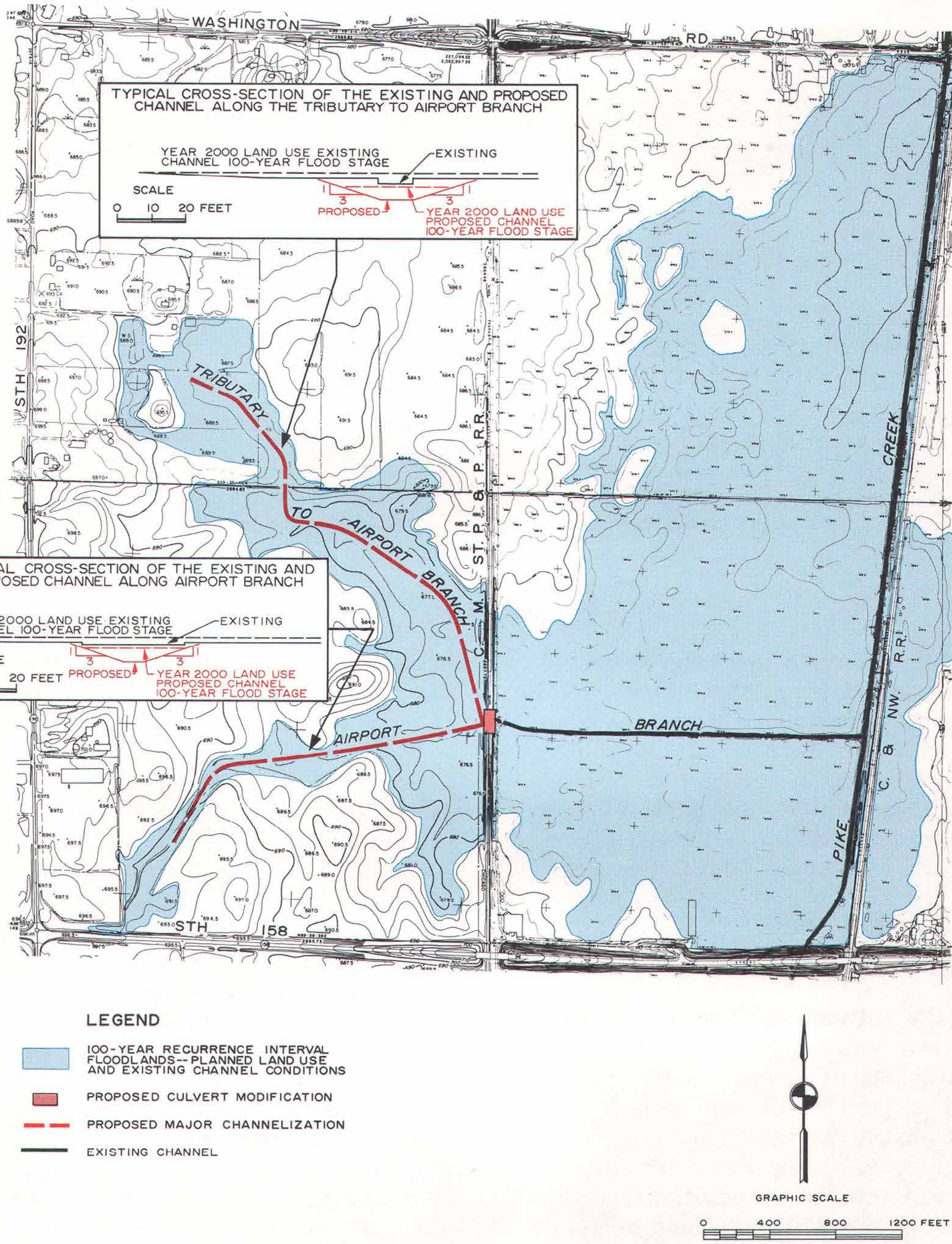
Combination Onsite Storage and Major Channelization Alternative

An alternative flood control plan consisting of a combination of onsite storage and major channelization was developed for Airport Branch and the tributary to Airport Branch upstream of the Milwaukee Road crossing. This alternative assumes the adoption of a policy similar to that adopted by the Town of Mt. Pleasant requiring that onsite storm water detention facilities be provided as land is converted from rural to urban use to prevent any increase in peak flood discharges and corresponding stages resulting from such urbanization up to and including the 100-year recurrence interval event. This alternative plan element is similar to Alternative 2 as shown on Map 59, except that the provision of onsite storage would eliminate the need to modify the Milwaukee Road crossing. The physical characteristics and estimated costs of this alternative flood control plan element are set forth in Table 89.

Assuming that the onsite storage and major channelization alternative would be fully implemented, and utilizing an annual interest rate of 6 percent and a project life and amortization period of

Map 58

CULVERT MODIFICATION AND MAJOR CHANNELIZATION ALTERNATIVE FOR AIRPORT BRANCH AND THE TRIBUTARY TO AIRPORT BRANCH

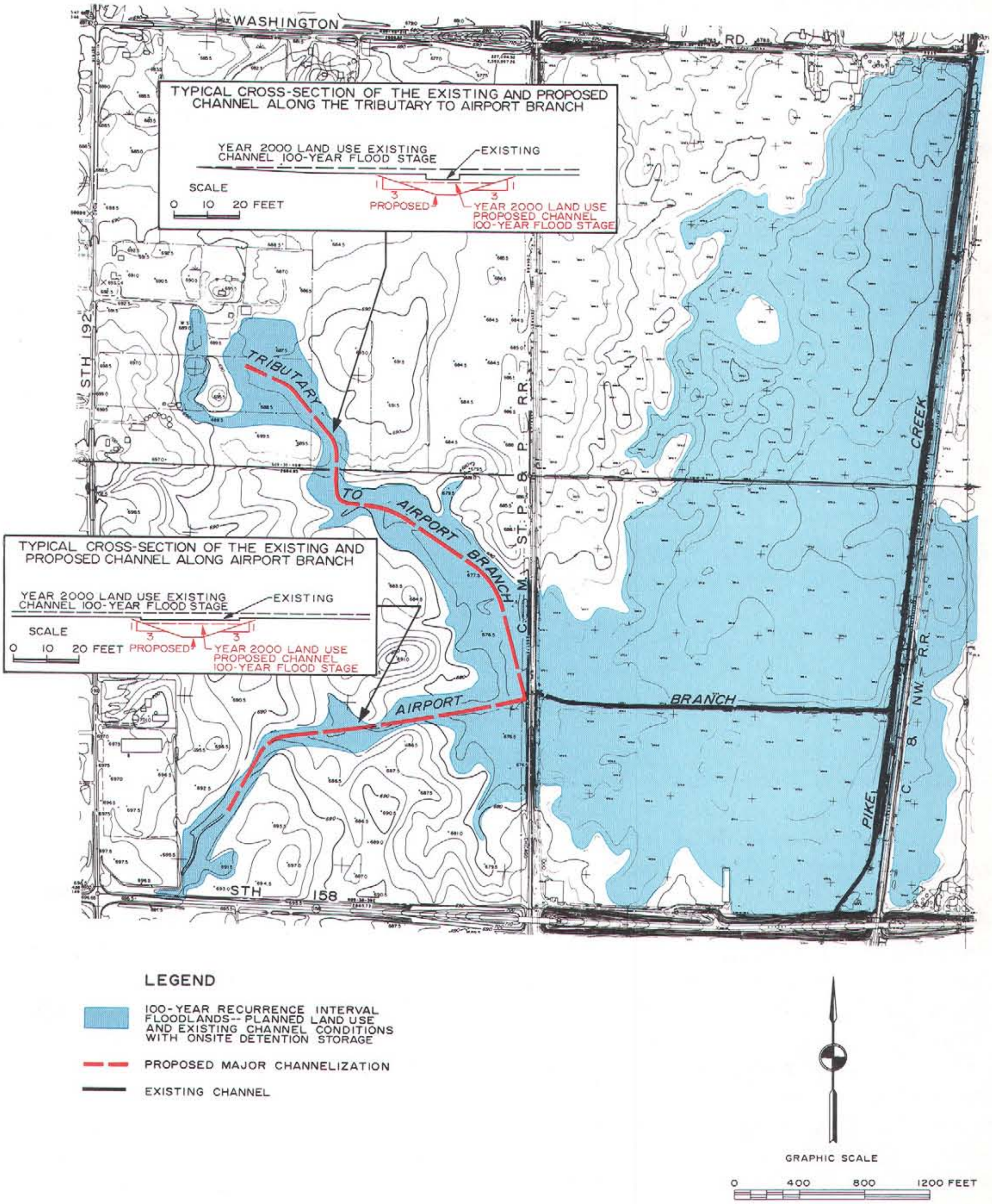


A culvert modification and major channelization alternative flood control plan was prepared and evaluated to determine if such a measure would provide a technically feasible and economically sound solution to the flood problem along Airport Branch and the Tributary to Airport Branch. Under this alternative, 0.9 mile of major channelization would be carried out and the conveyance capacity of the existing Milwaukee Road crossing would be increased. In the absence of precise development plans for the proposed industrial park development along these two creeks the benefits attributable to this alternative could not be estimated. Therefore, while the alternative was found to be technically feasible, it will not be feasible to determine whether the alternative is economically sound until the industrial park development plans concerned are further advanced.

Source: SEWRPC.

Map 59

COMBINATION ONSITE STORAGE AND MAJOR CHANNELIZATION ALTERNATIVE FOR AIRPORT BRANCH AND THE TRIBUTARY TO AIRPORT BRANCH



A combination onsite storage and major channelization alternative flood control measure was prepared and evaluated to determine if such a measure would provide a technically feasible and economically sound solution to the flood problem along Airport Branch and the tributary to Airport Branch. Under this alternative, 0.9 mile of major channelization would be carried out along with the provision of onsite detention storage facilities upstream from the Milwaukee Road crossing as land is converted from rural to urban use. In the absence of precise development plans for the proposed industrial park development along these two creeks the benefits attributable to this alternative could not be estimated. Therefore, while the alternative was found to be technically feasible, it will not be possible to determine whether the alternative is economically sound until the industrial park development plans concerned are further advanced.

Source: SEWRPC.

50 years, the average annual cost is estimated at $65,800, consisting of amortization of the $798,000 capital cost of the onsite storage facilities and channelization, and $15,500 in annual operation and maintenance cost of the onsite storage facilities and channelized reaches. Any benefits received would be directly attributable to the ability to develop the area for industrial purposes. In the absence of a precise development plan these benefits cannot be estimated at this time.

The cost of this floodland management plan element was also computed utilizing an annual interest rate of 10 percent to determine the effect on the average annual cost of this project. Assuming this interest rate the average annual cost is estimated at about $95,300.

In the alternative, it may be possible to design an industrial park development which would hold the flood hazard areas concerned in open uses and avoid any future flood damages without the construction of any major flood control works. These alternatives should be further explored as the precise development plans for the area are prepared.

ALTERNATIVE FLOODLAND MANAGEMENT PLAN ELEMENTS FOR NELSON CREEK

The Flood Problem

The hydrologic-hydraulic simulation of Nelson Creek under existing land use and existing channel and floodplain conditions indicated that there exists the potential for only minor flood damage to crops. Average annual monetary flood risks attributable to flood damage to crops are estimated, by application of the economic submodel, at less than $100 under existing conditions, and about $500 under plan year 2000 conditions. Under existing conditions, flood damages of about $900 during a 100-year recurrence interval flood event may be expected to be incurred; however, no damages should be incurred from a flood event having a recurrence interval of 10 years or less. Under plan year 2000 conditions, flood damages of about $1,900 and $1,300 would be expected to be incurred, respectively, during 100- and 10-year flood events.

No Action Plan Element

As noted above, only minor flood damage to crops on an average annual basis is expected to be incurred along Nelson Creek. As shown below, these damages would be relatively insignificant when compared to even the least costly of the action alternative plan elements such as dikes, detention ponds, or major channelization. Accordingly, the cost of any project implemented to prevent these minor flood damages would greatly exceed the benefits received. Therefore, a no-action plan element would be practicable for this reach of Nelson Creek.

Major Channelization Alternative

A major channelization plan element was developed for Nelson Creek upstream of CTH KR, which was considered to be the most practical and least costly of the action alternative plan elements. The physical characteristics and estimated costs of this alternative flood control plan element are shown on Map 60 and set forth in Table 90.

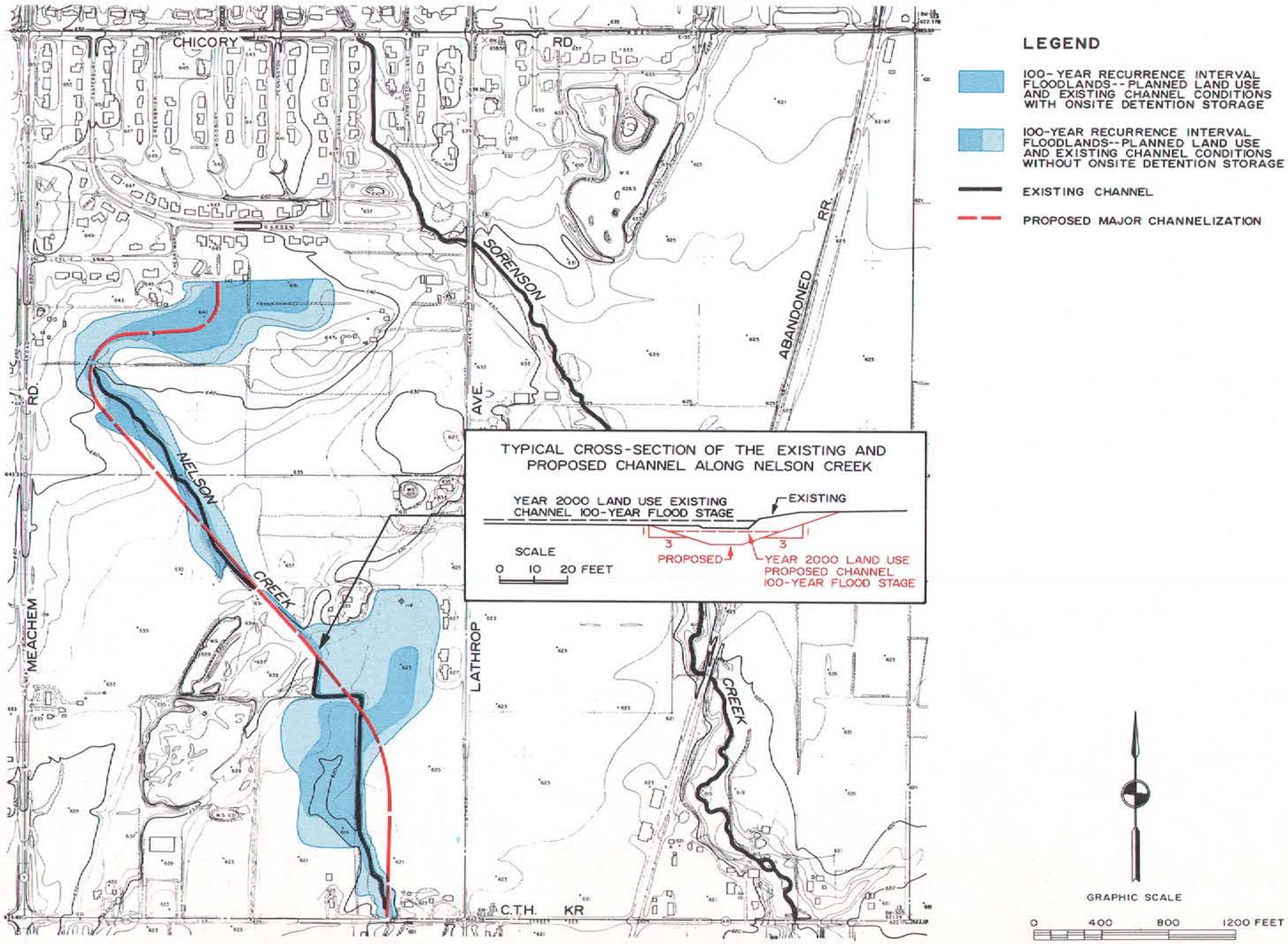
Utilizing an annual interest rate of 6 percent and a project life and amortization period of 50 years, the average annual cost is estimated at $6,100, consisting of amortization of the $86,200 capital cost and $600 in annual operation and maintenance cost of the channelized reaches. The average annual flood abatement benefits are about $500 and, as noted above, are relatively insignificant when compared to the average annual cost of this project. Therefore, the major channelization plan element, as described herein, as well as any of the other action alternatives such as dikes or detention ponds, while technically feasible, are not economically sound.

Combination Onsite Storage and Major Channelization Alternative

A combination onsite storage and major channelization plan element was prepared and evaluated for Nelson Creek upstream of CTH KR. This alternative assumes the continued application of the Town of Mt. Pleasant policy requiring that onsite storm water detention facilities be provided as land is converted from rural to urban use to prevent any increase in peak flood discharges and corresponding stages resulting from such urbanization up to and including the 100-year recurrence interval event. The analysis indicated that a channel of a smaller size than that required under Alternative 2, under planned land use conditions, would be required with the provision of onsite storm water detention storage. However, the channel proposed under Alternative 2 is near the smallest practical size that could be constructed if three on one side slopes were to be retained for maintenance purposes. Therefore, the provision of onsite storm water detention facilities would not significantly reduce the cost of a major channeliza-

Map 60

MAJOR CHANNELIZATION ALTERNATIVES FOR NELSON CREEK



A major channelization alternative flood control plan was prepared and evaluated to determine if such a measure would provide a technically feasible and economically sound solution to the flood problem along Nelson Creek. Under this alternative, 0.85 mile of channel would be constructed upstream of CTH KR. The provision of onsite detention storage as land is converted from rural to urban use upstream of CTH KR would have no significant impact on the size of the proposed channel. While technically feasible, this alternative was found to be economically unsound.

Source: SEWRPC.

Table 90

PRINCIPAL FEATURES, COSTS, AND BENEFITS OF FLOODLAND MANAGEMENT ALTERNATIVES FOR NELSON CREEK

Alternative			Technically Feasible	Economic Analysis[a]										
Number	Name	Description		Capital Cost: Item	Capital Cost (thousands)	Annual Amortized Capital Cost (thousands)	Annual Operation and Maintenance Cost (thousands)	Total Annual Cost (thousands)	Annual Benefits (thousands)	Excess of Annual Benefits Over Cost (thousands)	Benefit-Cost Ratio	Benefit-Cost Ratio Greater Than 1.0	Nontechnical and Noneconomic Considerations: Positive	Nontechnical and Noneconomic Considerations: Negative
1	No action	--	Yes	--	$ --	$ --	$ --	$0.5[c]	$ --	$ --	--	No	--	--
2	Major channelization	0.85 mile of major channelization[b]	Yes	Channelization	86.2	5.5	0.6	6.1	0.5	- 5.6	0.08	No	--	Aesthetic impact
3	Combined onsite detention storage and major channelization[d]	a. 0.85 mile of major channelization b. Provide onsite detention storage facilities	No	--	--	--	--	--	--	--	--	No	Potential to retain public open space	See Alternative 2 above

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

[b]The cost of the channel is based on a bottom width of 10 feet and side slopes of one on three.

Source: SEWRPC.

[c]The total annual cost consists of the average annual monetary flood damages.

[d]The economic analyses included costs for onsite storage. It should not be concluded that onsite storage is uneconomical based upon these data, since the use of onsite storage may permit the size and length of local storm water drainage facilities to be reduced with attendant cost reductions. The viability of onsite storage in this respect should be evaluated on a site specific basis.

tion alternative, and thus the onsite storage and major channelization alternative was not considered to be an economically sound solution to the flood problem along Nelson Creek.

ALTERNATIVE FLOODLAND MANAGEMENT PLAN ELEMENTS FOR SORENSON CREEK

The Flood Problem

The hydrologic-hydraulic simulation of Sorenson Creek under existing land use, channel, and floodplain conditions indicated that upstream of CTH KR there is the potential for significant flood damages to be incurred by residential structures along with some minor flood damage to crops; while, downstream of CTH KR there exists the potential for only minor damage to crops. Average annual monetary flood damages attributable to flood damage to residential structures and crops are estimated, by application of the economic submodel described in Chapter VIII, at $4,200 under existing land use, channel, and floodplain conditions; and $5,700 under plan year 2000 land use and existing channel and floodplain conditions. If additional flood-prone development were permitted in the flood hazard area, even higher monetary flood risks could be expected to be incurred. Under existing conditions, flood damages of about $27,900 during a 100-year recurrence interval flood event, and about $13,700 during a 10-year recurrence interval flood event may be expected to be incurred. Under year 2000 plan conditions, flood damages of about $31,900 and $19,600 may be expected to be incurred, respectively, during 100- and 10-year events.

As noted above, only minor flood damage to crops may be expected to be incurred along Sorenson Creek, amounting to about $500 on an average annual basis under plan year 2000 conditions, and about $200 under existing conditions. The cost of any technically feasible floodland management plan element which would alleviate these minor crop damages may be expected to greatly exceed the benefits received from its implementation. Accordingly, the alternative flood control measures were designed to abate urban damages only.

CTH KR Upstream to Abandoned Chicago, North Shore & Milwaukee Railroad Company (North Shore Line)

Structure Floodproofing and Elevation: A structure floodproofing, elevation and removal alternative flood control plan was analyzed to determine if such a structure-by-structure approach would be a technically and economically acceptable solution to the flood problem along this reach of Sorenson Creek. For the purpose of this analysis, the 100-year recurrence interval flood stage under plan year 2000 land use and existing channel and floodplain conditions was used to estimate the number of flood-prone structures to be floodproofed, elevated, or removed and the approximate costs involved.

As shown on Map 61, the analysis indicated that one structure may be expected to be located in the primary flood hazard area and one structure may be expected to be located in the secondary flood hazard area. The structure located in the primary flood hazard area would have to be elevated, and the structure located in the secondary flood hazard area would have to be floodproofed under this alternative plan element. Future flood damage to private residences along this reach would be virtually eliminated by the floodproofing and elevation. Table 91 sets forth the number and type of structures to be floodproofed and elevated and also summarizes the estimated costs and benefits.

Assuming that these structure floodproofing and elevation 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 $1,700, consisting entirely of the amortization of the $26,900 capital cost—$23,100 for structure elevation, and $3,800 for floodproofing. The average annual flood damage abatement benefit is estimated at $700 per year, yielding a benefit-cost ratio of 0.41. Therefore, the structure floodproofing and elevation alternative plan, as described herein, while technically feasible along this reach of Sorenson Creek, would not be economically sound.

Combination Onsite Storage and Structure Floodproofing and Elevation: A combination onsite storage and structure floodproofing, elevation and removal alternative flood control plan was prepared and analyzed to determine if such an approach would be a technically and economically acceptable solution to the flood problem along this reach of Sorenson Creek. This alternative assumes the continued application of the Town of Mt. Pleasant policy requiring that onsite storm water detention facilities be provided as land is converted from rural to urban use to prevent any increase in peak flood discharges and corresponding stages resulting from such urbanization.

This alternative plan element is similar to Alternative 2 as shown on Map 61, except that the provision of onsite storage would reduce the height of structure elevation. The analysis indicated that one structure may be expected to be located in the primary flood hazard area and one structure may be expected to be located in the secondary flood hazard area. The structure located in the primary flood hazard area would have to be elevated and the structure located in the secondary flood hazard area would have to be floodproofed under this alternative plan element. Future flood damage to private residences along this reach would be virtually eliminated by elevation of flood-prone structures. Table 91 sets forth the number and type of structures to be elevated and also summarizes the estimated costs and benefits.

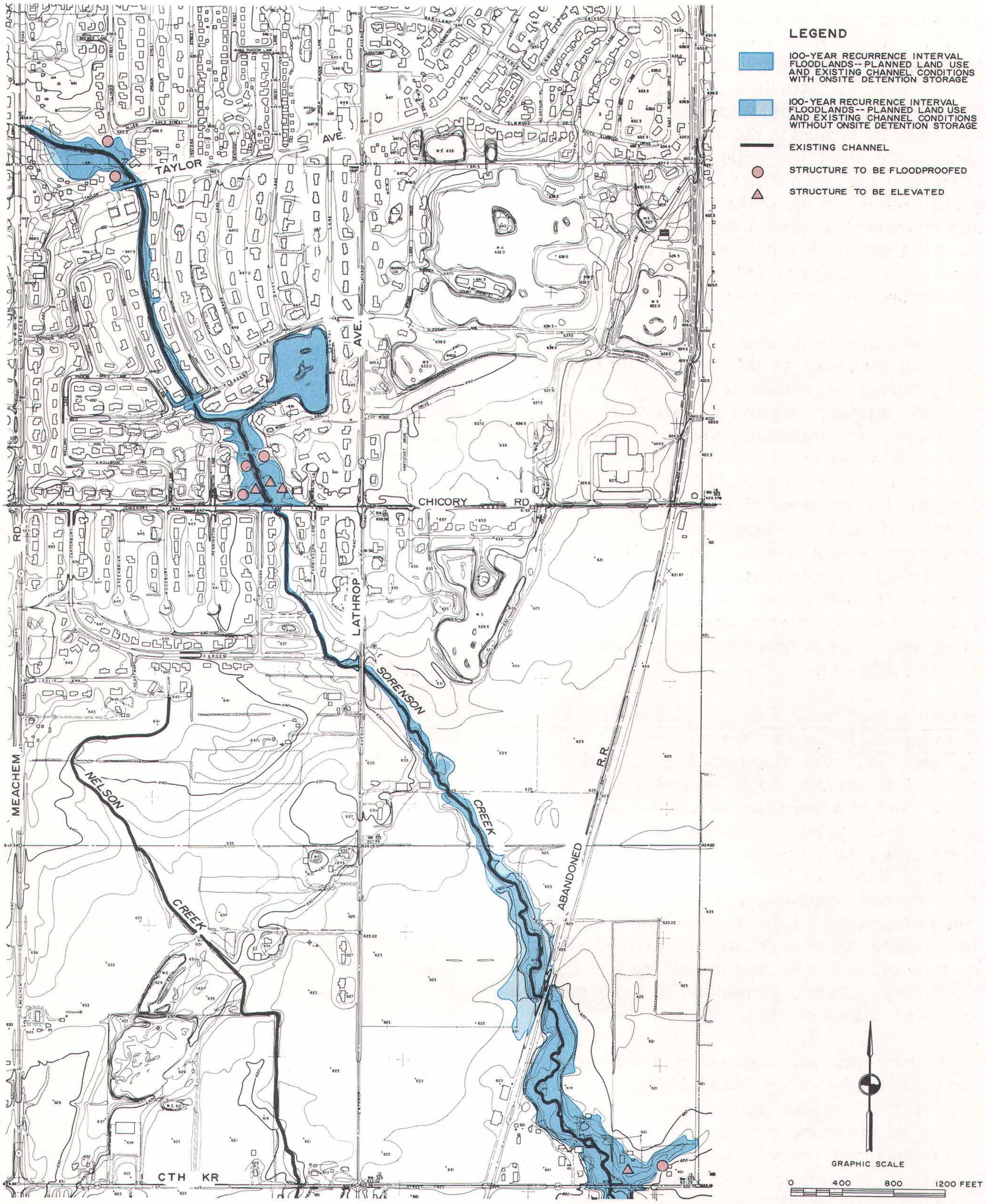
Assuming that the onsite storage and structure elevation measures would be fully implemented, and utilizing an annual interest rate of 6 percent and project life and amortization period of 50 years, the equivalent average annual cost is estimated at about $77,200, consisting of the amortization of the $908,200 capital cost for onsite storage and structure floodproofing and elevation, and $19,600 in annual operation and maintenance cost of the storage facilities. Although the onsite detention storage facilities could be provided by the land developer at no cost to the Town of Mt. Pleasant, the estimated capital cost of these facilities of $882,000, and the estimated annual operation and maintenance costs of $19,600 are properly included in any economic analyses of this alternative when evaluating major flood control alternatives on an areawide basis. The average annual flood damage abatement benefit is estimated at $700 per year, yielding a benefit-cost ratio of 0.01. On the basis of these findings, it should not be concluded that onsite storage is uneconomical in every case. In this respect it should be recognized that onsite storage may permit the size and length of local storm water drainage facilities to be reduced with attendant cost reductions. The viability of onsite storage in this respect should be evaluated on a site specific basis. Excluding the costs for onsite storage and the benefits attendant thereto, the ratio of total average annual benefits to public costs is only 0.41.

The onsite storage and structure floodproofing and elevation alternative plan, as described herein, while technically feasible, would not be economically sound.

No Action Plan Element: As noted above, average annual damages to residential structures are relatively small, only $700 per year. Analyses of alternative floodland management plan elements such as dikes, detention ponds, or major channelization for other stream reaches discussed in this chapter indicated that the cost of any other technically feasible floodland management plan element which would alleviate these minor flood damages would

Map 61

STRUCTURE FLOODPROOFING AND ELEVATION ALTERNATIVES FOR SORENSON CREEK



A structure floodproofing and elevation alternative flood control plan was prepared and evaluated to determine if such a measure would provide a technically feasible and economically sound solution to the flood problem along Sorenson Creek. Under this alternative, six structures would have to be floodproofed and four structures would have to be elevated. The provision of onsite detention storage as land is converted from rural to urban use upstream of CTH KR would have no significant impact on the number of structures which would have to be floodproofed nor on the number of structures which would have to be elevated. While technically feasible, this alternative was found to be economically unsound.

Source: SEWRPC.

Table 91

PRINCIPAL FEATURES, COSTS, AND BENEFITS OF FLOODLAND MANAGEMENT ALTERNATIVES FOR SORENSON CREEK

Reach	Alternative Number	Alternative Name	Alternative Description	Technically Feasible	Capital Cost Item	Capital Cost (thousands)	Economic Analysis[a]: Annual Amortized Capital Cost (thousands)	Annual Operation and Maintenance Cost (thousands)	Total Annual Cost (thousands)	Annual Benefits (thousands)	Excess of Annual Benefits Over Cost (thousands)	Benefit-Cost Ratio	Benefit-Cost Ratio Greater Than 1.0	Nontechnical and Noneconomic Considerations: Positive	Nontechnical and Noneconomic Considerations: Negative
CTH KR Upstream to the abandoned North Shore Line	1	No action	- -	Yes	- -	$ - -	$ - -	$ - -	$ 0.7[b]	$ - -	$ - -	- -	No	- -	- -
	2	Structure floodproofing and elevation	a. Floodproof one residential structure b. Elevate one residential structure	Yes	Floodproofing Elevating Subtotal	3.8 23.1 26.9	1.7	- -	1.7	0.7	- 1.0	0.41	No	Immediate partial flood relief at discretion of property owners Most of the costs would be borne by beneficiaries	Complete, voluntary implementation unlikely and therefore left with a significant residential flood problem Overland flooding and some attendant problems remain. Some floodproofing is likely to be applied without adequate professional advice and, as a result, structure damage may occur
	3	Combination onsite detention storage and floodproofing and elevation[c]	a. Elevate one residential structure b. Floodproof one residential structure c. Provide onsite detention storage facilities	Yes	Elevating Onsite detention storage facilities Floodproofing Subtotal	22.4 882.0 3.8 908.2	57.6	19.6	77.2	0.7	- 76.5	0.01	No	See Alternative 2 above	See Alternative 2 above
Chicory Road Upstream to Pleasant Lane	4	No action	- -	Yes	- -	- -	- -	- -	4.3[b]	- -	- -	- -	No	- -	- -
	5	Structure floodproofing and elevation	a. Floodproof up to three residential structures b. Elevate up to three residential structures	Yes	Floodproofing Elevating Subtotal	11.4 65.3 76.7	4.8	- -	4.8	4.3	- 0.5	0.90[d]	No	Immediate partial flood relief at discretion of property owners Most of the costs would be borne by beneficiaries	Complete, voluntary implementation unlikely and therefore left with a significant residential flood problems Overland flooding and some attendant problems remain Some floodproofing is likely to be applied without adequate professional advice and, as a result, structure damage may occur
	6	Culvert replacement	Replacement of one stream crossing	Yes	Bridge[e]	90.3	5.7	- -	5.7	4.3	- 1.4	0.75	No	- -	- -
	7	Combination onsite detention storage and structure floodproofing and elevation[c]	a. Floodproof up to three residential structures b. Elevate up to three residential structures c. Provide onsite detention storage facilities	Yes	Floodproofing Elevating Onsite detention storage facilities Subtotal	11.4 65.0 288.0 364.4	23.1	6.4	29.5	4.3	- 25.2	0.15[f]	No	See Alternative 5 above	See Alternative 5 above
	8	Combination onsite detention storage and culvert replacement[c]	a. Replacement of one stream crossing b. Provide onsite detention storage facilities	Yes	Bridge[e] Onsite detention storage facilities Subtotal	90.3 288.0 378.3	23.8	6.4	30.2	4.3	- 25.9	0.14[g]	No	Potential to retain public open space	- -
Taylor Avenue Upstream to Meachem Road	9	No action	- -	Yes	- -	- -	- -	- -	0.2[b]	- -	- -	- -	No	- -	- -
	10	Structure floodproofing	a. Floodproof two residential structures	Yes	Floodproofing	7.6	0.5	- -	0.5	0.2	- 0.3	0.40	No	Immediate partial flood relief at discretion of property owners Most of the costs would be borne by beneficiaries	Complete, voluntary implementation unlikely and therefore left with a significant residential flood problem. Overland flooding and some attendant problems remain Some floodproofing is likely to be applied without adequate professional advice and, as a result, structure damage may occur
	11	Combination onsite detention storage and structure floodproofing	a. Floodproof two residential structures b. Provide onsite detention storage facilities	Yes	Floodproofing Onsite detention storage facilities Subtotal	7.6 190.8 198.4	12.6	4.2	16.8	0.2	- 16.6	0.01	No	See Alternative 10 above	See Alternative 10 above

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

[b] *The total annual cost of this alternative consists of the average annual monetary flood damage.*

[c] *The economic analyses included costs for onsite storage. It should not be concluded that onsite storage is uneconomical based upon these data, since the use of onsite storage may permit the size and length of local storm water drainage facilities to be reduced with attendant cost reductions. The viability of onsite storage in this respect should be evaluated on a site specific basis.*

[d] *Excluding the costs for onsite storage and the benefits attendant thereto, the ratio of total average annual benefits to public costs is 0.07.*

Source: SEWRPC.

[e] *The cost of the bridge is based on an opening of 30 feet and reworking 100 feet of approach roads.*

[f] *Excluding the costs for onsite storage and the benefits attendant thereto, the ratio of total average annual benefits to public costs is 0.90.*

[g] *Excluding the costs for onsite storage and the benefits attendant thereto, the ratio of total average annual benefits to public costs is 1.23.*

[h] *Excluding the costs for onsite storage and the benefits attendant thereto, the ratio of total average annual benefits to public costs is 0.22.*

be more costly than the structure floodproofing and elevation alternative plan described above and would greatly exceed the benefits received from its implementation. Therefore, a no-action plan element would be practicable for this reach of Sorenson Creek.

Chicory Road Upstream to Pleasant Lane

Structure Floodproofing and Elevation: A structure floodproofing, elevation, and removal alternative flood control plan was analyzed to determine if such a structure-by-structure approach would be a technically and economically acceptable solution to the flood problem upstream of Chicory Road. For the purpose of this analysis, the 100-year recurrence interval flood stage under plan year 2000 land use and existing channel and floodplain conditions was used to estimate the number of flood-prone structures to be floodproofed, elevated, or removed and the approximate costs involved.

As shown on Map 61, the analysis indicated that a total of five structures may be expected to be located in the primary flood hazard area and one structure may be expected to be located in the secondary flood hazard area. Three structures located in the primary flood hazard area would have to be elevated, two structures would have to be floodproofed, and none would have to be removed under this alternative plan element. The structure located in the secondary flood hazard area would have to be floodproofed. Future flood damage to private residences along this reach would be virtually eliminated by the floodproofing and elevation. Table 91 sets forth the number and type of structures to be floodproofed and elevated and also summarizes the estimated costs and benefits.

Assuming that these structure floodproofing and elevation 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 $4,800 per year, consisting entirely of the amortization of the $76,700 capital cost, $11,400 for floodproofing and $65,300 for structure elevation. The average annual flood damage abatement benefit is estimated at $4,300 per year, yielding a benefit-cost ratio of 0.90. The structure floodproofing and elevation alternative plan, as described herein, while technically feasible, would not be economically sound.

Culvert Replacement Alternative: A bridge modification plan element was developed to eliminate the potential for the flood damage to residential structures located upstream of Chicory Road, as shown on Map 62. The 100-year recurrence interval flood discharge under plan year 2000 land use and existing channel and floodplain conditions was used as the basis for the preliminary design of this alternative.

The costs and benefits of this alternative plan element shown in Table 91 reflect the cost of replacing the existing dual culvert with a larger capacity clear span bridge which would cause no backwater effects and consequently eliminate the potential for causing upstream flood damages.

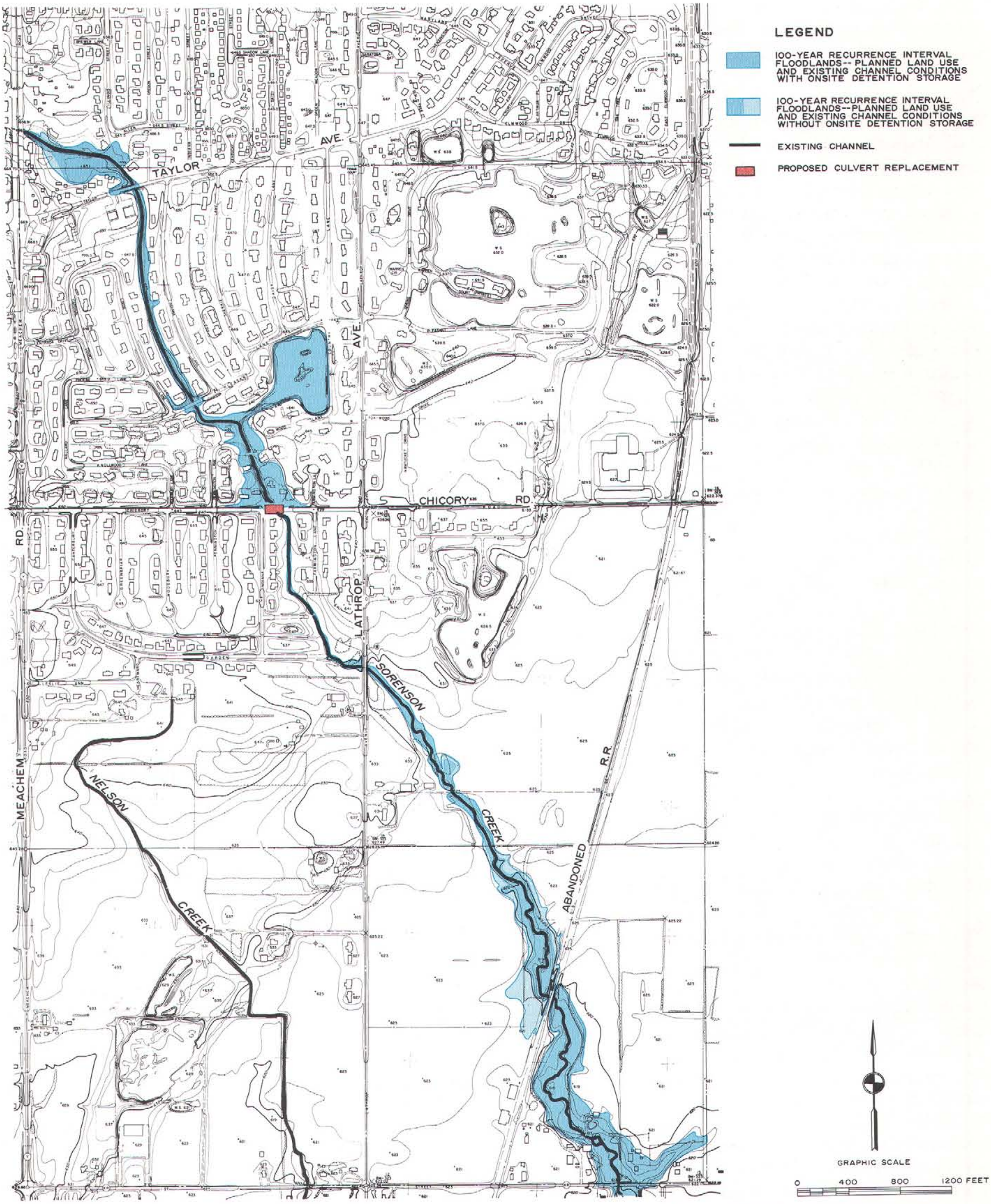
Assuming that the bridge replacement project would be implemented, and utilizing an annual interest rate of 6 percent and a project life of 50 years, the average annual cost is estimated at about $5,700 per year consisting entirely of the amortization of the $90,300 capital cost. The average annual flood abatement benefit is estimated at about $4,300 per year, yielding a benefit cost ratio of 0.75. Therefore, the bridge replacement plan element as described herein, while technically feasible would not be economically sound.

Combination Onsite Storage and Floodproofing and Elevation of Structures: A combination onsite storage and structure floodproofing, elevation, and removal alternative flood control plan was prepared and evaluated to determine if such an approach would be a technically and economically acceptable solution to the flood problem upstream of Chicory Road. This alternative assumes the continued application of the Town of Mt. Pleasant policy requiring that onsite storm water detention facilities be provided as land is converted from rural to urban use to prevent any increase in peak flood discharges and corresponding stages resulting from such urbanization.

This alternative plan element is similar to Alternative 5 as shown on Map 61, except that the provision of onsite storage would reduce the height of structure elevation. The analysis indicated that a total of five structures may be expected to be located in the primary flood hazard area and one may be expected to be located in the secondary flood hazard area. Three structures located in the primary flood hazard area would have to be elevated, two structures would have to be floodproofed, and none would have to be removed under this alternative plan element. The structure located in the secondary flood hazard area would have to be floodproofed. Future flood damage to private residences along this reach would be vir-

Map 62

CULVERT REPLACEMENT ALTERNATIVES FOR SORENSON CREEK



A culvert replacement alternative flood control plan was prepared and evaluated to determine if such a measure would provide a technically feasible and economically sound solution to the flood problem along Sorenson Creek. Under this alternative, the Chicory Road crossing of Sorenson Creek would be replaced with a clear span bridge. The provision of onsite detention storage as land is converted from rural to urban use upstream of CTH KR would have no significant impact on the size of the proposed bridge opening. While technically feasible, this alternative was found to be economically unsound.

Source: SEWRPC.

tually eliminated by the floodproofing and elevation. Table 91 sets forth the number and type of structures to be floodproofed and elevated and also summarizes the estimated costs and benefits.

Assuming that the onsite storage and structure floodproofing and elevation 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 $29,500 per year, consisting of the amortization of the $364,400 capital cost—$288,000 for onsite detention storage, $11,400 for floodproofing, and $65,000 for structure elevation—and $6,400 in annual operation and maintenance cost of the storage facilities. Although the onsite detention storage facilities could be provided by the land developer at no cost to the Town of Mt. Pleasant, the estimated capital cost of these facilities of $288,000, and the estimated annual operation and maintenance cost of $6,400 are properly included in any economic analysis of this alternative when evaluating major flood control alternatives on an areawide basis. The average annual flood damage abatement benefit is estimated at about $4,300 per year, resulting in a benefit-cost ratio of 0.15. On the basis of these findings, it should not be concluded that onsite storage is uneconomical in every case. In this respect it should be recognized that onsite storage may permit the size and length of local storm water drainage facilities to be reduced with attendant cost reductions. The viability of onsite storage in this respect should be evaluated on a site specific basis.

Excluding the costs for onsite storage and the benefits attendant thereto, the ratio of total average annual benefits to public costs is only 0.90. The onsite storage and structure floodproofing and elevating alternative plan, as described herein, while technically feasible, would not be economically sound.

Combination Onsite Storage and Culvert Replacement Alternative: A combination onsite storage and bridge modification plan element was prepared and evaluated to eliminate the potential for flood damage to residential structures located upstream of Chicory Road. This alternative assumes the continued application of the Town of Mt. Pleasant policy requiring that onsite storm water detention facilities be provided as land is converted from rural to urban use to prevent any increase in peak flood discharges and corresponding stages resulting from such urbanization up to and including the 100-year recurrence interval event. The analysis indicated that a clear span bridge as required under Alternative 3 under plan year 2000 land use conditions, as shown on Map 62, would also be required with the provision of onsite storm water detention storage. The size of the proposed bridge is based upon the top width of the existing channel, which would remain unchanged under both Alternative Plan 3 and this alternative.

Assuming that the onsite storage and bridge replacement project would be implemented, and utilizing an annual interest rate of 6 percent and a project life of 50 years, the average annual cost is estimated at about $30,200 per year, consisting of the amortization of the $378,300 capital cost of $288,000 for onsite detention storage and $90,300 for bridge replacement, and $6,400 in annual operation and maintenance cost of the storage facilities. Although the onsite detention storage facilities could be provided by the land developer at no cost to the Town of Mt. Pleasant, the estimated capital cost of these facilities of $288,000, and the estimated annual operation and maintenance cost of $6,400 are properly included in any economic analysis of this alternative when evaluating major flood control alternatives on an areawide basis. The average annual flood damage abatement benefit is estimated at about $4,300 per year, yielding a benefit-cost ratio of 0.14. On the basis of these findings, it should not be concluded that onsite storage is uneconomical in every case. In this respect it should be recognized that onsite storage may permit the size and length of local storm water drainage facilities to be reduced with attendant cost reductions. The viability of onsite storage in this respect should be evaluated on a site specific basis. Excluding the costs for onsite storage and the benefits attendant thereto, the ratio of total average annual benefits to public costs is 1.23. The onsite storage and bridge replacement plan element, as described herein, while technically feasible, was not found to be economically sound when considering both public and private costs along this reach of Sorenson Creek.

Taylor Avenue Upstream to Meachem Road Structure Elevation: A structure floodproofing, elevation, and removal alternative flood control plan was prepared and evaluated to determine if such a structure-by-structure approach would be a technically and economically acceptable solution to the flood problem upstream of Taylor Avenue. For the purpose of this analysis, the 100-year recurrence interval flood stage under plan year 2000 land use and existing channel and floodplain conditions was used to estimate the number of floodprone structures to be floodproofed, elevated, or removed and the approximate costs involved.

As shown on Map 61, the analysis indicated that two structures may be expected to be located in the secondary flood hazard area and none are expected to be located in the primary flood hazard area. The two structures located in the secondary flood hazard area would have to be floodproofed under this alternative plan element. Future flood damage to private residences along this reach would be virtually eliminated by the structure elevation. Table 91 sets forth the number and type of structures to be elevated and also summarizes the estimated costs and benefits.

Assuming that these structure elevation 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 $500 per year, consisting entirely of the amortization of the $7,600 capital cost for structure floodproofing. The average annual flood damage abatement benefit is estimated at $200 per year, yielding a benefit-cost ratio of 0.40. Therefore, the structure elevation alternative plan, as described herein, while technically feasible along this reach of Sorenson Creek, would not be economically sound.

Combination Onsite Storage and Elevation of Structures: A combination onsite storage and structure floodproofing, elevation, and removal alternative flood control plan was prepared and evaluated to determine if such a structure-by-structure approach would be a technically and economically acceptable solution to the flood problem upstream of Taylor Avenue. This alternative assumes the continued application of the Town of Mt. Pleasant policy requiring that onsite storm water detention facilities be provided as land is converted from rural to urban use to prevent any increase in peak flood discharges and corresponding stages resulting from such urbanization up to and including the 100-year recurrence interval event.

The analysis indicated that two structures may be expected to be located in the secondary flood hazard area and none are expected to be located in the primary flood hazard area, as also determined under Alternative 10 as shown on Map 61. The two structures located in the secondary flood hazard area would have to be floodproofed under this alternative plan element. Future flood damage to private residences along this reach would be virtually eliminated by the structure elevation. Table 91 sets forth the number and type of structures to be elevated and also summarizes the estimated costs and benefits.

Assuming that the onsite storage and structure elevation 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 $16,800 per year, consisting of the amortization of the $198,400 capital cost for onsite storage and structure floodproofing, and $4,200 in annual operation and maintenance cost of the storage facilities. Although the onsite detention storage facilities could be provided by the land developer at no cost to the Town of Mt. Pleasant, the estimated capital cost of these facilities of $190,800, and the estimated annual operation and maintenance costs of $4,200 are properly included in any economic analysis of this alternative when evaluating major flood control alternatives on an areawide basis. The average annual flood damage abatement benefit is estimated at $200, resulting in a benefit-cost ratio of 0.01. On the basis of these findings, it should not be concluded that onsite storage is uneconomical in every case. In this respect it should be recognized that onsite storage may permit the size and length of local storm water drainage facilities to be reduced with attendant cost reductions. The viability of onsite storage in this respect should be evaluated on a site specific basis. Excluding the cost for onsite storage and the benefits attendant thereto, the ratio of total average annual benefits to public costs is only 0.40. The onsite storage and structure elevation alternative plan, as described herein, while technically feasible, would not be economically sound along this reach of Sorenson Creek.

No Action Plan Element: As noted above, average annual damages to residential structures are relatively small, only $200 per year. Any technically feasible floodland management plan element which would alleviate these minor flood damages may be expected to be more costly than the structure elevation plan element described above and would greatly exceed the benefits received from its implementation. Therefore, the no action plan element would be practicable for this reach of Sorenson Creek.

ALTERNATIVE FLOODLAND MANAGEMENT PLAN ELEMENTS FOR KENOSHA BRANCH

The Flood Problem

The hydrologic-hydraulic simulation of Kenosha Branch under existing land use, channel, and floodplain conditions indicated that for the reach beginning 0.20 mile upstream from the confluence with the Pike River and extending upstream to 14th Street, there exists the potential for only minor flood damage to crops. Average annual monetary flood risks attributable to flood damage to crops are estimated by application of the economic submodel described in Chapter VIII, at about $100 under existing conditions, and $300 under plan year 2000 conditions. Under existing conditions, flood damages of about $500 during a 100-year recurrence interval flood event and about $300 during a 10-year recurrence interval flood event may be expected to be incurred. Under plan year 2000 land use and existing channel and floodplain conditions, flood damages of about $1,200 and $400 would be expected to be incurred, respectively, during 10- and 100-year flood events.

No Action Plan Element

As noted above, only minor flood damage to crops on an average annual basis is expected to be incurred along this reach of Kenosha Branch and would be relatively insignificant when compared to even the least expensive of the "action" alternative plan elements such as dikes, detention ponds, or major channelization. Accordingly, the cost of any project implemented to prevent these minor flood damages may be expected to greatly exceed the benefits received. Therefore, the no-action plan element would be practicable for this reach of Kenosha Branch.

ALTERNATIVE FLOODLAND MANAGEMENT PLAN ELEMENTS FOR PIKE CREEK

The Flood Problem

The hydrologic-hydraulic simulation of Pike Creek under existing land use and existing channel and floodplain conditions indicated that there exists the potential for flood damage to crops along almost the entire length of Pike Creek, beginning at CTH E and extending upstream of CTH K. There also exists the potential for flood damage to structures in the vicinity of the STH 142 crossing of Pike Creek, both upstream and downstream. Average annual monetary flood damages attributable to flood damage to structures and crops are estimated by application of the economic submodel described in Chapter VIII, at $64,000 under existing land use, channel, and floodplain conditions, and $93,500 under plan year 2000 land use and existing channel and floodplain conditions. If additional development were permitted in the flood hazard area, even higher monetary flood risks could be expected to be incurred. Under existing conditions, flood damages to crops and structures of about $134,000 and $79,000, respectively, during a 100-year recurrence interval flood event, and about $69,000 and $41,000, respectively, during a 10-year recurrence interval flood may be expected to be incurred. Under plan year 2000 conditions, flood damages to crops and structures of about $141,000 and $102,000, respectively, during a 100-year recurrence interval flood event, and about $91,000 and $74,000, respectively, during a 10-year recurrence interval flood event may be expected to be incurred.

Channel Enlargement Alternative

A channel enlargement plan element was developed and analyzed for the lands subjected to flooding by Pike Creek in order to determine if such a flood control measure would provide a technically and economically sound solution to the existing and anticipated future flood problem. The 100-year recurrence interval flood discharge under plan year 2000 land use conditions was used as the basis for the design of this alternative.

The channel enlargement alternative flood control plan element for Pike Creek is shown on Map 63, while the physical characteristics and estimated costs and benefits of this project are set forth in Table 92. Under this alternative plan element, the existing channel would be enlarged beginning at the confluence of Somers Branch with Pike Creek upstream to CTH K. Major channelization would be required from CTH K upstream to approximately one-quarter mile north of STH 50. The proposed channel would have a bottom width ranging from five to 20 feet with side slopes of one on three, and the existing streambed would be deepened upstream of the Town of Somers transfer station bridge. The deepening would range from three feet at CTH L to eight feet at CTH K, averaging about five feet. The proposed channels would be designed to provide two feet of freeboard during the design flood event.

This alternative plan element would also include replacement of the following six bridges over Pike Creek: 1) CTH E, 2) Town of Somers transfer station, 3) STH 142, 4) STH 158, 5) CTH K, and 6) the Milwaukee Road. It should be noted that the four highway bridges are designated for reconstruction under the Commission's year 2000 transportation plan set forth in SEWRPC Planning Report No. 25, A Regional Land Use Plan and a Regional Transportation Plan for Southeastern Wisconsin: 2000, which has been adopted by Kenosha County and the Wisconsin Department of Transportation. Therefore, the cost of the

Table 92

PRINCIPAL FEATURES, COSTS, AND BENEFITS OF FLOODLAND MANAGEMENT ALTERNATIVES FOR PIKE CREEK

Alternative				Economic Analysis[a]										
Number	Name	Description	Technically Feasible	Capital Cost: Item	Capital Cost (thousands)	Annual Amortized Capital Cost (thousands)	Annual Operation and Maintenance Cost (thousands)	Total Annual Cost (thousands)	Annual Benefits (thousands)	Excess of Annual Benefits Over Cost (thousands)	Benefit-Cost Ratio	Benefit-Cost Ratio Greater Than 1.0	Nontechnical and Noneconomic Considerations: Positive	Nontechnical and Noneconomic Considerations: Negative
1	No action	- -	Yes	- -	$ - -	$ - -	$ - -	$ 93.5[b]	$ - -	$ - -	- -	No	- -	- -
2	Channel enlargement	a. 4.7 miles of channel enlargement (10- to 20-foot bottom width, one on three side slopes) b. 3.3 miles of channel deepening (one- to eight-foot deepening) c. 0.8 mile of major channelization (five- to 10-foot bottom width, one on three side slopes) d. Replacement of six bridges	Yes	Channel enlargement and major channelization Bridge replacement Subtotal	489.0 119.0[c] 608.0	38.0	6.0	44.3	93.5	49.2	2.11	Yes	- -	- -
3	Combination channel enlargement and diking	a. 4.7 miles of channel enlargement (five- to 10-foot bottom width, one on three side slopes) b. 3.3 miles of channel deepening (one- to eight-foot deepening) c. 0.8 mile of major channelization (five- to 10-foot bottom width, one on three side slopes) d. Replacement of six bridges e. 5.5 miles of dikes along both sides of channel	Yes	Channel enlargement and major channelization Bridge replacement Dikes Subtotal	330.0 111.0[c] 55.0 496.0	31.2	38.6	69.8	93.5	23.7	1.34	Yes	- -	- -
4	Detention storage reservoir	a. Two reservoirs b. 3.1 miles of channel clearing and debrushing c. 0.6 mile of channel enlargement and deepening (five-foot bottom width, one on three side slopes, one- to five-foot deepening) d. 0.4 mile of major channelization (five-foot bottom width. One on three side slopes)	Yes	Reservoirs Channel clearing and debrushing Channel enlargement and major channelization Subtotal	733.0 90.0 77.0 900.0	56.7	5.0	61.7	93.5	31.8	1.52	Yes	Potential to retain public open space	- -
5	Combination onsite storage and channel enlargement	a. 4.7 miles of channel enlargement (10- to 20-foot bottom width, one on three side slopes) b. 3.3 miles of channel deepening (one- to eight-foot deepening) c. 0.8 mile of major channelization (five-foot bottom width, one on three side slopes) d. Replacement of six bridges e. Provide onsite detention storage facilities	Yes	Channel enlargement and major channelization Bridge replacement Onsite detention storage facilities Subtotal	459.0 111.0[c] 4,644.0 5,214.0	328.0	109.0	437.0	93.5	-376.1	0.21[d]	No	See Alternative 4 above	- -
6	Combination onsite storage and detention storage reservoir	a. Two reservoirs b. 3.1 miles of channel clearing and debrushing c. 0.8 mile of channel enlargement and deepening (five-foot bottom width, one on three side slopes, one- to five-foot deepening) d. 0.4 mile of major channelization (five-foot bottom width, one on three side slopes) e. Provide onsite detention storage facilities	Yes	Reservoirs Channel clearing and debrushing Channel enlargement and major channelization Onsite detention storage facilities Subtotal	610.0 90.0 99.0 4,644.0 5,399.0	340.0	108.0	448.0	93.5	-354.5	0.21[e]	No	See Alternative 4 above	- -

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

[b] *The total annual cost consists of the average annual monetary flood damages.*

[c] *The bridge replacement costs do not include the costs associated with four bridges designated for reconstruction under the Commission's year 2000 transportation plan.*

[d] *Excluding the costs for onsite storage and the benefits attendant thereto, the ratio of total average annual benefits to annual public costs is 1.53.*

[e] *Excluding the costs for onsite storage and the benefits attendant thereto, the ratio of total average annual benefits to annual public costs is 1.16.*

Source: SEWRPC.

replacement of these bridges—totaling $990,000—was not included in the cost analysis of the alternative flood control plan elements.

Utilizing an annual interest rate of 6 percent and an amortization period and project life of 50 years, the average annual cost of the channel enlargement alternative is estimated at $44,300, consisting of amortization of the $608,000 capital cost of channel enlargement, major channelization, and bridge replacement; and $6,000 in annual operation and maintenance cost of the channelized reach. The average annual flood abatement benefit is estimated at $93,500, resulting in an excess of $49,200 in annual benefits over costs, and a benefit-cost ratio of 2.11. Therefore, the channel enlargement alternative plan, as described herein, may be considered to be both technically feasible and economically sound.

The cost of this alternative plan element was also computed utilizing an annual interest rate of 10 percent to determine the effect on the average annual cost of this project. Assuming this interest rate, the average annual cost is estimated at about $66,800, resulting in an excess of $26,700 in annual benefits over costs, and a benefit-cost ratio of 1.40. Therefore, the channel enlargement alternative plan would also be economically sound under a 10 percent annual interest rate.

Combination Channel
Enlargement and Dike Alternative

A combination channel enlargement and dike alternative plan element was developed and analyzed for the lands subjected to flooding by Pike Creek in order to determine if such a flood control measure would provide a technically and economically sound solution to the existing and anticipated future flood problem. The 100-year recurrence interval flood discharge under plan year 2000 land use conditions was used as the basis for the preliminary design of this alternative.

The combination channel enlargement and dike alternative flood control plan element is shown on Map 64, while the physical characteristics and estimated costs and benefits of this project are set forth in Table 92. The assumed dike design is shown in Figure 52. Under this alternative plan element, a similar channel improvement as proposed in the channel enlargement alternative plan element would be carried out, except that the additional provision of dikes along both sides of the channel would allow for a channelized reach with a bottom width of not more than 10 feet, thus reducing the amount of excavation required. The dikes would have an average height of about two feet, would not exceed four feet in height, and would be designed to provide about two feet of freeboard during the design flood event.

Utilizing an annual interest rate of 6 percent and an amortization period and project life of 50 years, the average annual cost of the combination channel enlargement and dike alternative is estimated at $69,800, consisting of amortization of the $496,000 capital cost of the channel enlargement, major channelization, dike construction, and bridge replacement, and $38,600 in annual operation and maintenance cost of the enlarged channel and dikes. The average annual flood abatement benefit is estimated at $93,500, resulting in an excess of $23,700 in annual benefits over costs and a benefit-cost ratio of 1.34. Therefore, the channel enlargement and dike alternative plan, as described herein, is considered to be both technically feasible and economically sound.

The cost of this alternative plan element was also computed utilizing an annual interest rate of 10 percent to determine the effect on the average annual cost of this project. Assuming this interest rate, the average annual cost is estimated at about $88,200, resulting in an excess of $5,300 in annual benefits over costs, and a benefit-cost ratio of 1.06. Therefore, the combination channel enlargement and dike alternative plan would also be economically sound under a 10 percent annual interest rate.

Detention Storage Reservoir Alternative

A detention storage reservoir plan element was developed and analyzed for the lands subject to flooding by Pike Creek in order to determine if such a flood control measure would provide a technically and economically sound solution to the existing and anticipated future flood problem. The 100-year recurrence interval flood discharge under plan year 2000 land use conditions was used as the basis for the preliminary design of this alternative.

The detention storage reservoir alternative flood control plan element for Pike Creek is shown on Map 65, while the physical characteristics and estimated costs and benefits of this project are set forth in Table 92. The assumed reservoir outlet control structure design is shown in Figure 57. Under this alternative plan element, two detention storage reservoir sites would be provided—one located immediately upstream of STH 142, and another located immediately upstream of the Milwaukee Road. The STH 142 reservoir would be confined by the existing STH 142 embankment on the north, the Chicago & North Western Transportation Company enbankment on the east, and confined elsewhere by the existing topography, encompassing an area of about 180 acres. The Milwaukee Road reservoir would be confined by a proposed earthen dike on the north, the Milwaukee Road on the east, and confined elsewhere by the existing topography, encompassing an area of about 64 acres. Also under this alternative, clearing and debrushing of the existing channel from the confluence of Somers Branch upstream to STH 142 would be required, along with channel enlargement and deepening from STH 158 upstream to CTH K, and major channelization from CTH K upstream to the Milwaukee Road. The proposed channel would have a bottom width of five feet with side slopes of one on three. The deepening would range from one to five feet averaging about three feet. The following four bridges would also be replaced: 1) STH E, 2) STH 142, 3) STH 158, and 4) CTH K. As noted above in the discussion of the channel enlargement alternative, the replacement cost of these four bridges was not included in the cost analysis of alternative flood control plan elements.

Utilizing an annual interest rate of 6 percent and an amortization period and project life of 50 years, the average annual cost of the detention storage reservoir alternative is estimated at $61,700, consisting of amortization of the $900,000 capital cost of land acquisition, channel enlargement, major channelization, channel clearing and debrushing, and dike construction; and $5,000 in annual operation and maintenance cost of the channelized reaches and earthen dikes. The average annual flood abatement benefit is estimated at $93,500, resulting in an excess of $31,800 in annual benefits over costs, and a benefit-cost ratio of 1.52. Therefore, the detention storage reservoir plan element, as described herein, may be considered to be both technically feasible and economically sound.

The cost of this alternative plan element was also computed utilizing an annual interest rate of 10 percent to determine the effect on the average annual cost of this project. Assuming this interest rate, the average annual cost is estimated at about $95,000, resulting in an excess of $1,500 in annual costs over benefits, and a benefit-cost ratio of 0.98. Therefore, the estimated annual cost of the detention storage reservoir alternative plan would not be economically sound using a 10 percent annual interest rate.

Combination Onsite Storage and Channel Enlargement Alternative

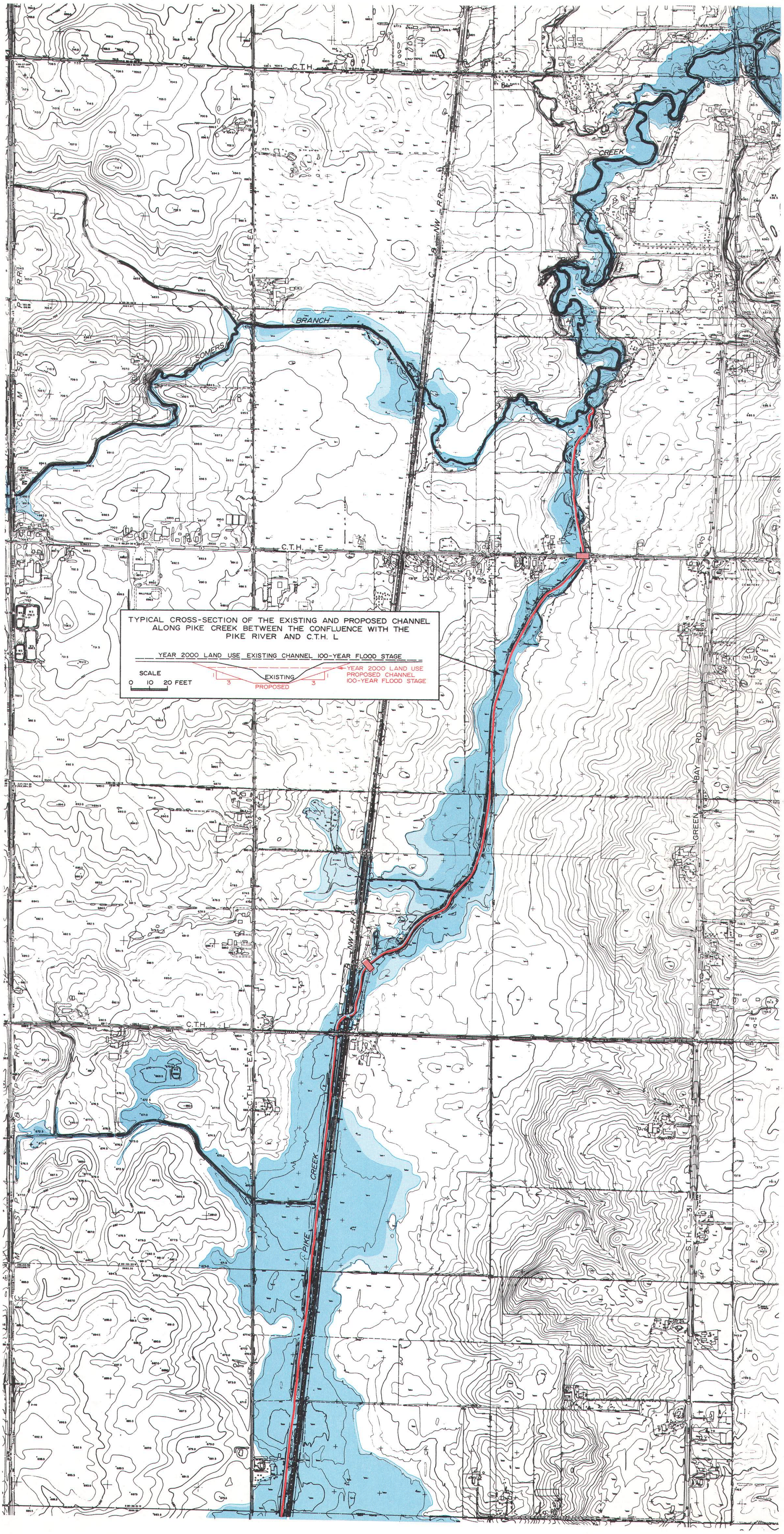
A combination onsite storage and channel enlargement plan element was developed and analyzed for the lands subject to flooding by Pike Creek in order to determine if such a flood control measure would provide a technically and economically sound solution to the existing and anticipated flood problems. This alternative assumes the adoption of an ordinance similar to that adopted by the Town of Mt. Pleasant requiring that onsite storm water detention facilities be provided as land is converted from rural to urban use to prevent any increase in peak flood discharges and corresponding stages resulting from such urbanization.

The onsite storage and channel enlargement alternative flood control plan element for Pike Creek is shown on Map 63, while the physical characteristics and estimated costs and benefits of this project are set forth in Table 92. Under this alternative plan element, a similar channel improvement as proposed in the channel enlargement alternative plan element would be carried out, except that the provision of onsite storage facilities on newly developed land under this alternative plan element would allow for a smaller channel upstream of STH 142 with a bottom width of not more than 10 feet, thus reducing the amount of excavation required. The existing channel would be enlarged beginning at the confluence of Somers Branch with Pike Creek upstream to CTH K. Major channelization would be required from CTH K upstream to approximately one-quarter mile north of STH 50. The proposed channel would have a bottom width ranging from five to 10 feet with side slopes of one on three, and the existing streambed would be deepened upstream of the Town of Somers transfer station bridge to CTH K. The deepening would range from three feet at STH L to eight feet at CTH K, averaging about four feet. The proposed channels would be designed to provide two feet of freeboard during the design flood event. This alternative plan element would also include replacement of the following six bridges over Pike Creek: 1) CTH E, 2) Town of Somers transfer station, 3) STH 142, 4) STH 158, 5) CTH K, and 6) the Milwaukee Road. As noted above in the discussion of the channel enlargement alternative, the replacement cost of the four highway bridges was not included in the cost analysis of alternative flood control plan elements.

Utilizing an annual interest rate of 6 percent and an amortization period and project life of 50 years, the average annual cost of the onsite detention storage and channel enlargement alternative is estimated at $437,000, consisting of amortization of the $5,214,000 capital cost of the onsite detention storage, channel enlargement, and bridge replacement; and $109,000 in annual operation and maintenance cost of the storage facilities and enlarged channel. Although the onsite detention storage facilities could be provided by the land developer at no cost to the Town of Somers, the estimated capital cost of these facilities of $4,644,000, and the estimated annual operation and maintenance cost of $103,000—are properly included in the total average annual cost of this alternative when evaluating major flood control alternatives on an areawide basis. The average annual flood abatement benefit is estimated at $93,500, resulting in an excess of $376,100 in annual costs over benefits, and a benefit-cost ratio of 0.21. On the basis

Map 63

CHANNEL ENLARGEMENT ALTERNATIVES FOR PIKE CREEK



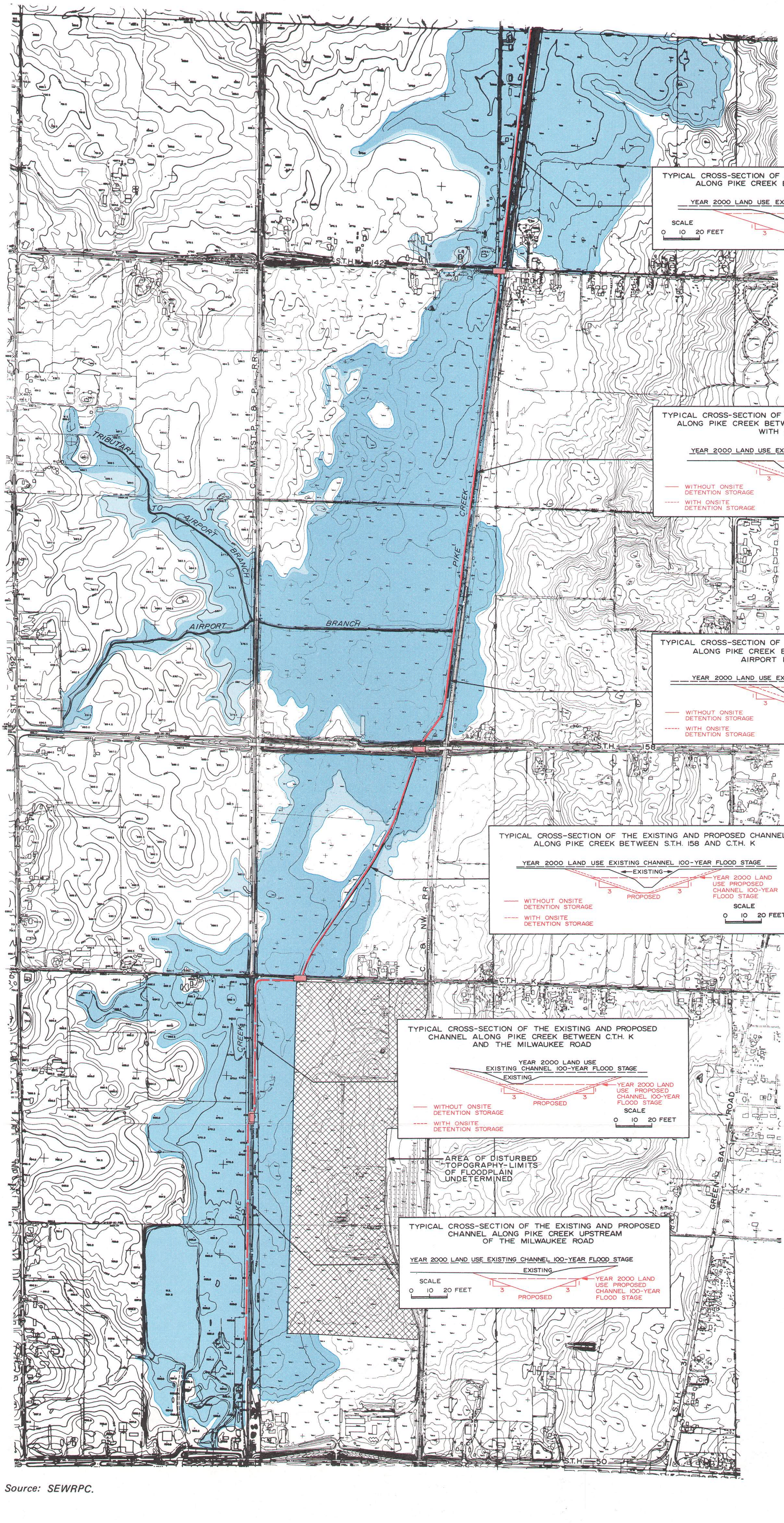
LEGEND

- 100-YEAR RECURRENCE INTERVAL FLOODLANDS--PLANNED LAND USE AND EXISTING CHANNEL CONDITIONS WITH ONSITE DETENTION STORAGE
- 100-YEAR RECURRENCE INTERVAL FLOODLANDS--PLANNED LAND USE AND EXISTING CHANNEL CONDITIONS WITHOUT ONSITE DETENTION STORAGE
- EXISTING CHANNEL
- PROPOSED CHANNEL ENLARGEMENT
- PROPOSED MAJOR CHANNELIZATION
- PROPOSED BRIDGE REPLACEMENT

GRAPHIC SCALE

0 400 800 1200 FEET

Map 63 (continued)

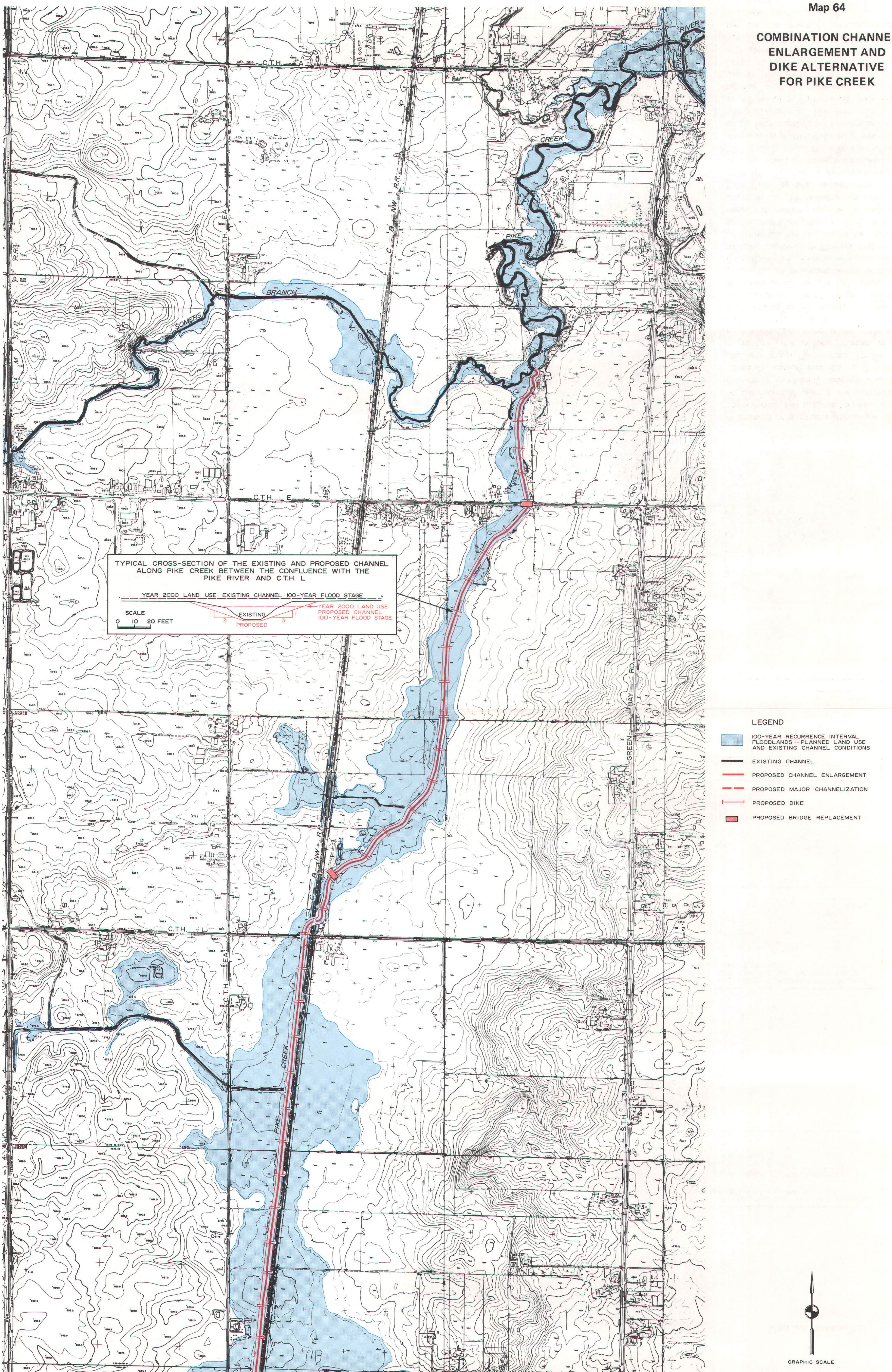


Source: SEWRPC.

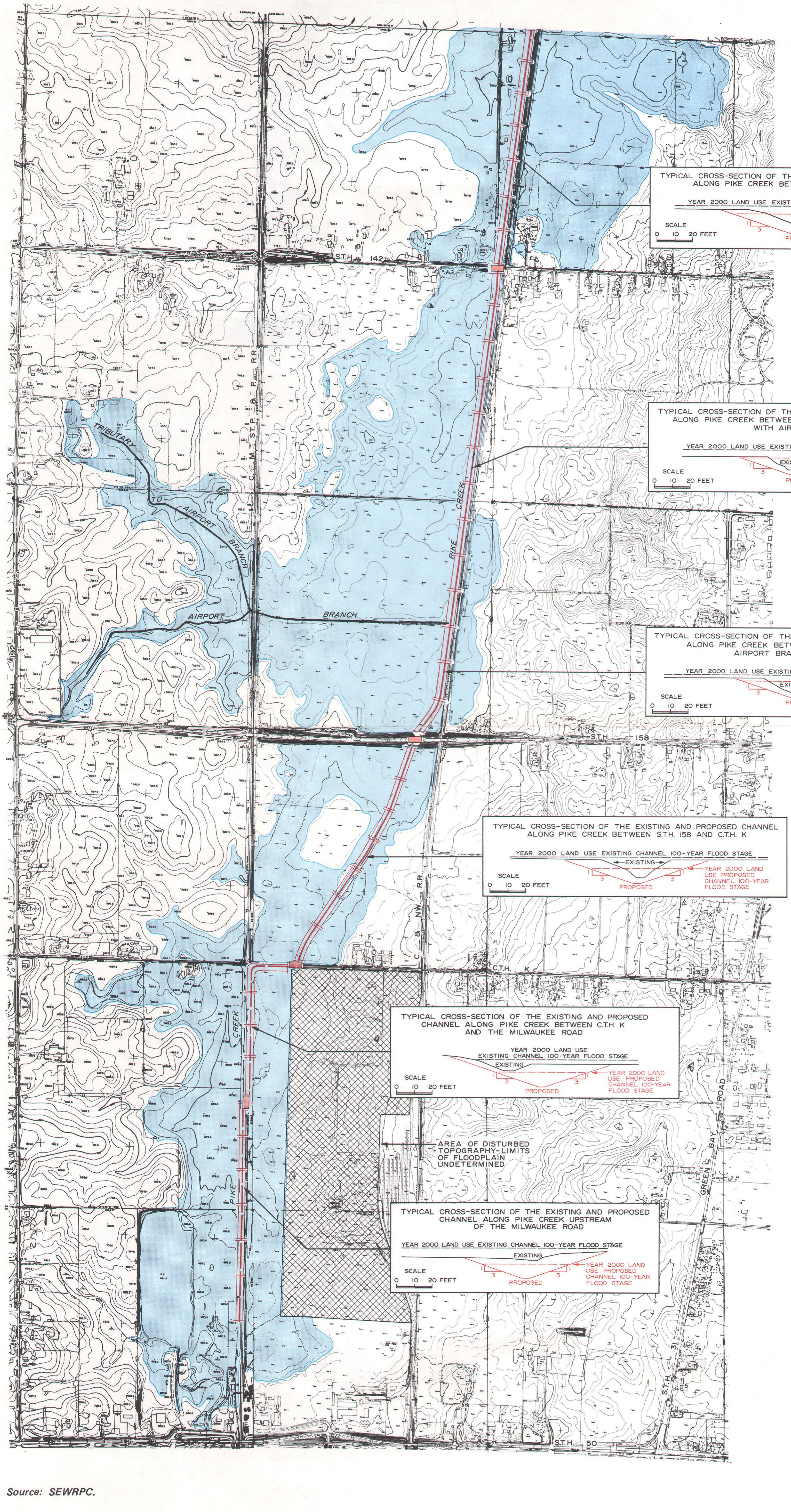
A channel enlargement alternative flood control plan was prepared and evaluated to determine if such a measure would provide a technically feasible and economically sound solution to the flood problem along Pike Creek. Under this alternative, the existing channel would be modified beginning at the confluence with Somers Branch and extending upstream to approximately one quarter mile north of STH 50. Channel clearing and debrushing would be carried out beginning at the confluence with the Pike River and extending upstream to the confluence with Somers Branch. In addition, six bridges would be replaced to accommodate the larger channel. If onsite detention storage is provided upstream of the confluence with the Pike River as land is converted from rural to urban use, a somewhat smaller channel could be provided upstream of STH 142. Without the provision of such onsite storage, this alternative was found to be both technically feasible and economically sound. However, economic soundness of this alternative with onsite storage must be evaluated on a site specific basis since the additional cost of onsite storage may not be offset by the cost savings attendant to reductions in the size of the channel improvement and the size and length of local stormwater drainage facilities covered.

Map 64

COMBINATION CHANNEL ENLARGEMENT AND DIKE ALTERNATIVE FOR PIKE CREEK



Map 64 (continued)

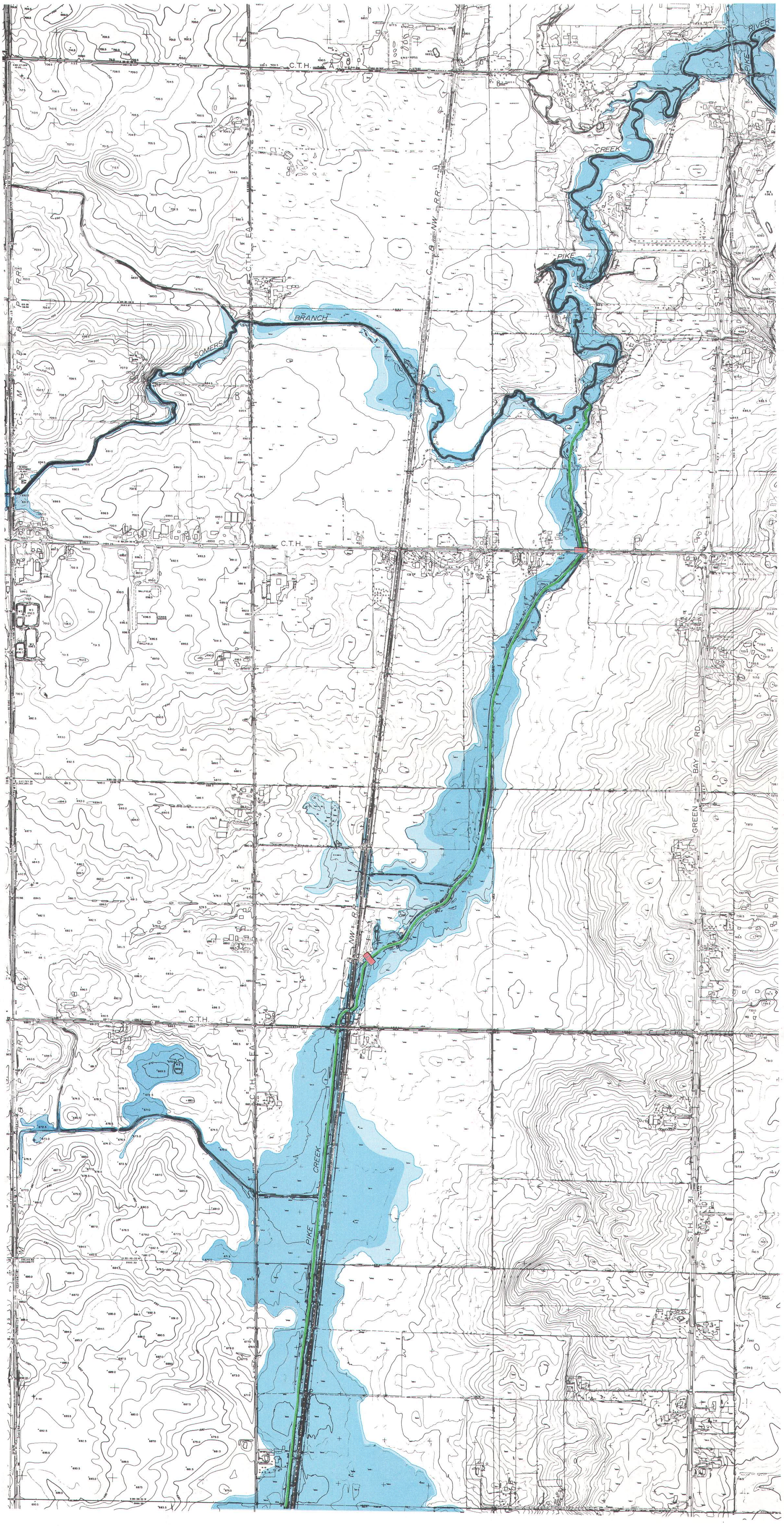


Source: SEWRPC.

A combination channel enlargement and dike alternative flood control plan was prepared and evaluated to determine if such a measure would provide a technically feasible and economically sound solution to the flood problem along Pike Creek. Under this alternative, the existing channel would be modified beginning at the confluence with Somers Branch and extending upstream to approximately one quarter mile north of STH 50. In addition, dikes would be constructed along both sides of the enlarged channel, and six bridges would be replaced to accommodate the larger channel. This alternative was found to be both technically feasible and economically sound.

Map 65

DETENTION STORAGE RESERVOIR ALTERNATIVES FOR PIKE CREEK



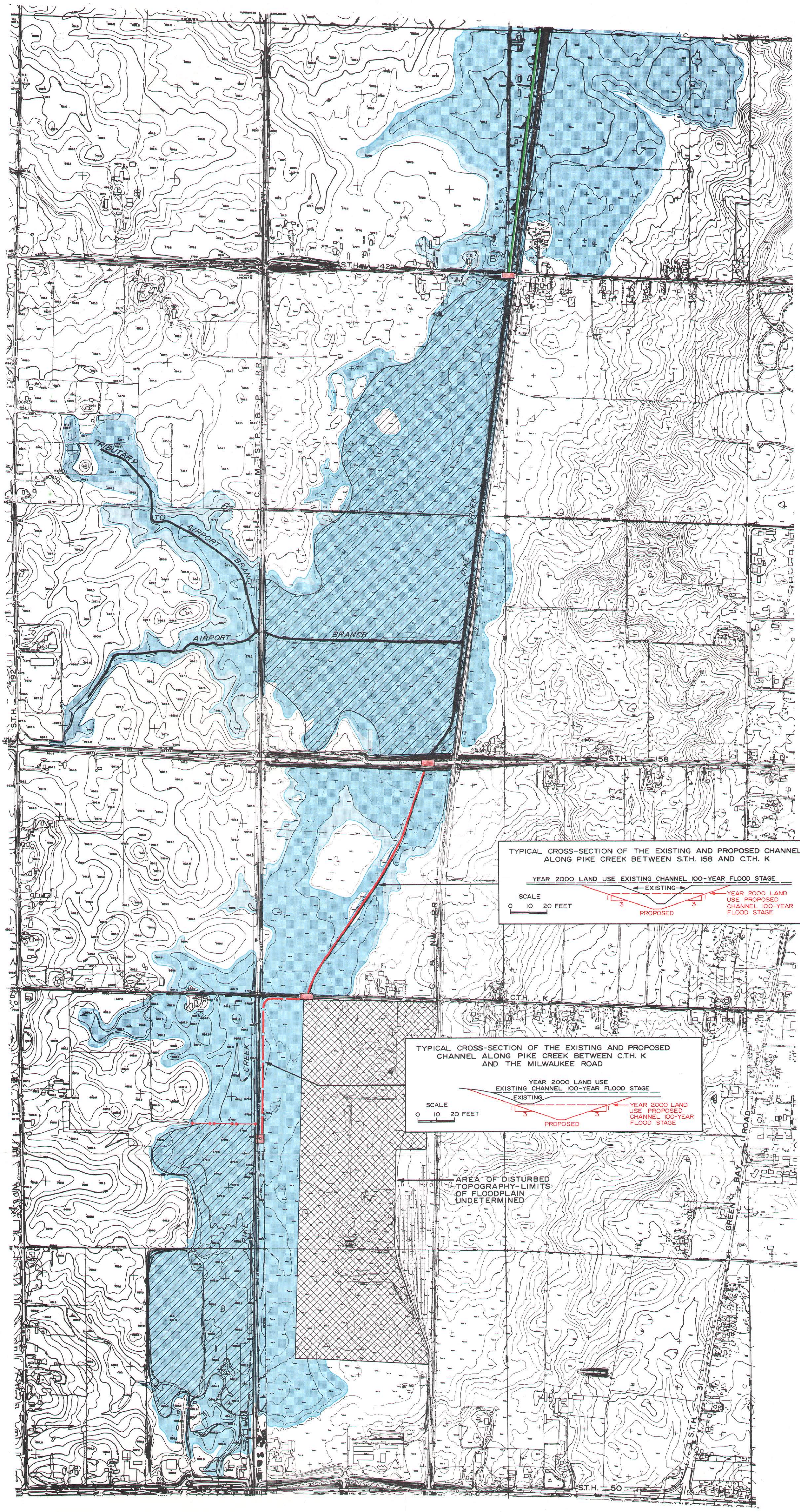
LEGEND

- 100-YEAR RECURRENCE INTERVAL FLOODLANDS--PLANNED LAND USE AND EXISTING CHANNEL CONDITIONS WITH ONSITE DETENTION STORAGE
- 100-YEAR RECURRENCE INTERVAL FLOODLANDS--PLANNED LAND USE AND EXISTING CHANNEL CONDITIONS WITHOUT ONSITE DETENTION STORAGE
- EXISTING CHANNEL
- PROPOSED CHANNEL CLEARING AND DEBRUSHING
- PROPOSED CHANNEL ENLARGEMENT
- PROPOSED MAJOR CHANNELIZATION
- PROPOSED DETENTION STORAGE RESERVOIR
- PROPOSED EARTHEN EMBANKMENT
- EXISTING CULVERT PROPOSED TO ACT AS RESERVOIR OUTLET CONTROL STRUCTURE
- PROPOSED BRIDGE REPLACEMENT

GRAPHIC SCALE

0 400 800 1200 FEET

Map 65 (continued)



Source: SEWRPC.

A detention storage reservoir alternative flood control plan was prepared and evaluated to determine if such a measure would provide a technically feasible and economically sound solution to the flood problem along Pike Creek. Under this alternative, two detention storage reservoirs would be provided—one located immediately upstream of STH 142 providing about 600 acre-feet of storage on an area of about 180 acres; and another located immediately upstream of the Milwaukee Road crossing providing about 170 acre-feet of storage on an area of about 64 acres. In addition, 3.1 miles of channel clearing and debrushing, and 1.0 mile of channel modification would be required, along with replacement of four bridges. If onsite storage is provided upstream of the STH 142 reservoir site as land is converted from rural to urban use, the size of the STH 142 reservoir could be reduced to about 400 acre-feet of storage on an area of about 144 acres; and the size of the Milwaukee Road reservoir could be reduced to about 140 acre-feet of storage on an area of about 57 acres. Without the provision of onsite storage, this alternative was found to be both technically feasible and economically sound. However, the economic soundness of this alternative with onsite storage must be evaluated on a site specific basis since the additional cost of the onsite storage may not be offset by the cost savings attendant to the reduction in the reservoir sizes or to the reductions in the size and length of local stormwater drainage facilities.

of these findings, it should not be concluded that onsite storage is uneconomical in every case. In this respect it should be recognized that onsite storage may permit the size and length of local storm water drainage facilities to be reduced with attendant cost reductions. The viability of onsite storage in this respect should be evaluated on a site specific basis. Excluding the cost for onsite storage and the benefits attendant thereto, the ratio of total average annual benefits to annual public costs is 1.53, and annual benefits exceed the annual cost by $22,100.

The onsite detention storage and channel enlargement alternative plan, as described herein, may be considered technically feasible. The alternative was found not to be economically sound if both public and private costs are considered.

Combination Onsite Storage and Detention Storage Reservoir Alternative

A combination onsite storage and detention storage reservoir plan element was developed and analyzed for the lands subject to flooding by Pike Creek in order to determine if such a flood control measure would provide a technically and economically sound solution to the existing and anticipated future flood problem. This alternative assumes the adoption of a policy similar to that adopted by the Town of Mt. Pleasant requiring that onsite storm water detention facilities be provided as land is converted from rural to urban use to prevent any increase in peak flood discharges and corresponding stages resulting from such urbanization up to and including the 100-year recurrence interval event.

The onsite storage and detention storage reservoir alternative flood control plan element for Pike Creek is shown on Map 65, while the physical characteristics and estimated costs and benefits of this project are set forth in Table 92. The assumed reservoir outlet control structure design is shown in Figure 57. This alternative plan element is similar to Alternative 6, except that provision of onsite storage would require less land for the two detention reservoirs. The STH 142 reservoir would be confined by the existing STH 142 embankment on the north, the Chicago & North Western Transportation Company enbankment on the east, and confined elsewhere by the existing topography, encompassing an area of about 144 acres. The Milwaukee Road reservoir would be confined by a proposed earthen dike on the north, the Milwaukee Road on the east, and confined elsewhere by the existing topography, encompassing an area of about 57 acres. Also under this alternative, clearing and debrushing of the existing channel from the confluence of Somers Branch upstream to STH 142 would be required, along with channel enlargement and deepening from STH 158 upstream to CTH K, and major channelization from CTH K upstream to the Milwaukee Road. The proposed channel would have a bottom width of five feet with side slopes of one on three. The deepening would range from one to five feet, averaging about three feet. The following four bridges would also be replaced: 1) STH E, 2) STH 142, 3) STH 158, and 4) CTH K. As noted above in the discussion of the channel enlargement alternative, the replacement cost of these four bridges was not included in the cost analysis of alternative flood control plan elements.

Utilizing an annual interest rate of 6 percent and an amortization period and project life of 50 years, the average annual cost of the onsite storage and detention storage reservoir alternative is estimated at $448,000, consisting of amortization of the $5,399,000 capital cost of the onsite detention storage, land acquisition, channel enlargement, channel clearing and debrushing, bridge replacement, and dike construction; and $108,000 in annual operation and maintenance cost of the onsite storage facilities and channelized reaches. Although the onsite detention storage facilities could be provided by the land developer at no cost to the Town of Somers, the estimated capital cost of these facilities of $4,644,000, and the estimated annual operation and maintenance cost of $103,000, are properly included in any economic analysis of this alternative when evaluating major flood control alternatives on an areawide basis. The average annual flood abatement benefit is estimated at $93,500, resulting in an excess of $354,500 in annual costs over benefits and a benefit cost ratio of 0.21. On the basis of these findings, it should not be concluded that onsite storage is uneconomical in every case. In this respect it should be recognized that onsite storage may permit the size and length of local storm water drainage facilities to be reduced with attendant cost reductions. The viability of onsite storage in this respect should be evaluated on a site specific basis. Excluding the costs for onsite storage and the benefits attendant thereto, the ratio of total average annual benefits to public annual costs is 1.16, and annual benefits exceed the annual costs by $8,700.

The onsite storage and detention storage reservoir alternative plan, as described herein, may be considered technically feasible. However, estimated annual costs exceed annual benefits by a substantial amount and the alternative is not economically sound when considering both public and private costs.

Hydraulic Analysis of the Bridge Over Pike Creek Near the Town of Somers Solid Waste Transfer Station

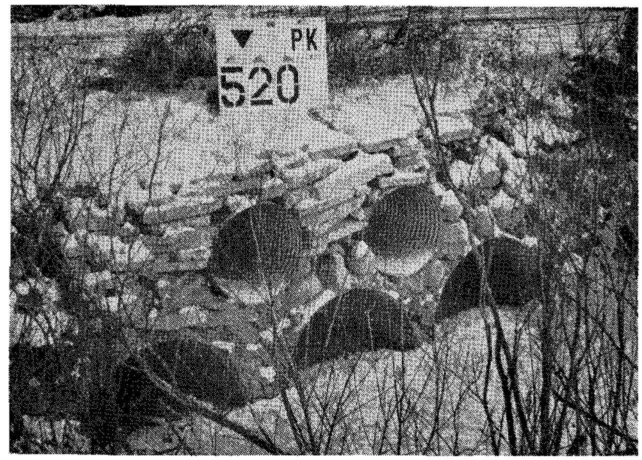
In early 1980, the Kenosha County Drainage Board ordered the Town of Somers to replace the culverts carrying the access road to the Town solid waste transfer station over Pike Creek in order to relieve flooding conditions in fields upstream, reportedly caused by the backwater effects of the bridge. After discussion with the Pike River Watershed Committee, it was concluded that any recommendations concerning alternative floodland management measures for this structure on Pike Creek should be preceded by appropriate hydraulic analyses to be conducted as part of the watershed study. Accordingly, the Town of Somers reached an agreement with the Kenosha County Drainage Board to postpone action on this matter until both bodies could consider the findings and recommendations of the watershed study.

The subject creek crossing consists of two three-foot diameter culverts placed over three five-foot diameter culverts placed directly on the stream bottom, as shown in Figure 58. Hydraulic analyses conducted by the Commission staff indicated the culverts have a combined hydraulic capacity adequate to assure no significant hydraulic backwater. Figure 59 illustrates the upstream extent of such backwater effects for the 10- and 100-year recurrence interval flood events if the bridge opening is not blocked by debris. Under 10-year recurrence interval flood conditions, the backwater caused by the bridge absent any blockage becomes less than 0.2 foot—at a point about 0.4 mile upstream. Furthermore, the 10-year event, though not contained entirely within the channel, would normally cause high water conditions for less than 12 hours. In a 100-year recurrence interval flood event, the entire bridge becomes submerged and thereby becomes hydraulically insignificant.

The potential exists, however, for the waterway openings in the structure to become blocked by debris. Should such blockage of the waterway openings occur, flow may be expected to be forced over the top of the bridge during even relatively small storm events which are likely to occur several times annually, resulting in stages as high as the 10-year flood with attendant inundation of agricultural drainage tile outlets, thus inhibiting the effectiveness of drainage from adjacent fields. Moreover, these high water levels may be sustained for long periods of time if the culverts are left severely blocked. No overbank flooding would be attributable to such obstructed flow conditions, however, because the banks are high in the affected reach upstream.

Figure 58

BRIDGE OVER PIKE CREEK NEAR THE TOWN OF SOMERS SOLID WASTE TRANSFER STATION



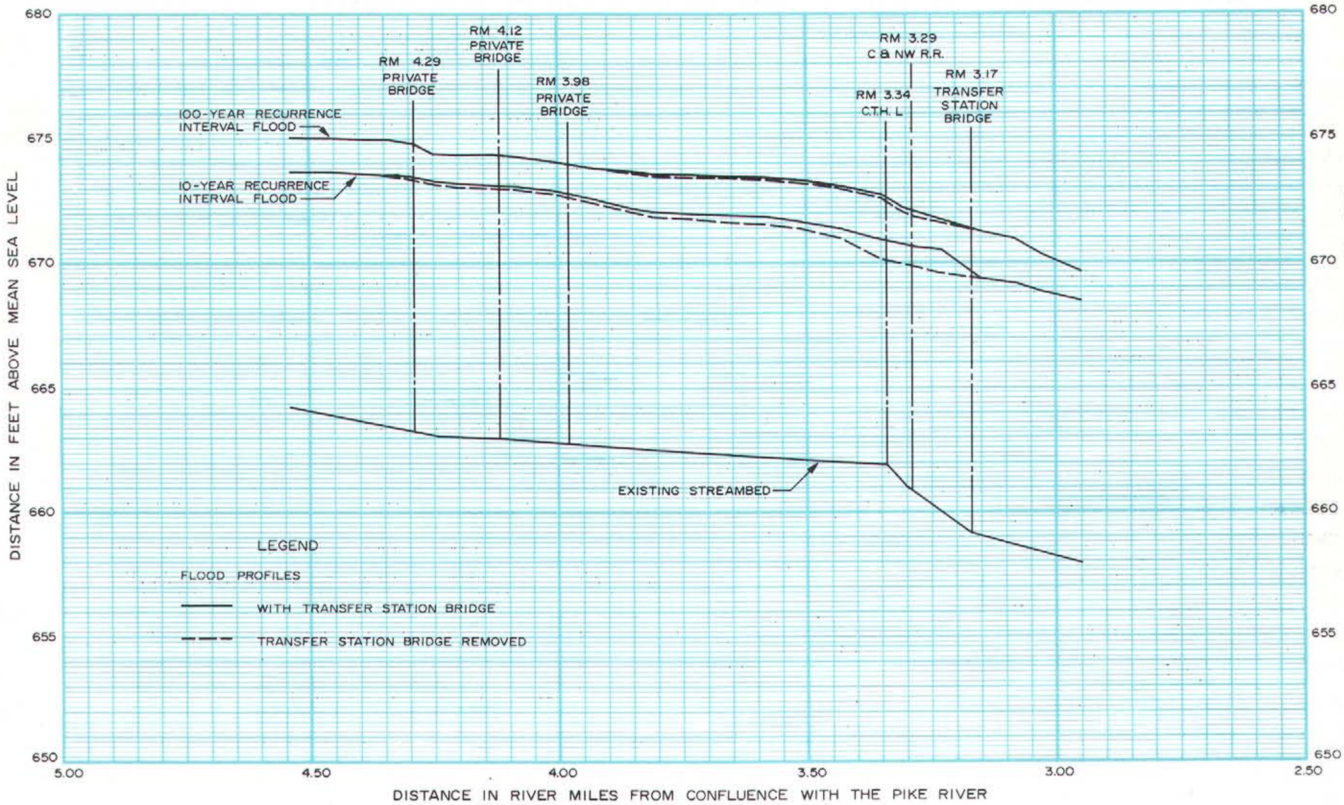
Source: SEWRPC.

Two alternatives exist to alleviate the potential problems associated with this structure. The first alternative would provide for the replacement of the structure with a new structure having a clear span opening, thus reducing the potential for blockage of the opening by water borne debris or ice. The Town of Somers has already obtained design plans for such a replacement structure, that being a timber structure having an estimated construction cost of about $40,000 in 1980 dollars.

The second alternative consists of retaining the existing structure and providing a maintenance program for removal of debris from the structure opening. Under such a program, debris would be removed from the structure opening after significant storm events, thus preventing the buildup of debris and eventual blockage of the opening when future storm events occur. This structure maintenance program could be expected to cost approximately $250 annually. This cost estimate assumes

Figure 59

EFFECTS OF TOWN OF SOMERS TRANSFER STATION BRIDGE ON FLOOD STAGES ALONG PIKE CREEK



Source: SEWRPC.

debris removal five times annually, requiring a single Town employee at a cost of $11 per hour, a vehicle operating cost of $5 per round trip, and approximately four hours to complete the debris removal effort.

ALTERNATIVE FLOODLAND MANAGEMENT PLAN ELEMENTS FOR THE UPPER PIKE RIVER

The Flood Problem

The hydrologic-hydraulic simulation of the Upper Pike River under existing land use, channel, and floodplain conditions indicated that there exists the potential for flood damage to crops along the entire length of this stream reach. There also exists the potential for flood damage to structures at five locations along this stream reach. Average annual monetary flood damages attributable to flood damage to structures and crops are estimated, by application of the economic submodel described in Chapter VIII, at $11,100 under existing land use, channel, and floodplain conditions, and $42,100 under plan year 2000 land use and existing channel and floodplain conditions. If additional development were permitted in the flood hazard area, even higher monetary flood risks could be expected to be incurred. Under existing land use, channel, and floodplain conditions, flood damages to crops and structures of about $29,800 and $169,000, respectively, during a 100-year recurrence interval flood event, and about $4,200 and $24,200, respectively, during a 10-year recurrence interval flood may be expected to be incurred. Under plan year 2000 land use and existing channel and floodplain conditions, flood damages to crops and structures of about $46,000 and $310,000, respectively, during a 100-year recurrence interval flood event, and about $20,400 and $113,000, respectively, during a 10-year recurrence interval flood event may be expected to be incurred.

Channel Enlargement Alternative

A channel enlargement alternative flood control plan was developed and analyzed for the lands subjected to flooding by the Upper Pike River to determine if such a flood control measure would provide a technically and economically sound solution to the existing and anticipated flood problem. The 100-year recurrence interval flood discharge under plan year 2000 land use conditions was used as the basis for the design of this alternative.

The channel enlargement alternative flood control plan element for the Upper Pike River is shown on Map 66, while the physical characteristics and estimated costs and benefits of this project are set forth in Table 93. Under this alternative plan element, the existing channel would be enlarged and deepened beginning 0.35 mile south of CTH KR upstream to CTH C. Major channelization would be required downstream of the reach noted above to the confluence of Pike Creek with the Pike River. The proposed channel would have a bottom width ranging from five to 20 feet with side slopes of one on three. The deepening would range from one to four feet, averaging about three feet. The enlarged channel would be designed to provide two feet of freeboard during the design flood event.

This alternative plan element would also include replacement of 10 bridges over the Upper Pike River: 1) STH 31, 2) CTH KR, 3) Braun Road, 4) STH 11, 5) Chicago, Milwaukee, St. Paul & Pacific Railroad, 6) Oakes Road, 7) STH 20, 8) private drive 0.29 mile upstream of STH 20, 9) private drive 0.77 mile upstream of STH 20, and 10) Spring Street. It should be noted that five of these eight bridges—STH 31, CTH KR, Braun Road, STH 11, and STH 20—are designated for reconstruction for highway capacity purposes under the year 2000 regional transportation system plan as set forth in SEWRPC Planning Report No. 25, A Regional Land Use Plan and a Regional Transportation Plan for Southeastern Wisconsin: 2000, which has been adopted by Racine County and the Wisconsin Department of Transportation. Therefore, the cost of the replacement of these five bridges—totaling $1,500,000—was not included in the cost analysis of the alternative flood control plan elements.

Utilizing an annual interest rate of 6 percent and an amortization period and project life of 50 years, the average annual cost of the channel enlargement alternative is estimated at $70,400, consisting of amortization of the $997,000 capital cost of channel enlargement, major channelization, and bridge replacement; and $7,600 in annual operation and maintenance cost of the enlarged channel. The average annual flood abatement benefit is estimated at $42,100, resulting in an excess of $28,300 in annual costs over benefits and a benefit-cost ratio of 0.60. The channel enlargement alternative plan, as described herein, while technically feasible, was not found to be economically sound.

Combination Dike and Structure Floodproofing and Elevation Alternative

A combination dike and structure floodproofing and elevation plan element was also developed and analyzed in order to determine if such a structural measure would provide a technically feasible and economically sound solution to the flood problems along the Upper Pike River. The 100-year recurrence interval flood discharge under plan year 2000 land use and existing channel conditions was used as the basis for the design of this alternative.

The dike and structure floodproofing and elevation elements of this alternative flood control plan for the Upper Pike River are shown on Map 67 and the costs and benefits attendant to this alternative are set forth in Table 93. The assumed dike design is shown in Figure 52. Under this alternative plan element, protection from flood damage by floodproofing, elevation, or diking would be provided for structures located in the four areas shown on Map 67. However, no flood control measures would be provided to eliminate the potential for relatively minor flood damage to crops along the Upper Pike River.

As shown on Map 67, the analysis indicated that 42 structures may be expected to be located in the primary flood hazard area, and 27 structures may be expected to be located in the secondary flood hazard area along the Upper Pike River. In the area south of Spring Street, 20 structures would have to be floodproofed and six structures would have to be elevated. In the area located east of Oakes Road, eight structures would have to be floodproofed and two structures would have to be elevated. The area located north of the S. C. Johnson & Son plant would require a dike along the west side of Stuart Road about 1,500 feet long with an average height of about four feet and a maximum height of about six feet. A buried conduit about 700 feet long would also be required to drain the area west of the dike, and would be equipped with an inlet with a backwater gate to drain the area between the Chicago & North Western Railroad and Stuart Road. In the area north of STH 11, a dike would be required west of the Pike River with a length of about 900 feet and an average height of about four feet, and a maximum height of about six feet. In addition, five structures would have to be flood-

Table 93

PRINCIPAL FEATURES, COSTS, AND BENEFITS OF FLOODLAND MANAGEMENT ALTERNATIVES FOR THE UPPER PIKE RIVER MAIN STEM

Alternative				Economic Analysis[a]										
			Technically Feasible	Capital Cost		Annual Amortized Capital Cost (thousands)	Annual Operation and Maintenance Cost (thousands)	Total Annual Cost (thousands)	Annual Benefits (thousands)	Excess of Annual Benefits Over Cost (thousands)	Benefit-Cost Ratio	Benefit-Cost Ratio Greater Than 1.0	Nontechnical and Noneconomic Considerations	
Number	Name	Description		Item	(thousands)								Positive	Negative
1	No action	--	Yes	--	--	--	--	$ 42.1[b]	--	--	--	No	--	--
2	Channel enlargement	a. 5.6 miles of channel enlargement (five- to 20-foot bottom width, one on three side slopes) b. 1.2 miles of major channelization (20-foot bottom width, one on three side slopes) c. 5.6 miles of channel deepening (one- to four-foot deepening) d. Replacement of 10 bridges	Yes	Channel enlargement and major channelization Bridge replacement Subtotal	763.0 234.0[c] 997.0	62.8	7.6	70.4	42.1	- 28.3	0.60	No	--	--
3	Combination dike and structure floodproofing and elevation	a. 2,400 feet of dikes b. Local drainage control c. Floodproof up to 33 residential structures d. Elevate up to 10 residential structures	Yes	Dikes Land acquisition Excavation Drainage culverts Buried conduit Floodproofing Elevating Subtotal	171.2 3.6 31.6 3.0 31.6 80.0 245.0 566.0	36.0	2.0	38.0	33.1	- 4.9	0.87	No	Immediate partial flood relief at discretion of property owners Most of the costs would be borne by beneficiaries	Complete, voluntary implementation unlikely and therefore left with a significant residual flood problem Some floodproofing is likely to be applied without adequate professional advice and, as a result, structure damage may occur
4	Combination onsite detention storage and channel enlargement	a. 5.6 miles of channel enlargement (five- to 20-foot bottom width, one on three side slopes) b. 1.2 miles of major channelization (20-foot bottom width, one on three side slopes) c. 2.6 miles of channel deepening (one-to four-foot deepening) d. Replacement of 10 bridges e. Provide onsite detention storage facilities	Yes	Channel enlargement and major channelization Bridge replacement Onsite detention storage facilities Subtotal	541.0 234.0[c] 4,860.0 5,635.0	355.0	116.0	471.0	42.1	- 428.9	0.09[d]	No	Potential to retain public open space	--
5	Combination onsite detention storage, dike, and structure floodproofing and elevation	a. 2,400 feet of dikes b. Local drainage control c. Floodproof up to 26 residential structures d. Elevate up to six residential structures	Yes	Dikes Land acquisition Excavation Drainage culverts Buried conduit Floodproofing Elevating Onsite detention storage facilities Subtotal	128.4 3.6 31.5 3.0 31.5 27.0 154.0 4,860.0 5,239.0	332.0	110.0	442.0	33.1	- 408.9	0.07	No	See Alternative 3 above	Aesthetic impact of visual barrier
6	Combination onsite detention storage and detention storage reservoir	a. Four reservoirs b. Replacement of 10 bridges c. 6.8 miles of channel clearing and debrushing d. 3.6 miles of dikes along both sides of channel (two-foot average height) e. Provide onsite detention storage facilities	Yes	Reservoirs Bridge replacement Channel clearing and debrushing Dikes Onsite detention storage facilities Subtotal	493.0 234.0[c] 108.0 1,241.0 4,860.0 6,936.0	437.0	191.0	628.0	42.1	- 585.9	0.07[e]	No	See Alternative 3 above	--

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

[b] *The total annual cost consists of the average annual monetary flood damages.*

[c] *The bridge replacement costs do not include the costs associated with five bridges designated for reconstruction under the Commission's year 2000 transportation plan.*

Source: SEWRPC.

[d] *Excluding the costs for onsite storage and the benefits attendant thereto, the ratio of total average benefits to annual public costs is 0.20.*

[e] *Excluding the costs for onsite storage and the benefits attendant thereto, the ratio of the total average annual benefits to annual public costs is 0.05.*

proofed and two structures would have to be elevated in this area. No structures would have to be removed under this alternative, and future flood damage to private residences and commercial structures along the Upper Pike River would be virtually eliminated by these flood control measures. Table 93 sets forth the number and type of structures to be floodproofed and elevated and also summarizes the estimated costs and benefits.

Assuming that the combination dike and structure floodproofing and elevation 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 $38,000, consisting of the amortization of the $566,000 capital cost—$80,000 for floodproofing, $245,000 for structure elevation, and $241,000 for the dikes, buried conduit, and local drainage control measures—and $2,000 per year for operation and maintenance of dikes. The average annual flood damage abatement benefit is estimated at $33,100, resulting in an excess in annual costs over benefits and a benefit-cost ratio of 0.87.

The combination dike and structure floodproofing and elevation plan element, as described herein, while technically feasible, was not found to be economically sound.

Combination Onsite Detention Storage and Channel Enlargement Alternative

A combination onsite detention storage and channel enlargement plan element was developed and analyzed for the lands subject to flooding by the Upper Pike River in order to determine if such a flood control measure would provide a technically and economically sound solution to the existing and anticipated flood problems. This alternative assumes the continued application of the Town of Mt. Pleasant policy requiring that onsite storm water detention facilities be provided as land is converted from rural to urban use to prevent any increase in peak flood discharges and corresponding stages resulting from such urbanization up to and including the 100-year event.

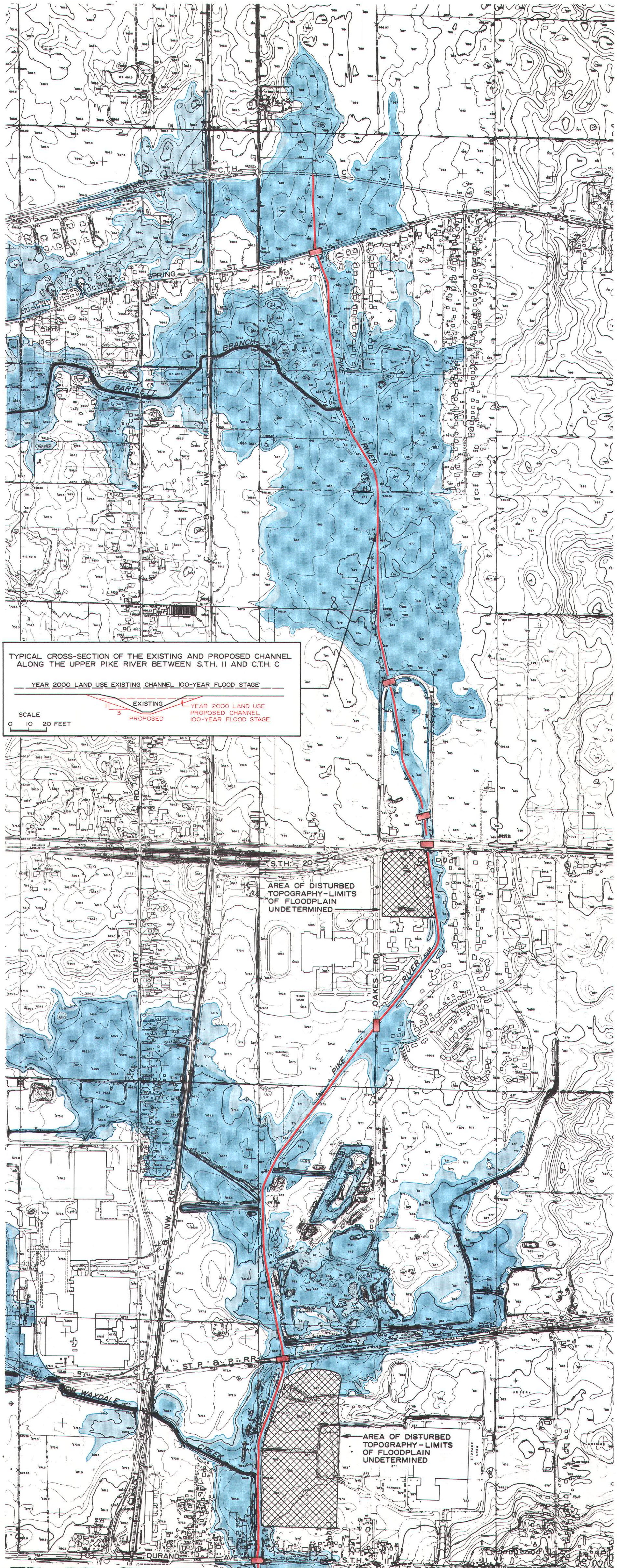
The combination onsite detention storage and channel enlargement alternative flood control plan element for the Upper Pike River is shown on Map 66, while the physical characteristics and estimated costs and benefits of this project are set forth in Table 93. Under this alternative plan element, a similar channel improvement as proposed in the channel enlargement alternative plan element would be carried out, except that the provision of onsite storage facilities on newly developed land under this alternative plan element would reduce the amount of channel deepening required. The existing channel would be enlarged beginning 0.35 mile south of CTH KR upstream to CTH C. Major channelization would be required downstream of the reach noted above to the confluence of Pike Creek with the Pike River. The proposed channel would have a bottom width ranging from five to 20 feet with side slopes of one on three, and the existing streambed would be deepened beginning at the confluence of Pike Creek with the Pike River upstream to Braun Road. The deepening would range from one to four feet, averaging about three feet. The enlarged channel would be designed to provide two feet of freeboard during the design flood event.

This alternative plan element would also include replacement of the following 10 bridges over the Pike River: 1) STH 31, 2) CTH KR, 3) Braun Road, 4) STH 11, 5) Chicago, Milwaukee, St. Paul & Pacific Railroad, 6) Oakes Road, 7) STH 20, 8) private drive 0.29 mile upstream of STH 20, 9) private drive 0.77 mile upstream of STH 20, and 10) Spring Street. As noted above in the discussion of the channel enlargement alternative, the cost of five of these eight bridges, which were recommended for replacement under the regional transportation plan, was not included in the cost analysis of alternative flood control plan elements.

Utilizing an annual interest rate of 6 percent and an amortization period and project life of 50 years, the average annual cost of the combination onsite detention storage and channel enlargement alternative is estimated at $471,000, consisting of amortization of the $5,635,000 capital cost of the onsite detention storage, channel enlargement, and bridge replacement; and $116,000 in annual operation and maintenance cost of the onsite storage facilities and proposed channel. Although the onsite detention storage facilities could be provided by the land developer at no cost to the Town of Mt. Pleasant, the estimated capital cost of these facilities—$4,860,000, and the estimated annual operation and maintenance cost of $108,000—are properly included in any economic analysis of this alternative when evaluating major flood control alternatives on an areawide basis. The average annual flood abatement benefit is estimated at $42,100, resulting in an excess of $428,900 in annual costs over benefits, and a benefit-cost ratio

Map 66

CHANNEL ENLARGEMENT ALTERNATIVES FOR THE UPPER PIKE RIVER



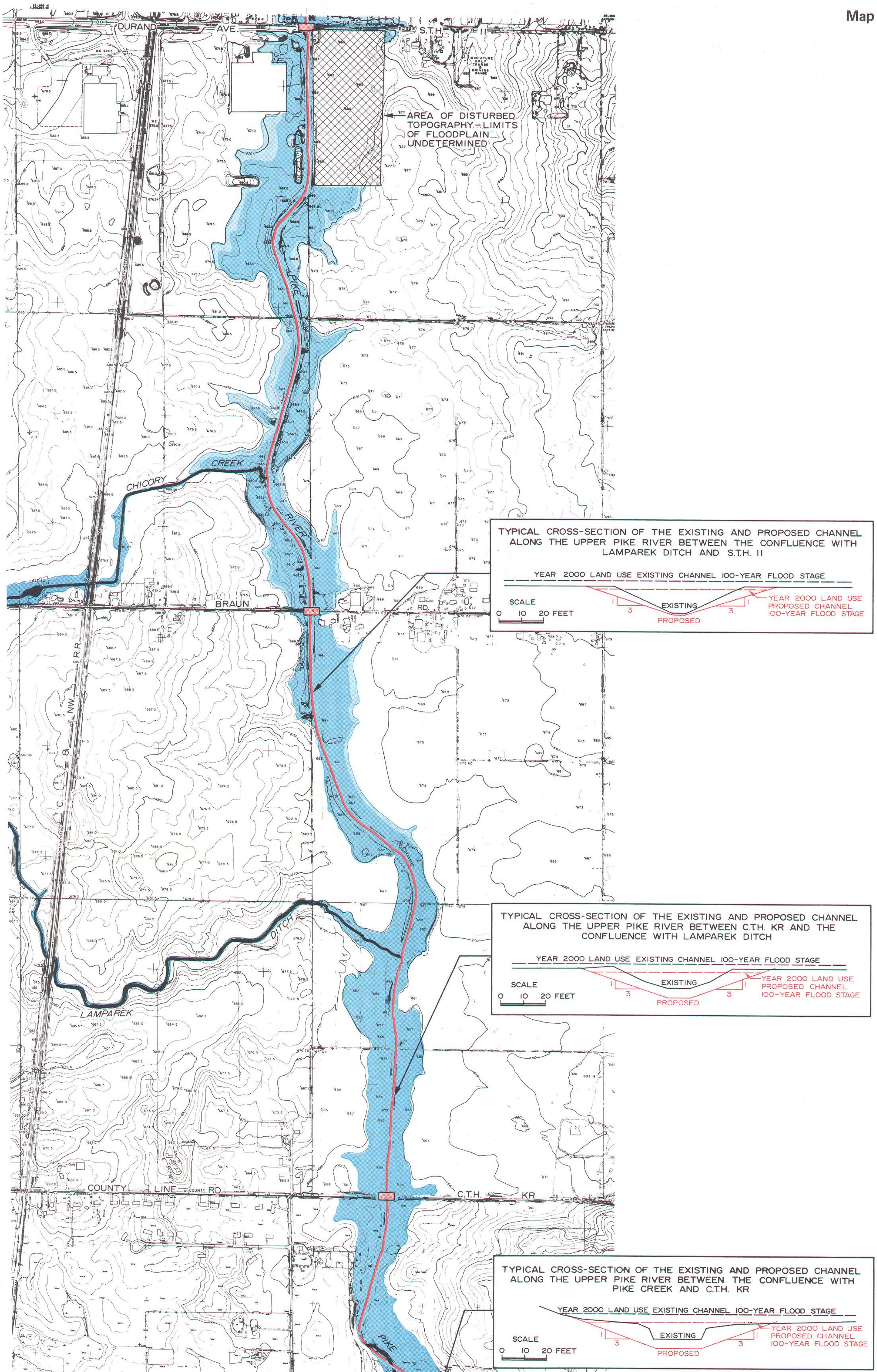
LEGEND

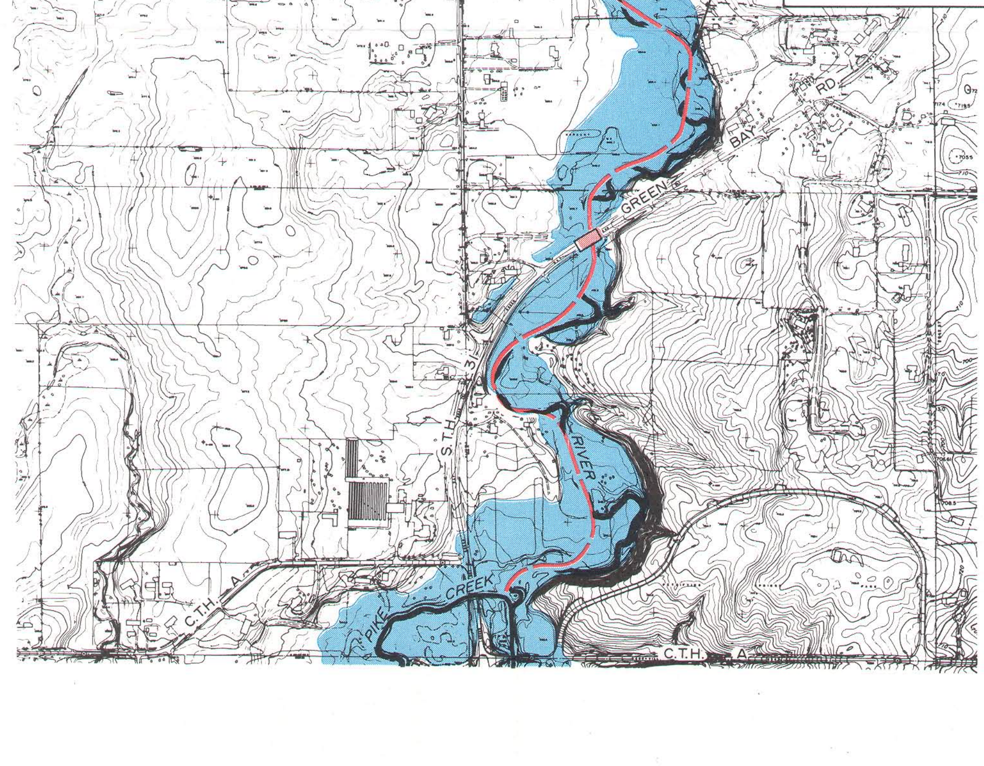
- 100-YEAR RECURRENCE INTERVAL FLOODLANDS--PLANNED LAND USE AND EXISTING CHANNEL CONDITIONS WITH ONSITE DETENTION STORAGE
- 100-YEAR RECURRENCE INTERVAL FLOODLANDS--PLANNED LAND USE AND EXISTING CHANNEL CONDITIONS WITHOUT ONSITE DETENTION STORAGE
- EXISTING CHANNEL
- PROPOSED CHANNEL ENLARGEMENT
- PROPOSED MAJOR CHANNELIZATION
- PROPOSED BRIDGE REPLACEMENT

GRAPHIC SCALE

0 400 800 1200 FEET

Map 66 (continued)



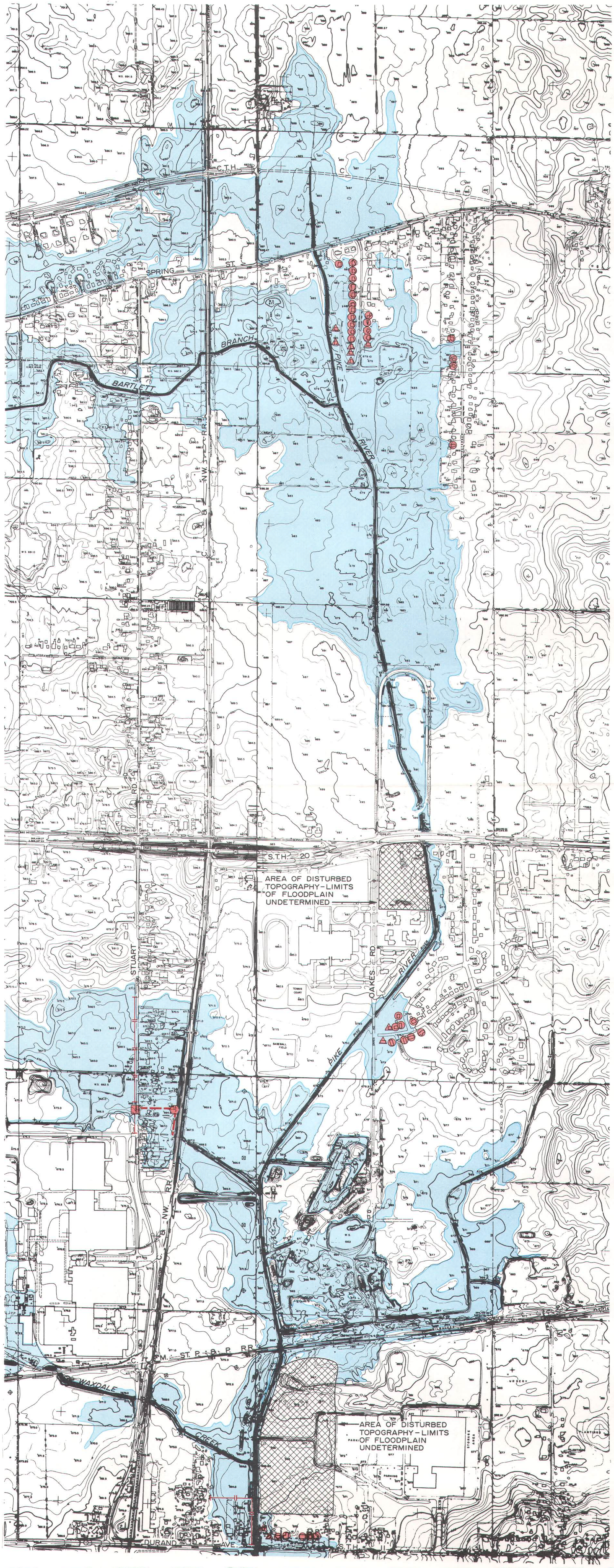


A channel enlargement alternative flood control plan was prepared and evaluated to determine if such a measure would provide a technically feasible and economically sound solution to the flood problem along the Upper Pike River. Under this alternative, the existing channel would be modified beginning at the confluence with Pike Creek and extending upstream to CTH C. In addition, 10 bridges would have to be replaced to accommodate the larger channel. If onsite detention storage is provided upstream of the confluence of Pike Creek as land is converted from rural to urban use, no channel deepening would be required upstream of Braun Road. While technically feasible, this alternative was found to be economically unsound.

Source: SEWRPC.

Map 67

COMBINATION DIKE AND STRUCTURE FLOODPROOFING AND ELEVATION ALTERNATIVE FOR THE UPPER PIKE RIVER



LEGEND

- 100-YEAR RECURRENCE INTERVAL FLOODLANDS-- PLANNED LAND USE AND EXISTING CHANNEL CONDITIONS
- EXISTING CHANNEL
- STRUCTURE TO BE FLOODPROOFED
- STRUCTURE TO BE ELEVATED
- PROPOSED DIKE
- PROPOSED OUTLET CONTROL STRUCTURE
- PROPOSED BURIED CONDUIT
- PROPOSED CONDUIT INLET WITH BACKWATER GATE

GRAPHIC SCALE

0 400 800 1200 FEET

A combination dike and structure floodproofing and elevation alternative flood control plan was prepared and evaluated to determine if such a measure would provide a technically feasible and economically sound solution to the urban flood problem along the Upper Pike River. Under this alternative, protection from flood damage by floodproofing, elevation, or diking would be provided for structures located in four areas along the Upper Pike River. More specifically, a total of 33 structures would be floodproofed, 10 structures would be elevated, and dikes would be constructed at two of the four locations. While technically feasible, this alternative was found to be economically unsound.

Source: SEWRPC.

of 0.09. On the basis of these findings, it should not be concluded that onsite storage is uneconomical in every case. In this respect it should be recognized that onsite storage may permit the size and length of local storm water drainage facilities to be reduced with attendant cost reductions. The viability of onsite storage in this respect should be evaluated on a site specific basis. Excluding the costs associated with onsite storage and the benefits attendant thereto, the ratio of total average annual cost benefits to public costs is still 0.20. The combination onsite detention storage and channel enlargement alternative plan, as described herein, while technically feasible, is not economically sound.

Combination Onsite Storage, Dike and Structure Floodproofing and Elevation Alternative

A combination onsite storage, dike, and structure floodproofing and elevation plan element was developed and analyzed in order to determine if such a structural measure would provide a technically feasible and economically sound solution to the flood problems along the Upper Pike River. This alternative assumes the continued application of the Town of Mt. Pleasant policy requiring that onsite stormwater detention facilities be provided as land is converted from rural to urban use to prevent any increase in peak flood discharges and corresponding stages resulting from such urbanization, up to and including the 100-year recurrence interval event.

The dike and structure floodproofing and elevation elements of this alternative flood control plan for the Upper Pike River are shown on Map 68 and the costs and benefits attendant to this alternative are set forth in Table 93. The assumed dike design is shown in Figure 52. Under this alternative plan element, protection from flood damage by floodproofing, elevation, or diking would be provided for structures located in the four areas shown on Map 68. However, no flood control measures would be provided to eliminate the potential for relatively minor flood damage to crops along the Upper Pike River.

As shown on Map 68, the analysis indicated that 36 structures may be expected to be located in the primary flood hazard area, and 22 structures may be expected to be located in the secondary flood hazard area along the Upper Pike River. In the area south of Spring Street, 17 structures would have to be floodproofed and five structures would have to be elevated. In the area located east of Oakes Road, five structures would have to be floodproofed and one structure would have to be elevated. The area located north of the S. C. Johnson & Son plant would require a dike along the west side of Stuart Road about 1,500 feet long with an average height of about two feet and a maximum height of about four feet. A buried conduit about 700 feet long would also be required to drain the area west of the dike, and would be equipped with an inlet with a backwater gate to drain the area between the Chicago & North Western Railroad and Stuart Road. In the area north of STH 11, a dike would be required west of the Pike River with a length of about 900 feet, an average height of about three feet, and a maximum height of about five feet. In addition, four structures would have to be floodproofed in this area. No structures would have to be removed under this alternative. and future flood damage to private residences and commercial structures along the Upper Pike River would be virtually eliminated by these flood control measures. Table 93 sets forth the number and type of structures to be floodproofed and elevated and also summarizes the estimated costs and benefits.

Assuming that the combination onsite storage, dike, and structure floodproofing and elevation 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 $442,000, consisting of the amortization of the $5,239,000 capital cost—$4,860,000 for the onsite detention storage, $27,000 for floodproofing, $154,000 for structure elevation, and $198,000 for the dikes, buried conduit, and local drainage control measures—and $110,000 per year for operation and maintenance of the storage facilities and dikes. Although the onsite detention storage facilities could be provided by the land developer at no cost to the Town of Mt. Pleasant, and the estimated capital cost of these facilities of $4,860,000, and the estimated annual operation and maintenance cost of $108,000 are properly included in any economic analyses of this alternative when evaluating major flood control alternatives on an areawide basis. The average annual flood damage abatement benefit is estimated at $33,100, resulting in a benefit-cost ratio of 0.07. On the basis of these findings, it should not be concluded that onsite storage is uneconomical in every case. In this respect, it should be recognized that onsite storage may permit the size and length of local stormwater drainage facilities to be reduced with attendant cost reductions. The viability of onsite storage in this respect should be evaluated on a site specific basis. Excluding the costs for onsite storage, the ratio of total average annual benefits to public costs is 1.27.

The combination onsite storage, dike, and structure floodproofing and elevation plan element, as described herein, while technically feasible, was not found to be economically sound.

Combination Onsite Storage and Detention Storage Reservoir Alternative

A combination onsite storage and detention storage reservoir plan element was developed and analyzed for the lands subject to flooding by the Upper Pike River in order to determine if such a flood control measure would provide a technically and economically sound solution to the existing and anticipated flood problem. This alternative assumes the continued application of the Town of Mt. Pleasant policy requiring that onsite stormwater detention facilities be provided as land is converted from rural to urban use to prevent any increase in peak flood discharges and corresponding stages resulting from such urbanization.

The combination onsite storage and detention storage reservoir alternative flood control plan element for the Upper Pike River is shown on Map 69, while the physical characteristics and estimated costs and benefits of this project are set forth in Table 93. The assumed reservoir outlet control structure design is shown in Figure 57. Under this alternative plan element, four detention storage reservoir sites would be provided—one located immediately upstream of CTH C, one located north of the S. C. Johnson & Son plant, one located north of the Wisconsin Electric Power Company bulk substation located east of the Village of Sturtevant, and another located north of the J. I. Case Company plant. Clearing and debrushing of the entire length of the existing channel would be required in addition to the provision of dikes along both sides of the existing channel in the following three reaches: 1) STH 31 to Braun Road, 2) River Mile 13.00 to River Mile 14.10, and 3) North Construction Road to the confluence of Bartlett Branch. The assumed dike design is shown in Figure 52. The dikes would have an average height of about two feet and would not exceed four feet in height, and would be designed to provide about two feet of freeboard during the design flood event. The following 10 bridges would also be replaced: 1) STH 31, 2) CTH KR, 3) Braun Road, 4) STH 11, 5) Chicago, Milwaukee, St. Paul & Pacific Railroad, 6) Oakes Road, 7) STH 20, 8) private drive 0.29 mile upstream of STH 20, 9) private drive 0.77 mile upstream of STH 20, and 10) Spring Street. As noted above in the discussion of the channel enlargement alternative, the replacement cost of five of these eight bridges, which were recommended for replacement under the regional transportation plan, was not included in the cost analysis of alternative flood control plan elements.

Utilizing an annual interest rate of 6 percent and an amortization period and project life of 50 years, the average annual cost of the combination onsite detention storage and detention storage reservoir alternative is estimated at $628,000, consisting of amortization of the $6,936,000 capital cost of the onsite detention storage, four detention storage reservoirs, channel clearing and debrushing, diking, and bridge replacement; and $191,000 in annual operation and maintenance cost of the onsite storage facilities and detention storage reservoirs. Although the onsite detention storage facilities could be provided by the land developer at no cost to the Town of Mt. Pleasant, the estimated capital cost of these facilities—of $4,860,000, and the estimated annual operation and maintenance cost of $108,000—are properly included in any economic analysis of this alternative when evaluating major flood control alternatives on an areawide basis. The average annual flood abatement benefit is estimated at $42,100, resulting in an excess of $585,900 in annual costs over benefits and a benefit-cost ratio of 0.07. On the basis of these findings, it should not be concluded that onsite storage is uneconomical in every case. In this respect it should be recognized that onsite storage may permit the size and length of local stormwater drainage facilities to be reduced with attendant cost reductions. The viability of onsite storage in this respect should be evaluated on a site specific basis. Excluding the costs for onsite storage, and the benefits attendant thereto, the ratio of total average annual benefits to costs is still 0.05. The combination onsite detention and offsite storage reservoir alternative plan, as described herein, while technically feasible, is not economically sound.

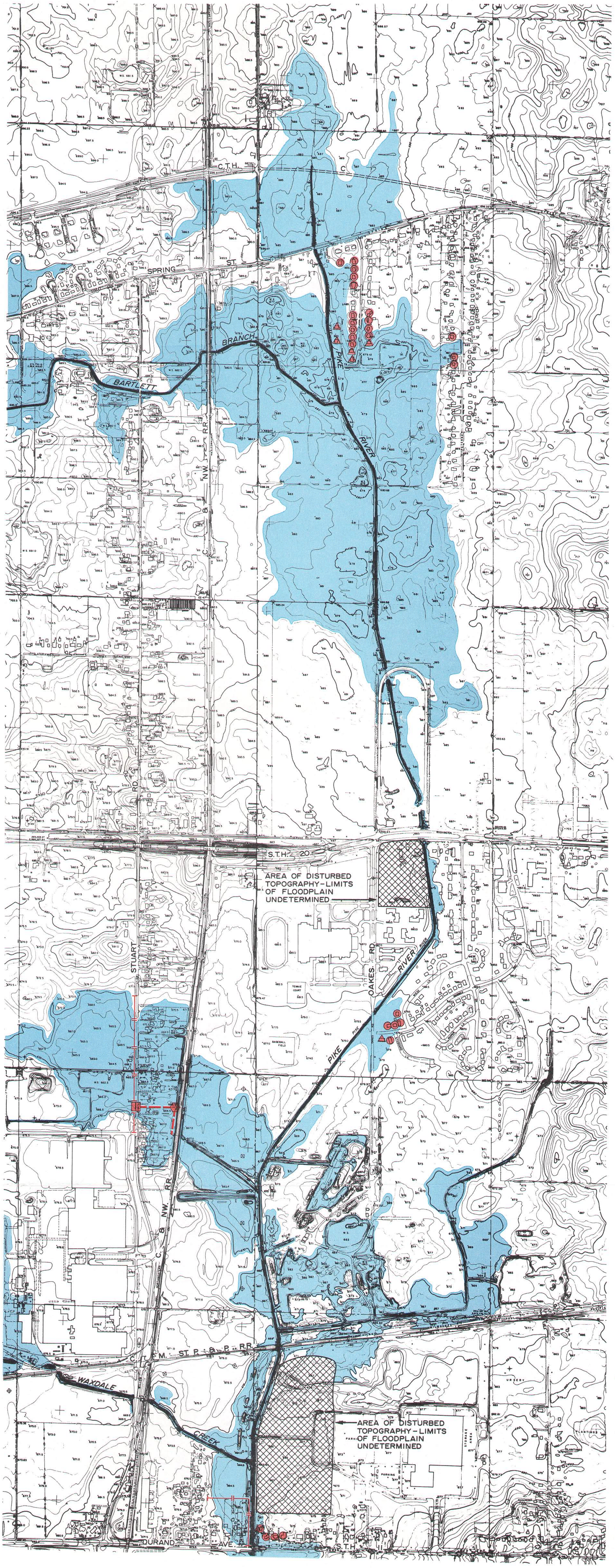
ALTERNATIVE FLOODLAND MANAGEMENT PLAN ELEMENTS FOR THE LOWER PIKE RIVER

The Flood Problem

The hydrologic-hydraulic simulation of the Lower Pike River under existing land use, channel, and floodplain conditions indicated that there exists the potential for flood damage to crops along most

Map 68

COMBINATION ONSITE STORAGE, DIKE, AND STRUCTURE FLOODPROOFING AND ELEVATION ALTERNATIVE FOR THE UPPER PIKE RIVER



LEGEND

- 100-YEAR RECURRENCE INTERVAL FLOODLANDS-- PLANNED LAND USE AND EXISTING CHANNEL CONDITIONS WITH ONSITE DETENTION STORAGE
- EXISTING CHANNEL
- STRUCTURE TO BE FLOODPROOFED
- STRUCTURE TO BE ELEVATED
- PROPOSED DIKE
- PROPOSED OUTLET CONTROL STRUCTURE
- PROPOSED BURIED CONDUIT
- PROPOSED CONDUIT INLET WITH BACKWATER GATE

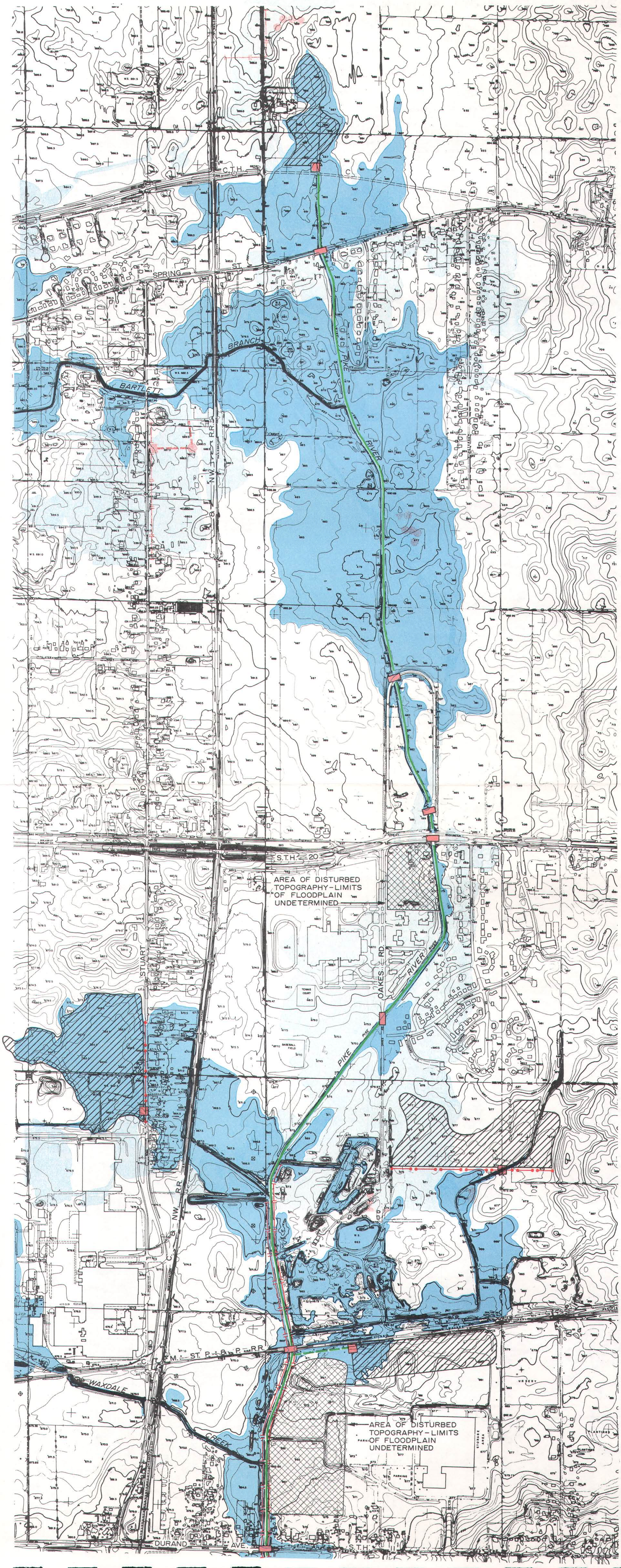
GRAPHIC SCALE

0 400 800 1200 FEET

A combination onsite storage, dike, and structure floodproofing and elevation alternative flood control plan was prepared and evaluated to determine if such a measure would provide a technically feasible and economically sound solution to the urban flood problem along the Upper Pike River. Under this alternative, protection from flood damage by floodproofing, elevation, or diking would be provided for structures located in four areas along the Upper Pike River. More specifically, a total of 26 structures would be floodproofed, six structures would be elevated, and two dikes would be constructed at these four locations. In addition, onsite detention storage facilities would be provided as land is converted from rural to urban use. While technically feasible, this alternative was found to be economically unsound.

Source: SEWRPC.

COMBINATION ONSITE STORAGE AND DETENTION STORAGE RESERVOIR ALTERNATIVE FOR THE UPPER PIKE RIVER



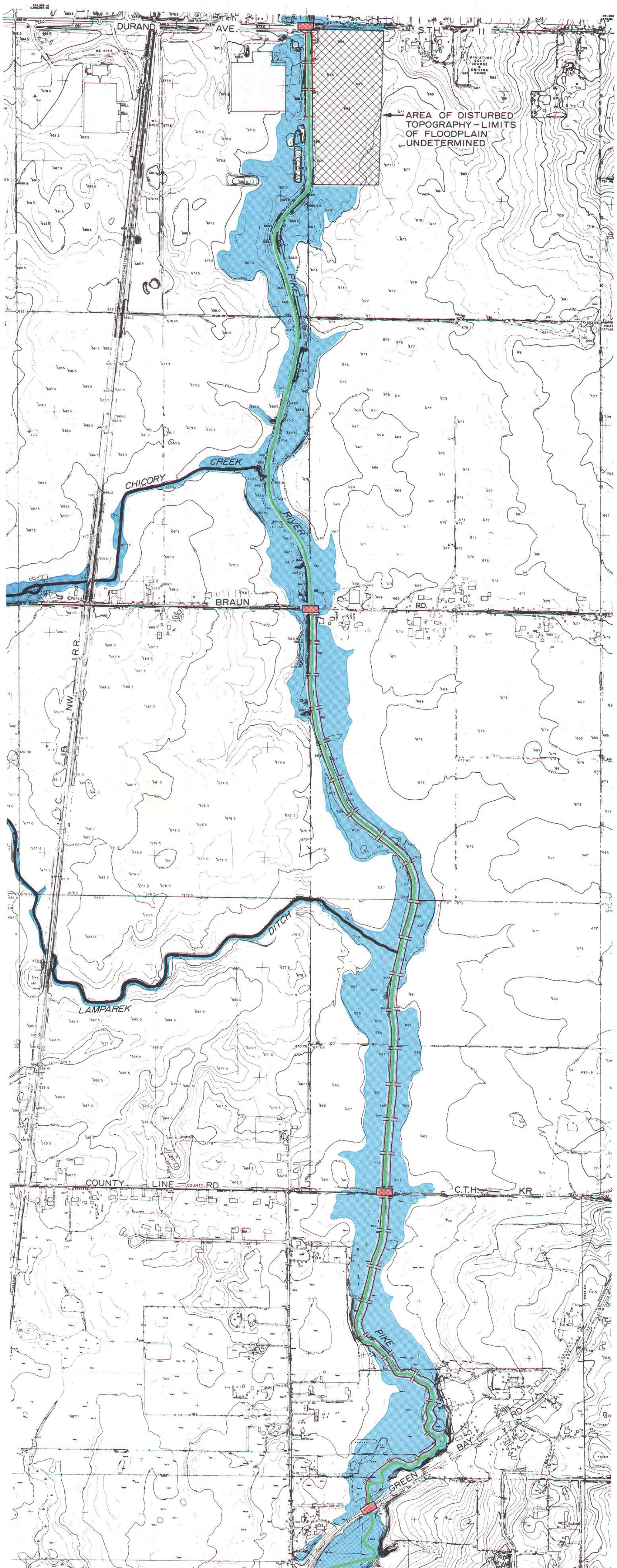
LEGEND

- 100-YEAR RECURRENCE INTERVAL FLOODLANDS--PLANNED LAND USE AND EXISTING CHANNEL CONDITIONS WITH ONSITE DETENTION STORAGE
- EXISTING CHANNEL
- PROPOSED CHANNEL CLEARING AND DEBRUSHING
- PROPOSED RESERVOIR DIVERSION DITCH
- PROPOSED DIKE
- PROPOSED EARTHEN EMBANKMENT
- PROPOSED DETENTION STORAGE RESERVOIR
- PROPOSED OUTLET CONTROL STRUCTURE
- PROPOSED BRIDGE REPLACEMENT

GRAPHIC SCALE

0 400 800 1200 FEET

Map 69 (continued)



A combination onsite storage and detention storage reservoir alternative was prepared and evaluated to determine if such a measure would provide a technically feasible and economically sound solution to the flood problem along the Upper Pike River. Under this alternative, four detention storage reservoir sites would be provided in addition to the provision of onsite detention storage facilities as land is converted from rural to urban use. Clearing and debrushing of the entire length of the existing channel would also be required along with the construction of dikes along both sides of the existing channel at three locations. While technically feasible, this alternative was found to be economically unsound.

Source: SEWRPC.

of the Lower Pike River upstream of the Chicago & North Western Transportation Company crossing, and the potential for flood damage to structures at three locations along this stream reach. There also exists the potential for flood damage to the Kenosha Country Club, located along the stream reach between Lathrop Avenue and CTH Y, in the form of both direct damages and revenue losses when the river occupies the adjacent floodplain. Under existing land use, channel, and floodplain conditions, flood damages to crops and structures of about $13,400 and $148,300, respectively, during a 100-year recurrence interval flood event and about $53,400 and $6,400, respectively, during a 10-year recurrence interval flood event may be expected to be incurred. Under plan year 2000 land use and existing channel and floodplain conditions, flood damages to crops and structures of about $66,200 and $158,000, respectively, during a 100-year recurrence interval flood event, and about $55,000 and $19,200, respectively, during a 10-year recurrence interval flood event may be expected to be incurred.

Major Channelization Alternative

A major channelization alternative flood control plan was prepared and evaluated for the lands subjected to flooding by the Lower Pike River in order to determine if such a flood control measure would provide a technically and economically sound solution to the existing and anticipated flood problem. The 100-year recurrence interval flood discharge under plan year 2000 land use conditions was used as the basis for the design of this alternative.

The major channelization alternative flood control plan element for the Lower Pike River is shown on Map 70, while the physical characteristics and estimated costs and benefits of this project are set forth in Table 94. Under this alternative plan element, a total of about eight miles of the Lower Pike River would be channelized. The channel would be constructed with a bottom width of approximately 50 feet and channel side slopes of one on three. The channel would be adequate to accommodate the 100-year recurrence interval flood flow with generally about two feet of freeboard.

This alternative plan element would also include replacement of 12 bridges over the Lower Pike River, both to provide adequate hydraulic capacity to pass flood flows and to accommodate the enlarged channel. The following bridges would be replaced: 1) STH 32, Alford Park Drive; 2) STH 32, Sheridan Road; 3) private drive into Carthage College; 4) STH 32, S. 32nd Street; 5) Chicago & North Western Transportation Company; 6) CTH E; 7) CTH A; 8) Lathrop Avenue; 9) Chicago, North Shore & Milwaukee Railroad Company; 10) CTH Y; 11) CTH G; and 12) CTH A. It should be noted that five of these bridges are highway bridges designated for reconstruction under the Commission's year 2000 transportation plan set forth in SEWRPC Planning Report No. 25, A Regional Land Use Plan and a Regional Transportation Plan for Southeastern Wisconsin: 2000, which has been adopted by Kenosha County and the Wisconsin Department of Transportation. Therefore, the cost of the replacement of the following five bridges—totaling $1,380,000—was not included in the cost analysis of the alternative flood control plan element: 1) STH 32, Alford Park Drive; 2) STH 32, Sheridan Road; 3) STH 32, S. 32nd Street; 4) CTH E; and 5) CTH Y.

Assuming that the major channelization 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 $295,000, consisting of the amortization of the $4,594,000 capital cost of channelization and bridge replacement, and $6,000 in annual operation and maintenance cost of the channel. The average annual flood abatement benefit is estimated at about $45,700, resulting in an excess of $249,300 in annual costs over benefits and a benefit-cost ratio of 0.15. Therefore, the major channelization plan element, as described herein, while technically feasible, would not be economically sound.

Diversion Channel Alternative

A diversion channel alternative flood control plan was developed and analyzed for the lands subject to flooding by the Lower Pike River in order to determine if such a flood control measure would provide a technically and economically sound solution to the existing and anticipated flood problem. The 100-year recurrence interval flood discharge under plan year 2000 land use conditions was used as the basis for the design of this alternative.

Two locations along the Lower Pike River, as shown on Map 71, were selected as potential sites for construction of diversion channels from the Pike River to Lake Michigan. The physical characteristics and estimated costs and benefits of the two projects are set forth in Table 94. It should be noted that a diversion channel could only be practically located downstream of the confluence of

Table 94

PRINCIPAL FEATURES, COSTS, AND BENEFITS OF FLOODLAND MANAGEMENT ALTERNATIVES FOR THE LOWER PIKE RIVER

Alternative				Economic Analysis[a]										
			Technically Feasible	Capital Cost		Annual Amortized Capital Cost (thousands)	Annual Operation and Maintenance Cost (thousands)	Total Annual Cost (thousands)	Annual Benefits (thousands)	Excess of Annual Benefits Over Cost (thousands)	Benefit-Cost Ratio	Benefit-Cost Ratio Greater Than 1.0	Nontechnical and Noneconomic Considerations	
Number	Name	Description		Item	(thousands)								Positive	Negative
1	No action	- -	Yes	- -	$ - -	$ - -	$ - -	$ 45.7[b]	$ - -	$ - -	- -	No	- -	- -
2	Major channelization	a. 8.0 miles of channelization (50 foot bottom width, one on three side slopes) b. Replace 12 bridges	Yes	Channelization Bridge replacement Subtotal	2,994.0 1,600.0[c] 4,594.0	289.0	6.0	295.0	45.7	- 249.3	0.15	No	- -	- -
3	Diversion channel to Lake Michigan													
	a. Site 1	a. 3,100 feet of major channelization (30-50 foot bottom width, one on one to one on three side slopes) b. Construct two bridges	Yes	Channelization Bridge construction Subtotal	1,639.0 654.0 2,293.0	144.6	0.4	145.0	27.7	- 117.3	0.19	No	- -	- -
	b. Site 2	a. 850 feet of major channelization (50-foot, bottom width, one on one side slope) b. Construct one bridge	Yes	Channelization Bridge construction Subtotal	442.9 156.0 598.9	38.0	0.1	38.1	8.9	- 29.2	0.23	No	- -	- -
4	Structure floodproofing and elevation	a. Floodproof one commercial structure and one recreational facility b. Elevate one residential structure	Yes	Floodproofing Elevation Subtotal	23.0 20.0 43.0	2.8	- -	39.4[d]	9,100.0	- 30.3	0.23	No	Immediate partial flood relief at discretion of property owners Most of the costs would be borne by beneficiaries	Complete, voluntary implementation unlikely and therefore left with a significant residual flood problem Overland flooding and attendant problems remain Some floodproofing is likely to be applied without adequate advice and as a result, structure damage may occur
5	Diking	a. 4.4 miles of dikes (average height from five to nine feet) b. Replace five bridges c. Floodproof one commercial and one recreational facility d. Elevate one residential structure	Yes	Dikes Bridge replacement Floodproofing Elevation Subtotal	2,006.0 - -[b] 23.0 20.0 2,049.0	129.0	13.0	142.0	45.7	- 96.3	0.32	No	See Alternative 4 above	See Alternative 4 above. Damages to crops would not be abated Aesthetic impact of visual barrier
6	Combination onsite detention storage detention storage, reservoir, and diking	a. One reservoir b. Replace five bridges c. 4.4 miles of dikes (average height from four to seven feet) d. Floodproof one commercial structure and one recreational structure e. Provide onsite detention storage facilities	Yes	Reservoir Bridge replacement Dikes Floodproofing Onsite detention storage facilities Subtotal	364.0 - -[c] 1,502.0 23.0 2,916.0 4,805.0	303.0	77.6	380.6	45.7	- 334.9	0.12[e]	No	See Alternative 4 above	Aesthetic impact of visual barrier See Alternative 4 above

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

[b] *The total annual cost consists of the average annual monetary flood damages.*

[c] *The bridge replacement costs do not include the costs associated with five bridges designated for reconstruction under the Commission's year 2000 transportation plan.*

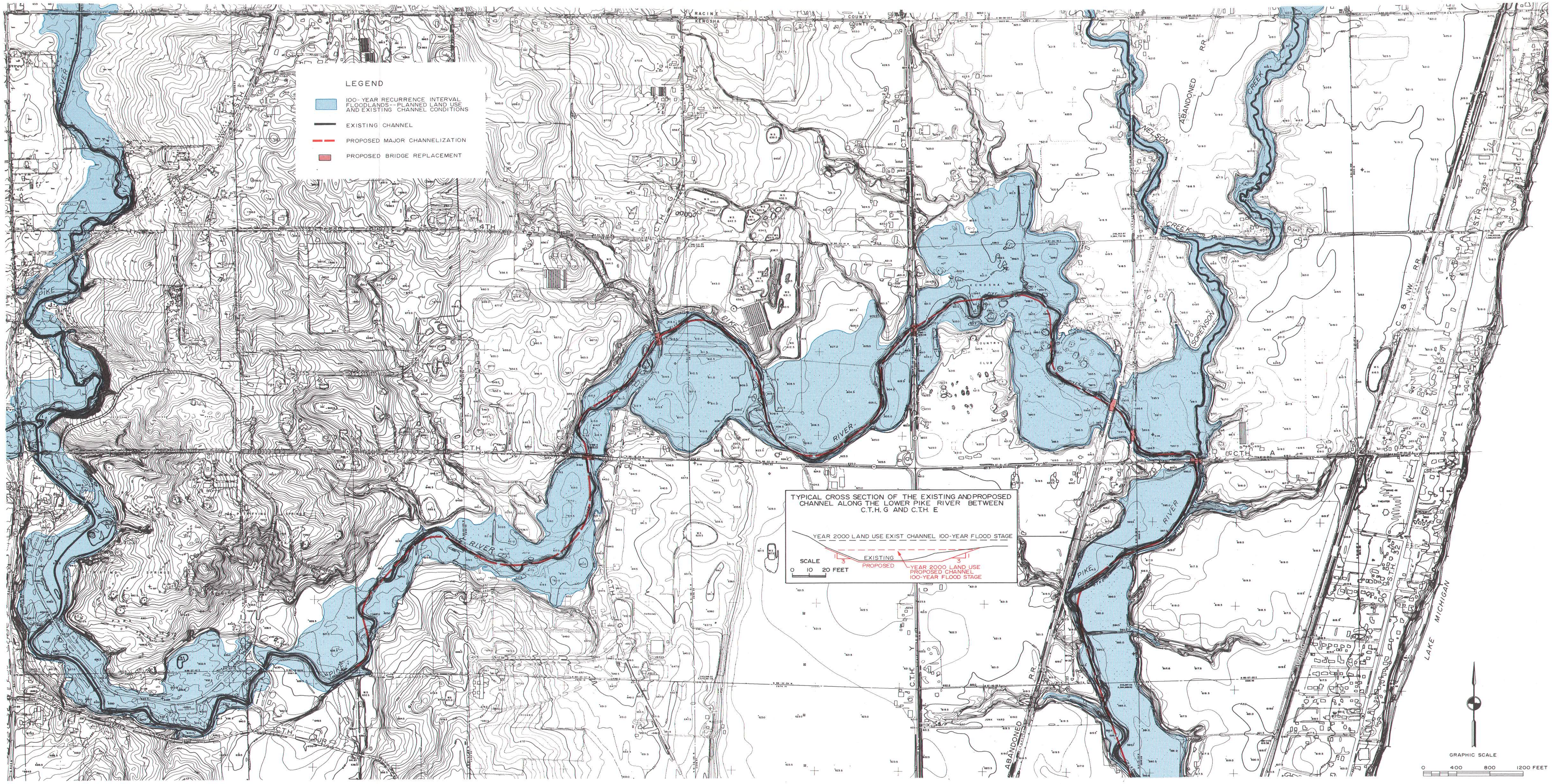
Source: SEWRPC.

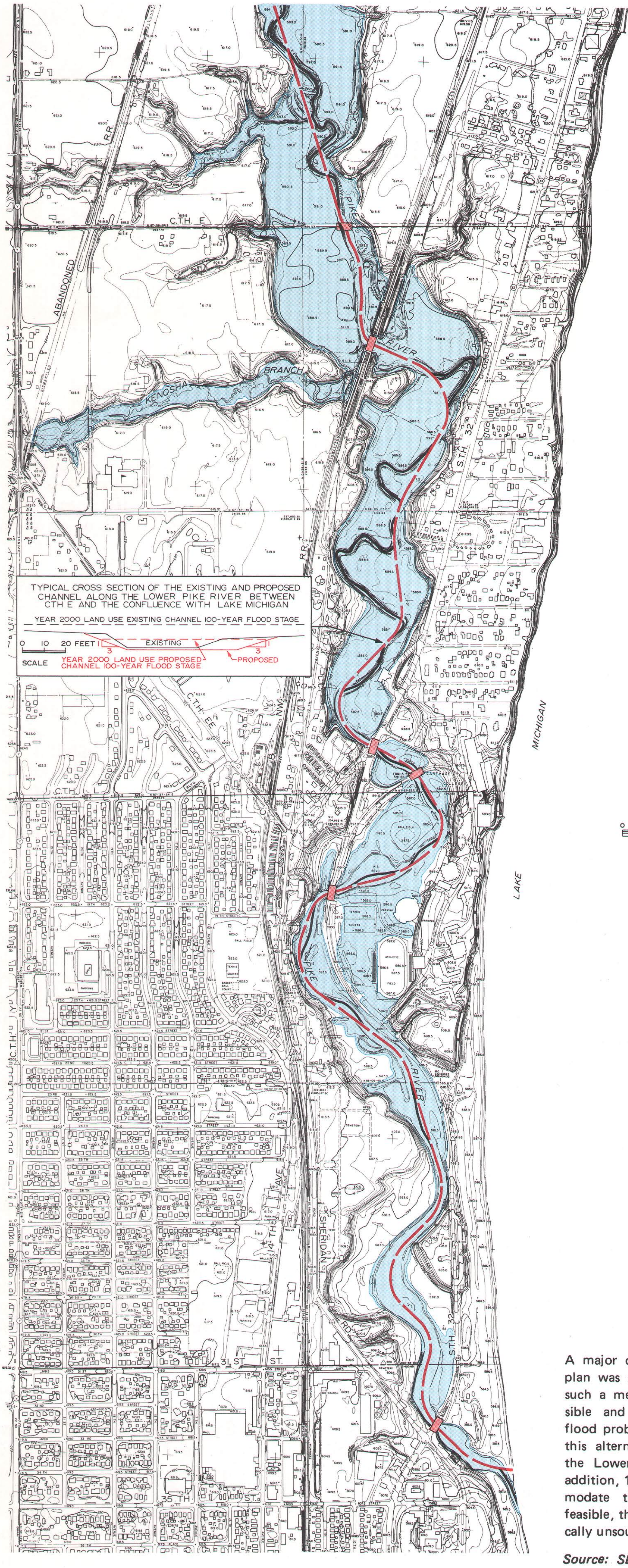
[d] *The total annual cost includes $36,600 in average annual crop damages which would continue upon implementation of this alternative.*

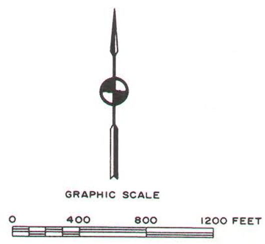
[e] *Excluding the costs for onsite storage and the benefits attendant thereto, the ratio of total average annual benefits to annual public costs is 0.21.*

Map 70

MAJOR CHANNELIZATION ALTERNATIVE FOR THE LOWER PIKE RIVER







A major channelization alternative flood control plan was prepared and evaluated to determine if such a measure would provide a technically feasible and economically sound solution to the flood problem along the Lower Pike River. Under this alternative, a total of about eight miles of the Lower Pike River would be channelized. In addition, 12 bridges would be replaced to accommodate the larger channel. While technically feasible, this alternative was found to be economically unsound.

Source: SEWRPC.

Sorenson Creek with the Pike River, thus potentially abating only flood problems occurring downstream. Therefore, a diversion channel would have to be combined with additional flood control measures to abate flood problems along the entire Lower Pike River.

The first site is located just south of CTH A downstream from the confluence of Sorenson Creek. The proposed diversion channel would be approximately 3,100 feet long and would be constructed with a bottom width of approximately 30 feet and side slopes of one on three west of the Chicago & North Western Transportation Company, and a bottom width of 50 feet and side slopes of one on one east of the railroad. This alternative plan element would also include replacement of the Chicago & North Western Transportation Company and STH 32 bridges to accommodate the diversion channel.

Assuming that this diversion channel 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 $145,000, consisting of the amortization of the $2,293,000 capital cost of channelization, land acquisition, and bridge replacement, and $400 in annual operation and maintenance cost of the channel. It should be noted that this capital cost does not include acquisition of a right-of-way through the urbanized area west of the Chicago & North Western Transportation Company structure. The average annual flood abatement benefit is estimated at about $27,700, resulting in an excess of $117,300 in annual costs over benefits and a benefit-cost ratio of 0.19. Therefore, the diversion channel plan element, as described herein, while technically feasible, would not be economically sound.

A second potential site for construction of a diversion channel is located about one-quarter mile downstream from the Chicago & North Western Transportation Company crossing. This proposed diversion channel would be approximately 850 feet long and would be constructed with a bottom width of approximately 50 feet and side slopes of one on one.

Assuming that this diversion channel 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 $38,100, consisting of the amortization of the $598,900 capital cost of channelization and land acquisition, and $100 in annual operation and maintenance cost of the channel. The average annual flood abatement benefit is estimated at about $8,900, resulting in an excess of $29,200 in annual costs over benefits and a benefit-cost ratio of 0.23. Therefore, this diversion channel alternative plan, as described herein, while technically feasible, would not be economically sound.

Structure Floodproofing and Elevation Alternative

A structure floodproofing, elevation, and removal alternative flood control plan was analyzed to determine if such a structure-by-structure approach would be a technically and economically acceptable solution to the flood problem associated with structures along the Lower Pike River. Flood damages to crops would continue to occur under this alternative and are considered to be an additional cost associated with this alternative in the following economic analysis. For the purpose of this analysis, the 100-year recurrence interval flood stage under plan year 2000 land use conditions was used to estimate the number of floodprone structures to be floodproofed, elevated, or removed and the approximate costs involved.

As shown on Map 72, the analysis indicated that three structures may be expected to be located in the primary flood hazard area, and no structures are expected to be located in the secondary flood hazard area. Of the three structures located in the primary flood hazard area, one structure would have to be elevated and two structures would have to be floodproofed and none of the structures would have to be removed under this alternative. Future flood damage to private residences and other structures along this reach would be virtually eliminated by these floodproofing measures. Table 94 sets forth the number and type of structures to be floodproofed and elevated and also summarizes the estimated costs and benefits.

Assuming that these 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 average annual cost is estimated at about $39,400 per year, consisting of the amortization of the $43,000 capital cost—$23,000 for floodproofing, $20,000 for structure elevation; and $36,600 in average annual crop damage. The average annual flood damage abatement benefit is estimated at $9,100 per year, yielding a benefit-cost ratio of 0.23. Therefore, the structure floodproofing and elevation alternative plan, as described herein, while technically feasible, would not be economically sound.

Diking Alternative

A diking alternative flood control plan was developed and analyzed for the lands subject to flooding by the Lower Pike River in order to determine if such a structural measure would provide a technically and economically sound solution to the existing and anticipated flood problem. The 100-year recurrence interval discharge under plan year 2000 land use conditions was used as the basis for the design of this alternative.

The diking alternative flood control plan element for the Lower Pike River is shown on Map 73, while the physical characteristics and estimated costs and benefits of this project are set forth in Table 94. The assumed dike design is shown in Figure 52. Under this alternative plan element, a total of about 4.4 miles of earthen dikes would be constructed along selected reaches averaging from five to nine feet in height with a maximum height of 11 feet.

In addition, culverts with backwater gates would be installed through the dikes to prevent the accumulation of lateral runoff behind the dikes, the backup of floodwaters through the culvert, and the attendant creation of local drainage problems. Floodproofing of two structures and elevation of one structure would also be required under this alternative plan element.

This alternative plan element would also include replacement of five bridges over the Lower Pike River: 1) STH 32, Alford Park Drive; 2) STH 32, Sheridan Road; 3) STH 32, S. 32nd Street; 4) CTH E, 12th Street; and 5) CTH Y, 22nd Avenue. As noted above in the discussion of the major channelization alternative, the replacement cost of these five bridges, which were recommended for replacement under the regional transportation plan, was not included in the cost analysis of the alternative flood control plan elements.

Assuming that the diking 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 $142,000, consisting of the amortization of the $2,049,000 capital cost of the dikes and structure floodproofing, and $13,000 in annual operation and maintenance cost of the dikes. The average annual flood abatement benefit is estimated at about $45,700, resulting in an excess of $96,300 in annual costs over benefits and a benefit-cost ratio of 0.32. The diking alternative plan, as described herein, would be technically feasible, but would not be economically sound.

Combination Onsite Storage, Detention Storage Reservoir, and Diking Alternative

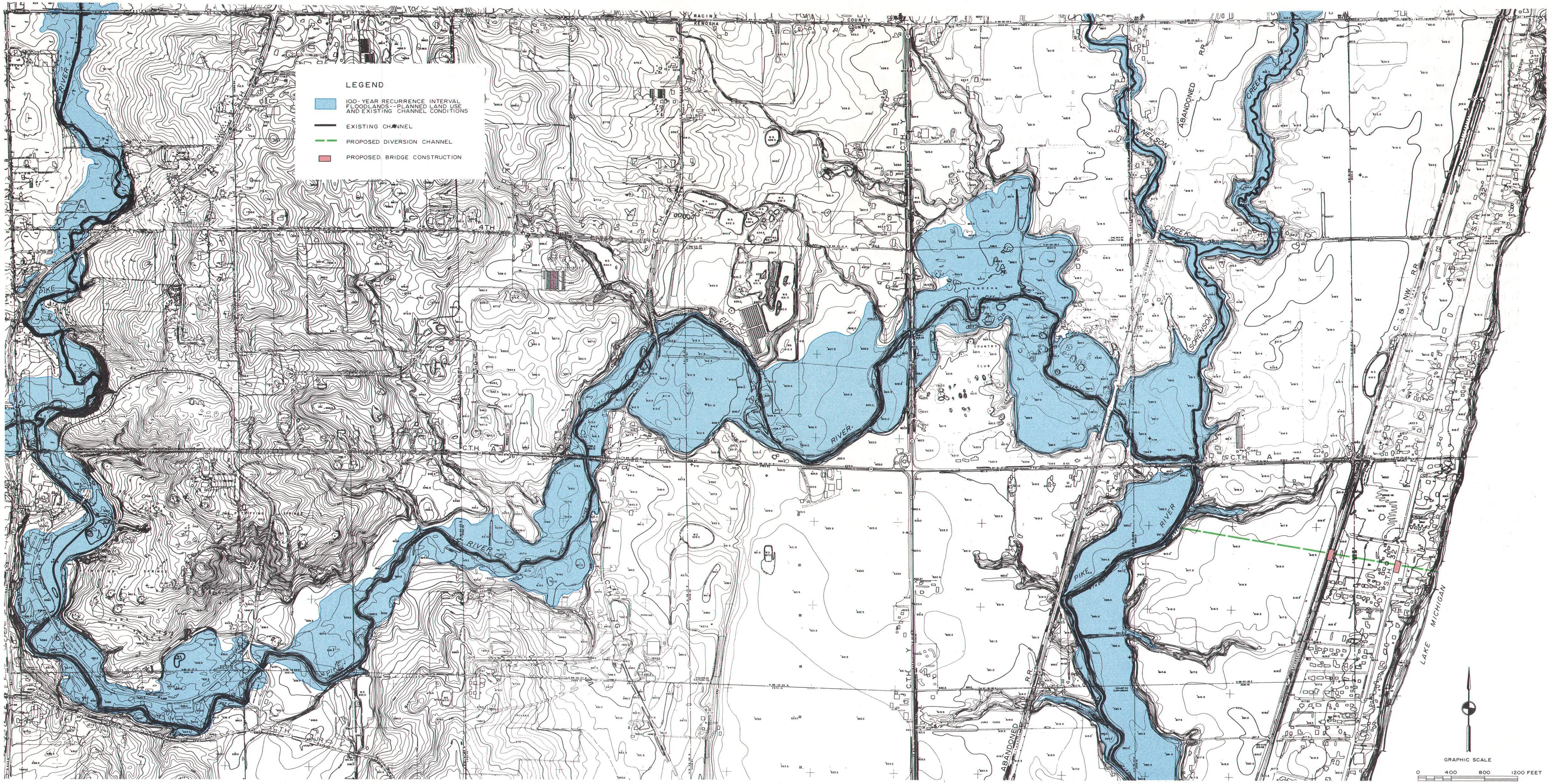
A combination onsite storage, detention storage reservoir, and diking alternative was developed and analyzed for the lands subject to flooding by the Lower Pike River in order to determine if such a flood control measure would provide a technically and economically sound solution to the existing and anticipated flood problem. This alternative assumes the adoption of a policy similar to that adopted by the Town of Mt. Pleasant, requiring that onsite stormwater detention facilities be provided as land is converted from rural to urban use to prevent any increase in peak flood discharges and corresponding stages resulting from such urbanization up to the 100-year recurrence interval event.

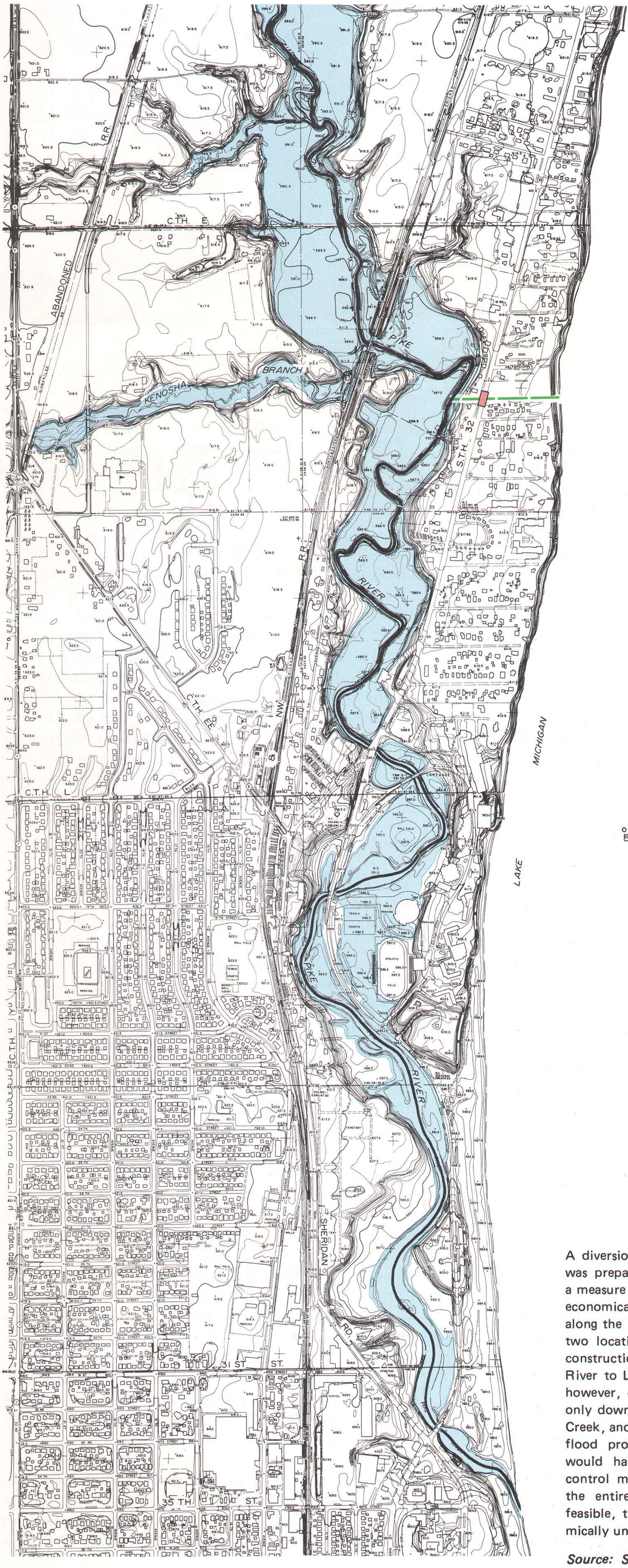
The onsite storage, detention storage reservoir, and diking alternative flood control plan element for the Lower Pike River is shown on Map 74, while the physical characteristics and estimated costs and benefits of this project are set forth in Table 94. The assumed dike design is shown in Figure 52, and the assumed reservoir outlet control structure design is shown in Figure 57.

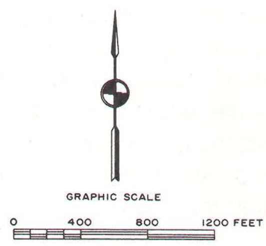
Under this alternative plan element, a detention storage reservoir would be located immediately upstream of CTH A within the University of Wisconsin-Parkside property and would extend upstream into Petrifying Springs Park, encompassing an area up to 150 acres. An earthen dam up to 15 feet higher than the CTH A road embankment would be required to provide the necessary storage capacity of the reservoir. A total of about 4.4 miles of earthen dikes would be constructed along selected reaches, averaging from four to seven feet in height and reaching a maximum height of nine feet. The assumed dike design is shown in Figure 52. In addition, culverts with backwater gates would be installed through the dikes to prevent the accumulation of lateral runoff behind the dikes, the backup of floodwaters through the culverts, and the attendant creation of local drainage problems. This alternative plan element would also include replacement of five bridges over the Lower Pike River: 1) STH 32, Alford Park Drive; 2) STH 32, Sheridan Road; 3) STH 32, S. 32nd Street; 4) CTH E; and 5) CTH Y. As noted above in the discussion of the major channelization alternative, however, the cost of these five bridges, which were recommended for replacement under the regional transportation plan, was not included in the cost analysis of alternative flood control plan elements. Floodproofing of two structures would also be required under this alternative plan element.

Map 71

DIVERSION CHANNEL ALTERNATIVE FOR THE LOWER PIKE RIVER







A diversion channel alternative flood control plan was prepared and evaluated to determine if such a measure would provide a technically feasible and economically sound solution to the flood problem along the Lower Pike River. Under this alternative, two locations were selected as potential sites for construction of diversion channels from the Pike River to Lake Michigan. These diversion channels, however, could as a practical matter be located only downstream of the confluence with Sorenson Creek, and would serve to abate only downstream flood problems. Therefore, a diversion channel would have to be combined with other flood control measures to abate flood problems along the entire Lower Pike River. While technically feasible, this alternative was found to be economically unsound.

Source: SEWRPC.

Utilizing an annual interest rate of 6 percent and an amortization period and project life of 50 years, the average annual cost of the onsite storage, detention storage reservoir, and diking alternative is estimated at $381,000, consisting of the amortization of the $4,805,000 capital cost of the onsite detention storage, detention storage reservoir, diking, and structure floodproofing; and $77,600 in annual operation and maintenance cost of the onsite storage facilities and dikes. Although onsite detention storage facilities could be provided by the land developer at no cost to the Towns of Somers and Mt. Pleasant, the estimated capital cost of these facilities—$2,916,000—and the estimated annual operation and maintenance cost of $64,800 are properly included in any economic analysis of this alternative when evaluating major flood control alternatives on an areawide basis. The average annual flood abatement benefit is estimated at $45,700, resulting in an excess of $335,000 in annual costs over benefits and a benefit-cost ratio of 0.12. On the basis of these findings, it should not be concluded that onsite storage is uneconomical in every case. In this respect it should be recognized that onsite storage may permit the size and length of local storm water drainage facilities to be reduced with attendant cost reductions. The viability of onsite storage in this respect should be evaluated on a site specific basis. Excluding the costs for onsite storage, the ratio of total average annual benefits to public costs is still only 0.21. The onsite storage, detention storage reservoir, and diking alternative plan element, as described herein, while technically feasible, is not economically sound.

ALTERNATIVE FLOODLAND MANAGEMENT PLAN ELEMENTS FOR THE PIKE RIVER ESTUARY

The Flood Problem

In addition to the flooding along the Pike River estuary caused by runoff from the Pike River watershed, flooding has also been caused along the estuary by phenomena associated with Lake Michigan. The first of these phenomena, and perhaps the most significant, is the damming of the mouth of the Pike River by littoral drift in Lake Michigan. During storms on Lake Michigan when onshore winds prevail, littoral drift rates increase landward of the surf zone and the mouth of the river can be dammed by the formation of a foreshore berm. Littoral drift is the longshore transport of shoreline deposits suspended by the action of breaking waves and translated by currents generated by waves breaking not parallel to the shoreline. The height of the berm is approximately equal to the elevation reached by wave runup, which is a function primarily of wave energy, depth, and beach slope and roughness.

Because wave runup is dependent on the energy of breaking waves, the larger the waves the higher the elevation of the resulting berm. Berms as high as six feet above the normal water level of the Pike River have been observed following severe northeasterly storms on the lake. Subsequent to berm formation, the water level in the Pike River estuary begins to rise and continues to do so until either hydrostatic pressure from the river pushes the berm into the lake, or until the river starts to flow over the crest of the berm, at which time rapid scouring of the sand and gravel deposits occurs with attendant rapid declines in water levels in the estuary. Photographs of such a breached berm about six feet tall are presented in Figure 60.

A second lake-related phenomenon causing flooding along the estuary, of lesser importance than the damming of the mouth, is storm induced water level fluctuation in Lake Michigan. Maximum instantaneous open-coast water levels occur during periods when annual lake levels are high and overlake storms occur. Such storms cause wind setup—that is a rise in lake level—along the lake shore and initiate the east-west seiche which generally has larger amplitudes on Lake Michigan at Kenosha than north-south seiches. Storm surges—a somewhat similar phenomena—are water level fluctuations associated with sharp declines in barometric pressure over the lake. In April 1973, a storm surge increased water levels in Kenosha Harbor about five feet, to an elevation of about 585.5 feet NGVD. Focusing effects of the harbor geometry may have contributed to the large change in water level. However, it may be assumed that water level increases in the Pike River estuary during that storm were of a similar magnitude. Annual maximum storm-induced water surface elevation changes for Lake Michigan at Milwaukee typically range from about 0.5 to 1.5 feet, based on records available for that location since 1906. Three storm events ranging from about 2.0 to 2.5 feet occurred in Milwaukee in April 1909, March 1954, and April 1966.

Water levels in the Pike River estuary are increased during Lake Michigan storms, the extent of the water level increase also being affected by the magnitude of watershed runoff flowing into the

Figure 60

PHOTOGRAPHS OF A BREACHED BERM AT THE MOUTH OF THE PIKE RIVER IN JANUARY 1982

DOWNSTREAM SIDE

Source: SEWRPC.

UPSTREAM SIDE

Source: SEWRPC.

estuary during the storm events. Harmonic amplification of lake levels within the estuary associated with seiching is unlikely because the natural period of resonance for the Pike River estuary—approximately 0.5 hour—is much smaller than the east-west seiche period for Lake Michigan—approximately 2.8 hours.

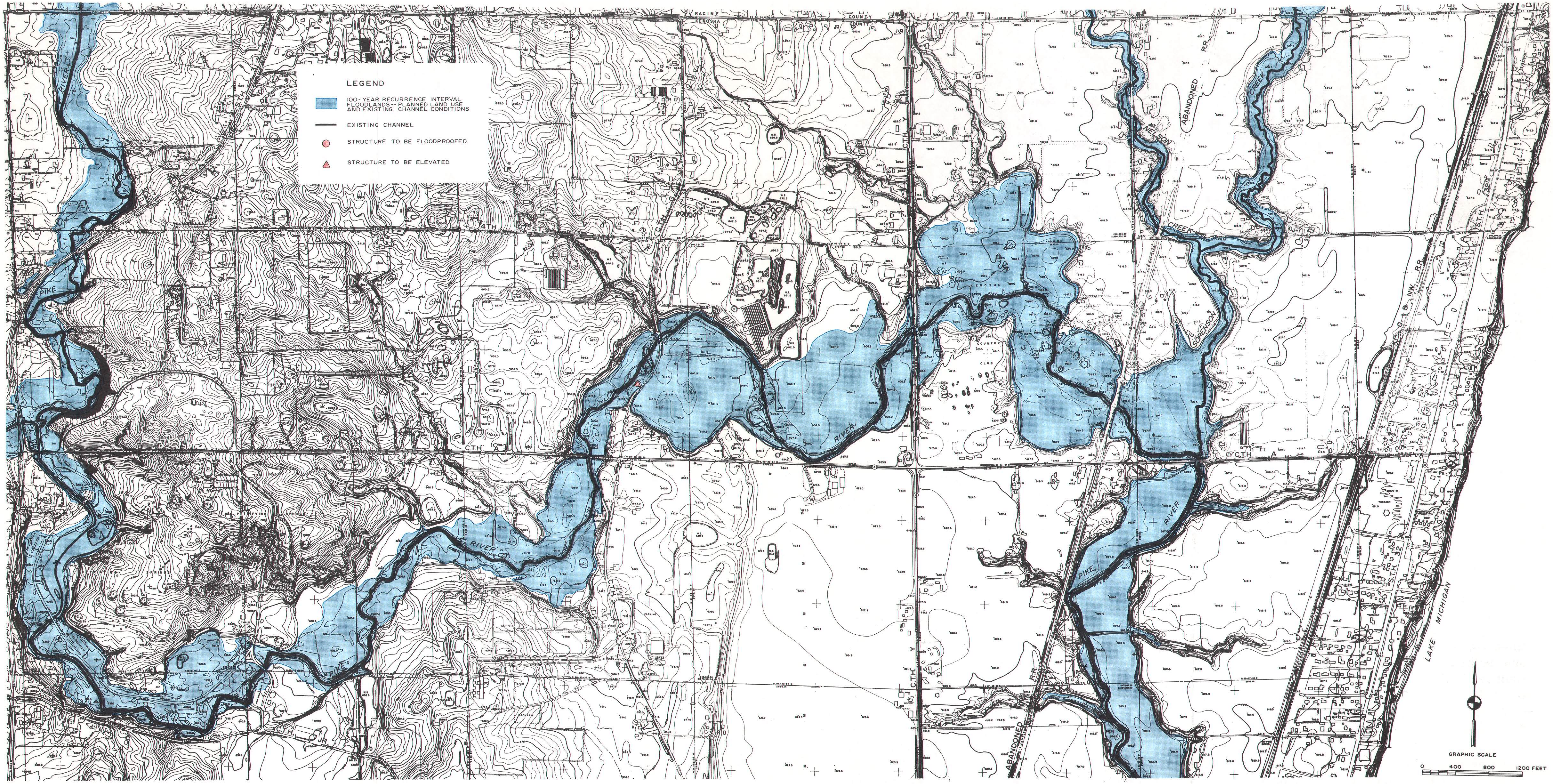
Interviews with City of Kenosha and Carthage College officials and a lifelong resident and observer of Lake Michigan and the Pike River estuary, Mr. Chester P. Wojnicz, indicate that seiching may cause minor flooding a few times each year when annual lake levels are high, but more severe lake-induced flooding problems occur when a berm blocks the mouth of the river during high watershed runoff events. Such a situation reportedly caused the highest flood stages in memory in the estuary in April of 1973. Flooding caused by the formation of a berm inundates the southbound lane of STH 32 near the south entrance to Carthage College—reportedly about three times each year—the campus athletic fields and parking areas, and the lowest floor of the campus fieldhouse. Water surface elevations at these locations approximate the 50-year flood stage for unobstructed flow conditions and are about one foot lower than the 100-year stage for existing land use conditions. It is estimated that when average annual lake levels are normal, flood stages within the estuary will range up to 585 or 586 feet NGVD a few times each year due to bar formation at the mouth. During extreme storm conditions and high annual lake levels, it is estimated that a bar crest elevation of about 588 feet might occur with a similar associated water surface elevation in the estuary. In August 1980 sudden breaching of the berm by the river caused the drowning deaths of two people who were swept into Lake Michigan from the beach at the mouth of the Pike River. A similar incident also occurred causing a drowning death in July 1968.

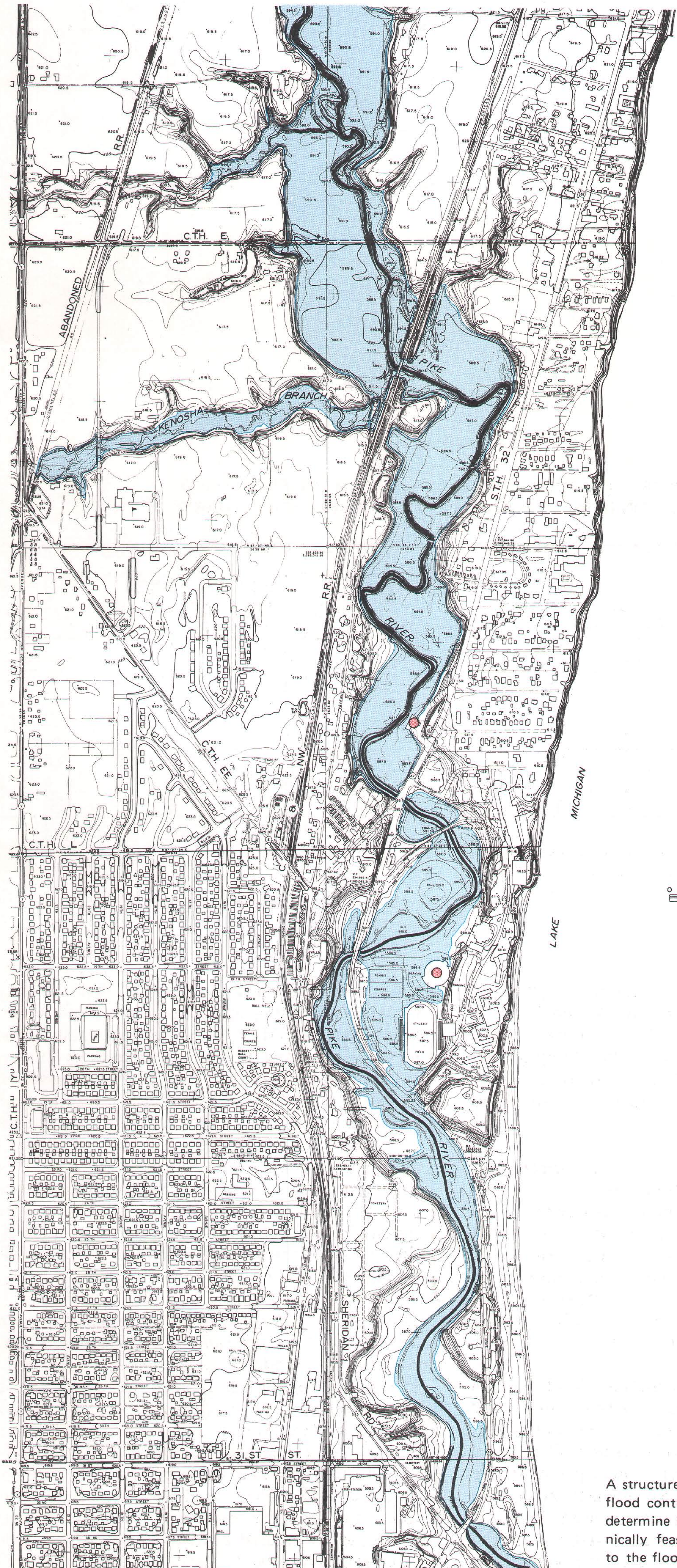
Under existing conditions, estimated direct monetary flood damages of about $89,700 during a 100-year recurrence interval flood event, and about $6,400 during a 10-year recurrence interval event are not expected to be increased significantly due to the lake-associated phenomena over the damages attributable solely to watershed runoff. Average annual damages are estimated to total about $11,200 under both existing and plan year 2000 conditions. About $7,400 of the average annual flood damage is estimated to be attributable to backwater from the berm at the mouth of the Pike River.

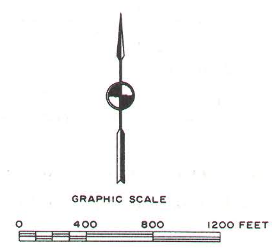
It should be noted that flooding due to lake-related phenomena is a relatively recent development, according to reports by longtime residents of the City of Kenosha. Reportedly, no significant problems existed until the Alford Park groin field was constructed under a federal Works Project Administration program in the 1930's. At that time the Pike River discharged to the lake through three mouths across a very narrow beach. Following

Map 72

STRUCTURE FLOODPROOFING AND ELEVATION ALTERNATIVE FOR THE LOWER PIKE RIVER







A structure floodproofing and elevation alternative flood control plan was prepared and evaluated to determine if such a measure would provide a technically feasible and economically sound solution to the flood problem along the Lower Pike River. Under this alternative, two structures would have to be floodproofed and one structure would have to be elevated. While technically feasible, this alternative was found to be economically unsound.

Source: SEWRPC.

Table 95

PRINCIPAL FEATURES, COSTS, AND BENEFITS OF FLOODLAND MANAGEMENT ALTERNATIVES FOR THE PIKE RIVER ESTUARY

Alternative		Economic Analysis[a]											
Name	Description	Technically Feasible	Capital Cost: Item	Capital Cost (thousands)	Annual Amortized Capital Cost (thousands)	Annual Operation and Maintenance Cost (thousands)	Total Annual Cost (thousands)	Annual Benefits (thousands)	Excess of Annual Benefits Over Cost (thousands)	Benefit-Cost Ratio	Benefit-Cost Ratio Greater Than 1.0	Nontechnical and Noneconomic Considerations: Positive	Nontechnical and Noneconomic Considerations: Negative
No action	--	Yes	--	$ --	$ --	$ --	$ --	$ --	$ --	--	No	--	--
Dredging	Dredging of berms about six times per year	Yes	Dredging	--	--	7.0	7.0	7.4	0.4	1.06	Yes	--	A continuous monitoring and surveillance program would be required at the mouth of the river in order to determine when dredging would be required
Jetty construction	a. Construction of two parallel jetties b. Dredging between jetties once per year	Yes	Jetties Dredging Subtotal	95.0 -- 95.0	6.0	1.1	7.1	7.4	0.3	1.04	Yes	--	--

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

[b]*The total annual cost for this alternative consists of the average annual monetary flood damages.*

Source: SEWRPC.

construction of the groin field, the beach gradually widened. At the present time the beach is about 200 feet wide, and two of the three original mouths have been permanently filled in by littoral drift, with the third and last mouth of the river experiencing periodic deposition and scour as described previously.

Two alternative measures were developed and evaluated to abate the flood problems caused primarily by the lake-related phenomenon—the formation of a berm at the outlet of the river. One of these alternatives consists of periodic removal of the berms by dredging. The other alternative consists of the construction of jetties to avoid formation of the berm at the river mouth.

Dredging Alternative

As already noted, an alternative flood control measure, consisting of dredging, was developed and analyzed to determine if such a measure would provide a technically and economically sound solution to the existing and anticipated future flood problems caused along the estuary by the most significant lake associated phenomenon. This alternative assumes the periodic dredging of the berms formed at the mouth of the river when those berms reach a height of approximately four feet. Berms over four feet in height may be expected to form at the mouth of the river on the average of about six times per year. Berms of this size can cause significant flooding problems along the estuary—depending upon the annual and seasonal levels of Lake Michigan—whereas, smaller berms may be expected to be washed out by the river before flood stages are reached. These berms form during storms on Lake Michigan and should be removed immediately following each large storm to prevent river back-up and associated flooding. This alternative assumes removal of these deposits six times per year by dragline or other suitable heavy duty excavation equipment. This alternative would require continued monitoring and surveillance at the mouth of the River in order to determine when dredging would be required.

The costs and benefits of this alternative plan elelent are set forth in Table 95. The average annual cost of the dredging alternative is estimated at $7,000, consisting entirely of removing deposits six times per year by dragline or other suitable, heavy-duty excavation equipment. The average annual flood abatement benefit is estimated at $7,400, resulting in an excess of benefits over costs of $400, and a cost benefit ratio of 1.06. Therefore, the dredging alternative plan, as described herein, is considered both technically feasible and economically sound.

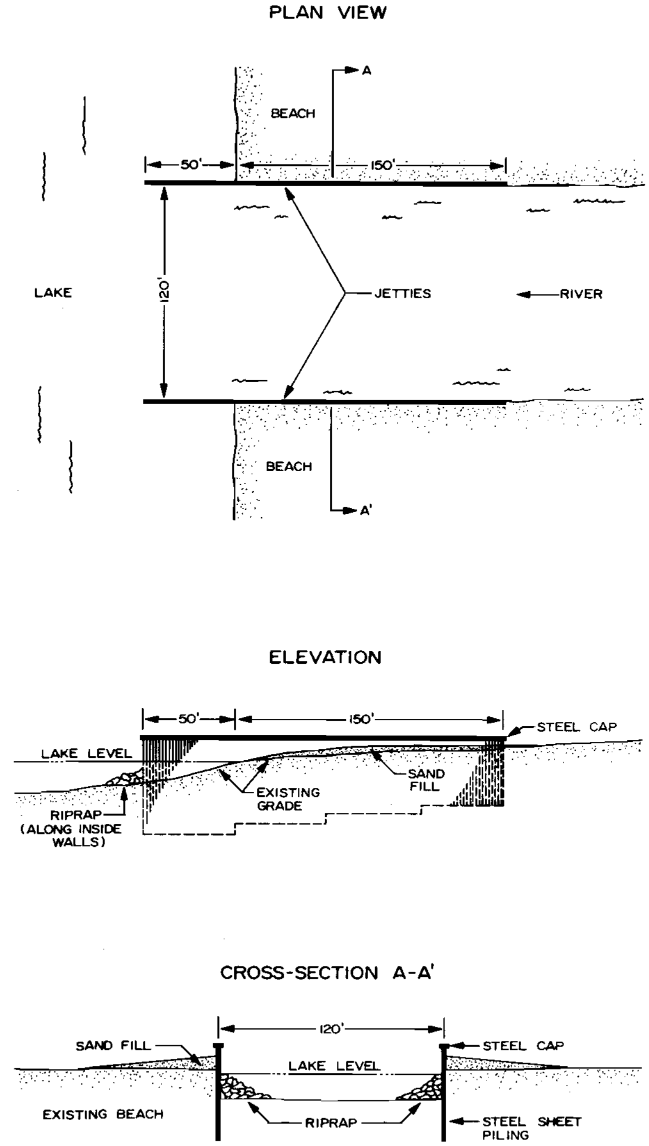
Jetty Construction Alternative

A second alternative flood control measure, consisting of the construction of jetties, was developed and analyzed to determine if such a measure would provide a technically and economically sound solution to the existing and anticipated future flood problems caused along the estuary by the most significant lake associated phenomenon. This alternative assumes the construction of jetties at the mouth to inhibit berm formation. Two parallel sheet-pile jetties extending about 50 feet into the lake and about 150 feet back into the beach, and 120 feet apart would be constructed under this alternative. Figure 61 presents a sketch of the jetty arrangement. The final design of the jetties should be made by a qualified coastal engineer and should be based upon a surveyed lakebed profile, and upon a design wave of appropriate recurrence interval and associated breaker depth, breaker energy, and wave runup. Seasonal and annual variation in lake level and storm set-up must also be taken into consideration in determining the jetty design. The jetties in the foreshore area should be higher than the design wave runup elevation to inhibit berm formation within the design channel. The top of the jetties could be much lower landward and lakeward from this location to minimize costs and potential for wave and ice damage. Under this alternative, dredging would be required once per year to remove accumulated sediments in the channel between the jetties.

The costs and benefits of this alternative plan element are set forth in Table 95. Using an annual interest rate of 6 percent and an amortization period and project life of 50 years, the average annual cost of the jetty construction alternative is estimated at $7,100, consisting of amortization of the $95,000 estimated capital cost for the jetty construction, and $1,100 in annual operation and maintenance cost for annual dredging. The average annual flood abatement benefit is estimated at $7.400, resulting in an excess of benefits over costs of $300, and a cost benefit ratio of 1.04. Therefore, the jetty construction alternative plan, as described herein, is considered to be both technically feasible and economically sound.

Figure 61

SKETCH OF PROPOSED JETTIES AT THE MOUTH OF THE PIKE RIVER



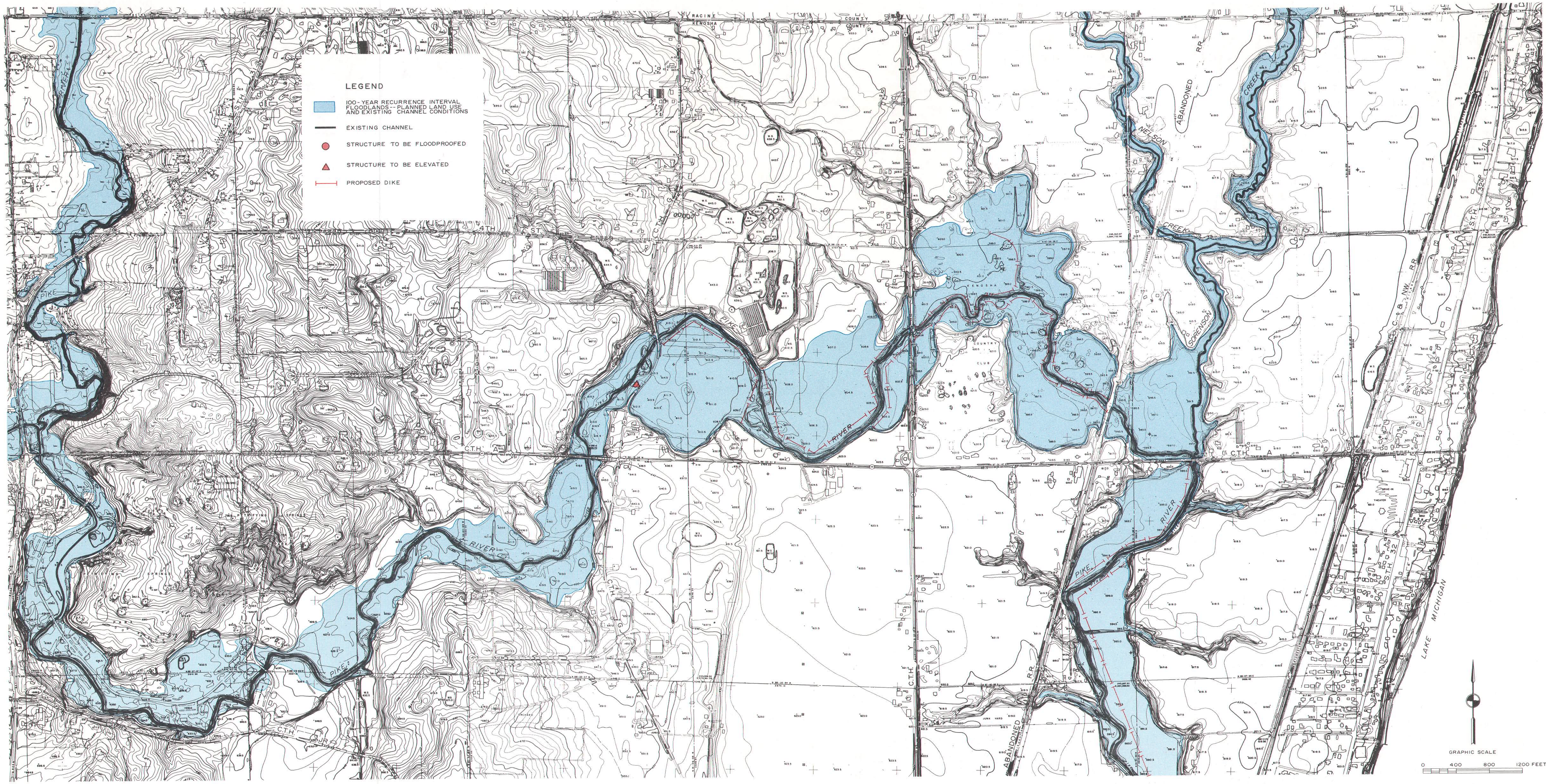
Source: SEWRPC.

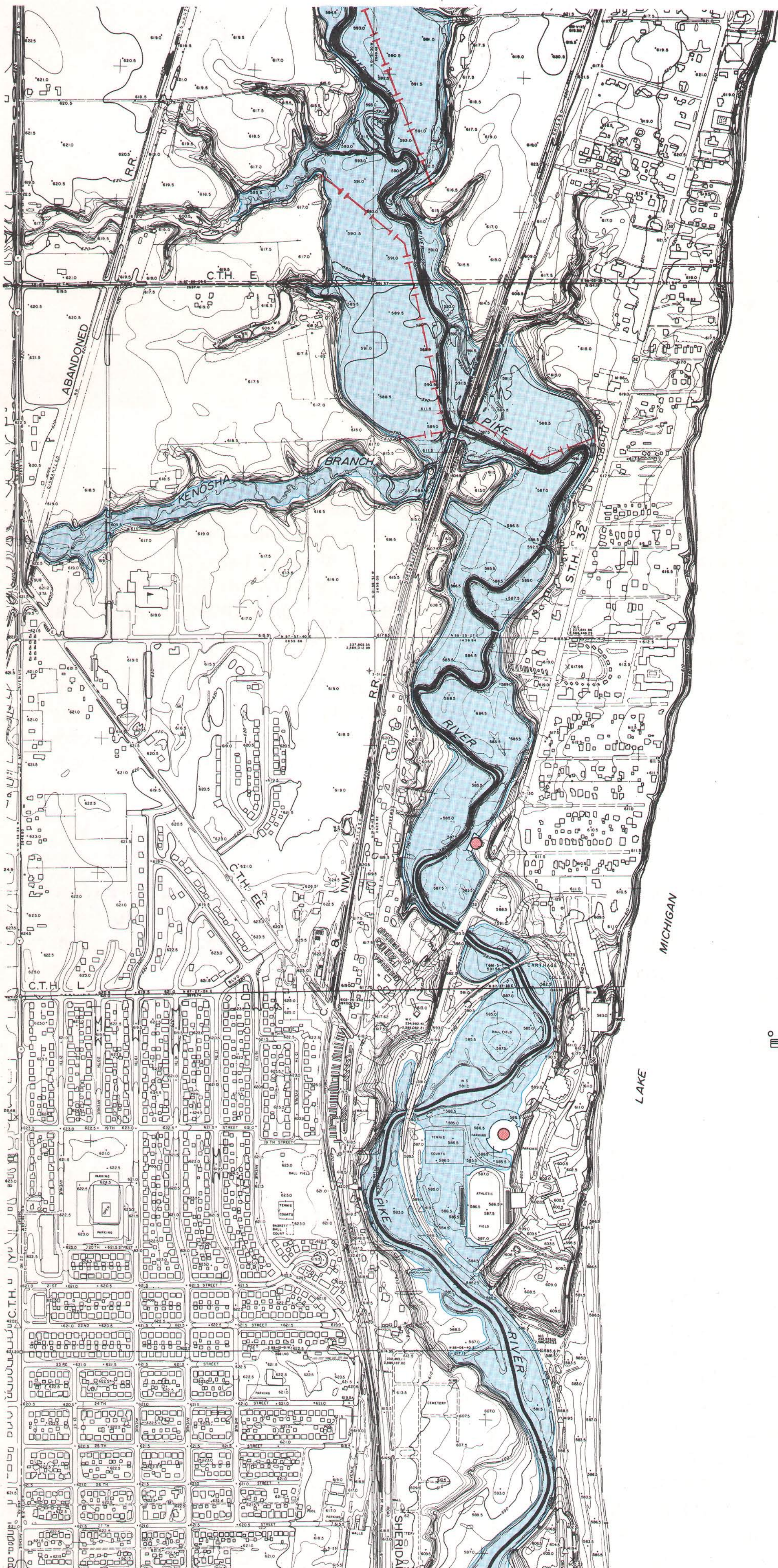
CONCLUDING STATEMENT

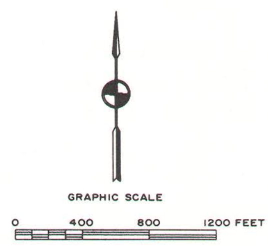
To enable the required analysis of alternative floodland management measures for the Pike River watershed, it was necessary to first consider the flood problems and possible solutions to those problems associated with smaller individual portions of the watershed. Therefore, the watershed was subdivided into the following 12 smaller drainage units for preliminary analysis purposes: 1) Bartlett Branch, 2) Waxdale Creek and the tributary to Waxdale Creek, 3) Chicory Creek, 4) Lamparek Ditch, 5) Somers Branch, 6) Airport Branch and the tributary to Airport Branch, 7) Nelson Creek, 8) Sorenson Creek, 9) Kenosha Branch, 10) Pike Creek, 11) Upper Pike River, and 12) Lower Pike River. In addition, an individual analysis of flooding problems and possible solutions to those problems was completed for the Pike River estuary.

Map 73

DIKING ALTERNATIVE FOR THE LOWER PIKE RIVER







A diking alternative flood control plan was prepared and evaluated to determine if such a measure would provide a technically feasible and economically sound solution to the flood problem along the Lower Pike River. Under this alternative, a total of about 4.4 miles of earthen dikes would be constructed along selected reaches of the Pike River. In addition, two structures would have to be floodproofed and one structure would have to be elevated. While technically feasible, this alternative was found to be economically unsound.

Source: SEWRPC.

Six different structural flood control measures—bridge or culvert replacement, channel modification, dikes, detention reservoirs, onsite storage, and floodwater diversion—and one nonstructural measure—structure floodproofing, elevation, and removal—and combinations thereof, were examined as possible solutions to the flood problems that exist along the Pike River and its tributaries. 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 analysis of the potential benefits associated with each of the other alternatives.

The principal features of, and the cost and benefits associated with, each of the floodland management alternatives are summarized in Table 85 through Table 94, together with the major favorable and unfavorable nontechnical and noneconomic considerations likely to influence selection of the most desirable solution. Excluding the "no action" approach, all of the above structural and nonstructural alternatives were found to be technically feasible; however, not all were found to be economically sound. Several alternatives, although not sound economically, were found to have sufficient intangible benefits to be maintained as viable alternatives.

Even though structure floodproofing, elevation, and removal constitutes a technically feasible and economically sound floodland management alternative for certain stream reaches in the Pike River watershed, successful implementation of this flood control measure may be difficult for several important reasons. First, complete implementation of a voluntary structure floodproofing and elevation program is unlikely and, with partial implementation, the respective public agency concerned 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. Furthermore, yard damages and cleanup costs remain with the structure floodproofing, elevation, and removal alternative, and sanitary and storm sewers would continue to experience surcharging. Also, some floodproofing is very likely to be applied without adequate professional advice. As a result, structure damage is likely to occur, and once again public agencies are likely to be asked to assist in resolution of the problem.

Although channel modification may constitute a technically feasible and economically sound flood control measure for certain stream reaches in the Pike River watershed, there exist two negative aspects of this flood control measure which must be considered when selecting the most favorable floodland management alternative for a particular stream reach. Major channelization may have a severe negative aesthetic impact, and may destroy the aquatic life and wildlife habitat provided by a natural water course. Channel enlargement may result in increased peak flood discharges downstream, possibly creating a need for additional flood control measures.

The construction of dikes also may have a negative aesthetic impact, particularly if this flood control measure is used in an urbanized area. Construction of dikes directly adjacent to a stream may also increase downstream peak flood discharges by eliminating floodwater storage.

Detention reservoirs are the only structural flood control measures which have the potential for providing significant intangible benefits. Such reservoirs can provide public open space for recreational uses and can assist in preserving natural areas.

After due consideration of the various technical and economic features and other intangible aspects of the alternative floodland management measures considered for the 12 individual subareas of the watershed and for the Pike River estuary, a preliminary recommendation of the most favorable alternative for each flood-damage prone reach of the watershed was made. It should be noted that the selection of recommended plans from among the alternatives considered was based upon consideration of probable future, as well as existing, land use conditions. Consideration of the effects upon design flood flows of implementation of a system of recommended flood control measures in the watershed was not as yet considered. Therefore, more refined recommendations based upon the implementation of a set of recommended flood control measures throughout the watershed are presented in Chapter XIV of this report.

The preliminary recommended flood control measures for the Pike River and its tributaries, and for the Pike River estuary, are presented in Table 96. It should be noted that certain alternatives, although not economically sound, were deemed by the watershed committee to possess sufficient intangible benefits to warrant recommendation. In this respect it should also be noted that the benefit component of the benefit-cost ratios herein pre-

Table 96

PRELIMINARY RECOMMENDED FLOOD CONTROL ALTERNATIVES FOR THE PIKE RIVER WATERSHED

Stream Reach	Number of Alternative	Description of Alternative	Reasons for Recommendation
Bartlett Branch	7	Onsite detention storage, dike, and structure floodproofing, and elevation	Most cost-effective, minimal construction required
Waxdale Creek and Tributary to Waxdale Creek	1	No action—except floodland zoning and channel maintenance	Minor monetary crop damages, no economically sound alternative
Chicory Creek	1	No action—except floodland zoning and channel maintenance	Minor monetary crop damages, no economically sound alternative
Lamparek Ditch	- -	No action—except floodland zoning and channel maintenance	No flood damages
Somers Branch Downstream of CTH EA	1	No action—except floodland zoning and channel maintenance	Minor monetary crop damages
Somers Branch Upstream of Milwaukee Road	6	Structure floodproofing and elevation	Most cost-effective alternative
Airport Branch and Tributary to Airport Branch	2	Culvert modification and major channelization	Least costly
Nelson Creek	1	No action—except floodland zoning and channel maintenance	Minor monetary crop damages, no economically sound alternative
Sorenson Creek CTH KR Upstream to the Abandoned North Shore Railway Right-of-Way	1	No action—except floodland zoning and channel maintenance	Only minor monetary residential structure damages
Sorenson Creek Chicory Road Upstream to Pleasant Lane	6	Culvert replacement	Most practicable
Sorenson Creek Taylor Avenue Upstream to Meacham Road	10	No action—except floodland zoning and channel maintenance	Only minor monetary residential structure damages
Kenosha Branch	- -	No action—except floodland zoning and channel maintenance	No flood damages
Pike Creek	2	Channel enlargement	Most cost-effective, most practicable
Upper Pike River	3	Onsite detention storage and channel enlargement	Most practicable
Lower Pike River	5 and 6	Diking and structure floodproofing	Least costly[a]
Pike River Estuary	2	Jetty construction	Reliability

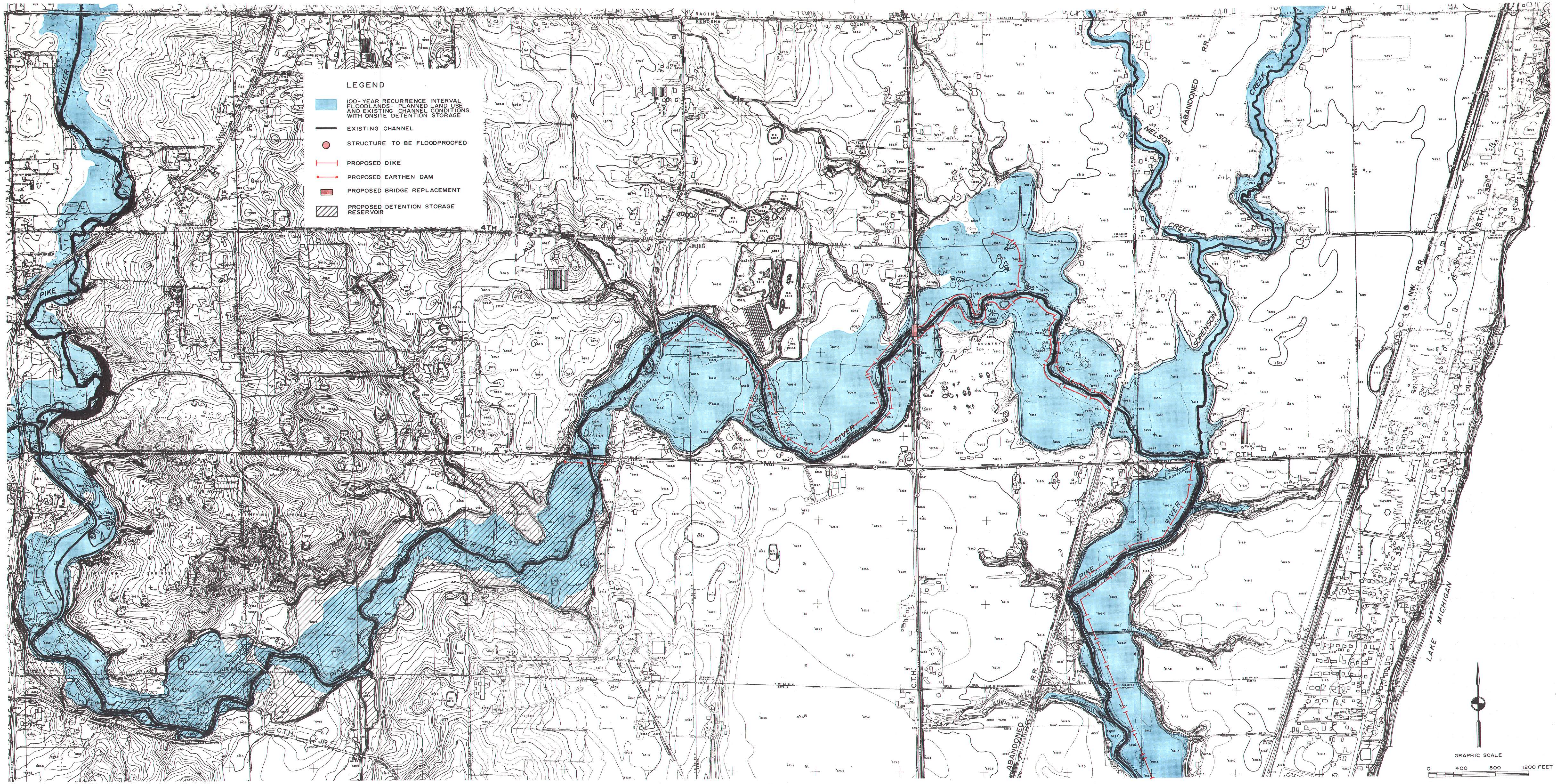
NOTE: Onsite storage has been included in the recommended alternatives for those stream reaches located in the Town of Mt. Pleasant because of the Town's policy in this regard. In other areas of the watershed, such onsite storage has not been included in the recommended alternatives. It is recommended that onsite storage in these areas be considered only on a site specific basis to determine if the costs of such storage would be offset by reduced costs of local storm water drainage systems.

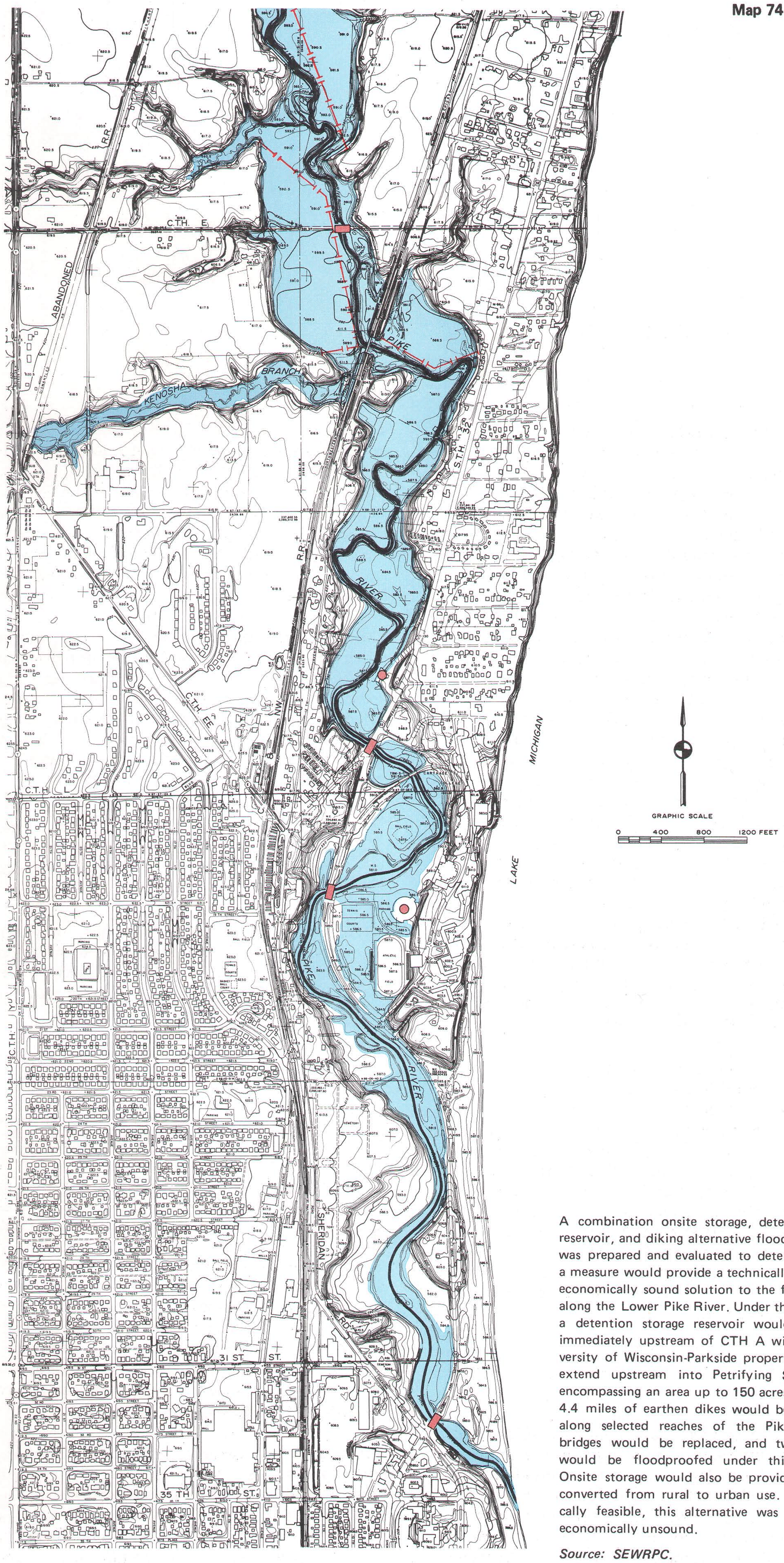
[a] *The dikes would be designed to contain a flood having a recurrence interval of up to and including five years.*

Source: SEWRPC.

Map 74

COMBINATION ONSITE STORAGE, DETENTION STORAGE RESERVOIR, AND DIKING ALTERNATIVE FOR THE LOWER PIKE RIVER





A combination onsite storage, detention storage reservoir, and diking alternative flood control plan was prepared and evaluated to determine if such a measure would provide a technically feasible and economically sound solution to the flood problem along the Lower Pike River. Under this alternative, a detention storage reservoir would be located immediately upstream of CTH A within the University of Wisconsin-Parkside property and would extend upstream into Petrifying Springs Park, encompassing an area up to 150 acres. In addition, 4.4 miles of earthen dikes would be constructed along selected reaches of the Pike River, five bridges would be replaced, and two structures would be floodproofed under this alternative. Onsite storage would also be provided as land is converted from rural to urban use. While technically feasible, this alternative was found to be economically unsound.

Source: SEWRPC.

sented are somewhat understated, being based solely upon the avoidance of the direct monetary expenditures required to restore flood-damaged property to preflood condition. Such expenditures include expenditures for cleaning, repairing and replacing residential, commercial, and industrial buildings and contents and other objects and materials located outside the buildings on the affected property. Such expenditures also include expenditures for cleaning, repairing, and replacing roads and bridges, storm water drainage systems, sanitary sewer systems, and other utility systems, as well as the cost of restoring damaged park and recreational lands. The benefits do not include expenditures such as expenditures for flood fighting, evacuation, and provision of emergency services; nor the indirect monetary losses entailed in lost wages, lost production, and lost sales; nor the increased highway and railroad transportation costs entailed in flood-caused detours. Such indirect costs, while difficult to estimate with accuracy, constitute a real monetary burden on the economy of an area. Similarly, the benefit-cost analyses herein presented do not reflect the avoidance of intangible costs associated with flood-associated health hazards, property value depreciation, and the general disruption of normal community activities. Intangible losses and risks also include the severe psychological stress experienced by owners or occupants of structures in flood-prone areas.

Benefit-cost analysis properly represents but one of many considerations in any determination to proceed with a public flood control project. There may be situations in which an affected local community may subjectively, but strongly, favor an alternative plan that has an objectively determined benefit-cost ratio of less than one; or conversely, may strongly oppose an alternative with a benefit-cost ratio of greater than one. Such determinations may be entirely proper if based upon careful deliberation concerning other than purely economic objectives by the responsible public governing bodies concerned.

BRIDGE AND CULVERT ALTERATION OR REPLACEMENT FOR TRANSPORTATION PURPOSES

Bridges and culverts that are inadequately designed from a hydraulic perspective can significantly increase flood stages and areas of inundation, and may be subject to closure during major flood events, thereby adversely affecting the operation of the highway transportation system. The approach used to identify flood-prone reaches of the watershed included a search for bridges that may cause or aggravate existing flood problems. The purpose of this section of the chapter is to identify those bridges and culverts that may 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 systems during major flood events.

The watershed development objectives and supporting principles and standards set forth in Chapter X 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 the resultant disruption of traffic by 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 recommended 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 stream crossing—that is, the classification as a minor land access and collector street, arterial street and highway, and as a freeway and expressway—is established in the adopted design year 2000 regional transportation system 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 systems can function properly.

Information contained within the hydrologic-hydraulic summary tables set forth in Appendices D, E, and F in combination with the bridge standards was used to identify the existing bridges and culverts in the watershed that have substandard capacity during major flood events. As set forth in

Table 97

STREAM CROSSINGS IN THE PIKE RIVER WATERSHED HAVING SUBSTANDARD HYDRAULIC CAPACITIES

Structure Identification[a]					Recommended Design Frequency (years)	Hydraulic Inadequacy	
Stream	Number[b]	Name	River Mile	Civil Division		Approach Road Overtopped	Bridge Deck Overtopped
Pike River	145	Lathrop Avenue	4.79	Town of Somers	50	X	
	270	CTH KR/County Line Road	11.15	Towns of Somers and Mt. Pleasant	50	X	
	275	Braun Road	12.23	Town of Mt. Pleasant	50	X	X
	285	STH 11/Durand Avenue	13.29	Town of Mt. Pleasant	50	X	
	295	Oakes Road	14.51	Town of Mt. Pleasant	10	X	X
Pike Creek	500	STH 31/Green Bay Road	0.09	Town of Somers	50	X	X
	520	Town of Somers Transfer Station Road	3.17	Town of Somers	10	X	X
	550	STH 142/S. 43rd Street	4.86	Town of Somers	50	X	
	565	CTH K/60th Street	6.45	Towns of Somers and Pleasant Prairie	50	X	X
	570	Chicago, Milwaukee, St. Paul & Pacific Railroad Company	6.85	Town of Pleasant Prairie	100	X	X
Bartlett Branch	340	Stuart Road	0.53	Town of Mt. Pleasant	50	X	X
	350	Clinton Lane extended	0.79	Town of Mt. Pleasant	10	X	X
Tributary to Waxdale Creek	425	90th Street	1.24	Village of Sturtevant	50	X	X
	430	CTH H/Wisconsin Street	1.89	Village of Sturtevant	50	X	X
Nelson Creek	1120	Lathrop Avenue	0.55	Town of Somers	50	X	X
	1125	Lathrop Avenue	0.62	Town of Somers	50	X	X
Sorenson Creek	1010	CTH KR/County Line Road	1.56	Towns of Somers and Mt. Pleasant	50	X	X
	1035	Chicory Road	2.93	Town of Mt. Pleasant	50	X	X
	1045	Pleasant Lane	3.15	Town of Mt. Pleasant	10	X	X
Kenosha Branch	1200	20th Avenue	0.76	Town of Somers	50	X	X
	1215	CTH Y/22nd Avenue	0.90	Town of Somers	50	X	X

[a] *This table identifies public bridges and culverts which, when considered in conjunction with their approach roadways, have substandard hydraulic capacities under plan year 2000 land use and existing channel conditions according to the water control facility standards set forth in Chapter X.*

[b] *Bridges and culverts are identified by structure number and are located on Map 29, Chapter V.*

Source: SEWRPC.

Table 97, 21 bridges and culverts may be expected to have substandard hydraulic characteristics under plan year 2000 land use and existing channel conditions. It is recommended that, when these bridges are modified or replaced by local or state highway agencies or by railroads as a part of highway and railroad improvement programs, the crossings be designed to provide adequate hydraulic capacity in accordance with recommended standards. Of the total number of substandard bridges and culverts, 20 are located on arterial streets and highways other than freeways and expressways where the 50-year recurrence interval standard is applicable; and one is located on a railroad where the 100-year recurrence interval standard is applicable.

The location and design of all new bridges and culverts, as well as the design of replacements of, or modifications to, existing bridges or culverts, should be based upon the applicable objectives and standards as set forth in Chapter X of this report. Of particular importance is the standard which requires that all new or replacement bridges and culverts be designed so as to accommodate the 100-year recurrence interval peak flood discharge under plan year 2000 land use conditions without raising the corresponding peak flood stage by more than 0.1 foot for the 100-year recurrence interval flood, as such stage is established in the adopted comprehensive watershed plan. This provision is intended to ensure 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.

RECOMMENDED NONSTRUCTURAL FLOODLAND MANAGEMENT MEASURES

Of the 11 available nonstructural floodland management measures set forth in Table 83 and discussed earlier in this chapter, two have been considered as specific alternatives for abatement of flood damages in the Pike River watershed. An additional three are particularly effective for minimizing aggravation of existing problems and for preventing development of future flood hazards. The six remaining nonstructural measures, when used in combination, have the potential to avoid the aggravation of existing flood problems, minimize the development of future flood hazards, and help to alleviate monetary flood losses incurred by owners of existing flood-prone property, and may substantially reduce the threat to life and health of residents of flood-prone areas. The recommended application of the three primary nonstructural floodland management measures—reservation of open floodlands for recreational and related open space uses, floodland use regulation, and channel maintenance—and the six secondary measures, are described below.

Primary Measures

Reservation of Floodland for Recreation and Related Open Space Uses: The land use plan element of the watershed plan recommends, as described in Chapter XI, the continued preservation in essentially natural open uses of 1.9 square miles of primary environmental corridor and 0.9 miles of secondary environmental corridor in the Pike River watershed. These corridor lands follow the alignment of the Pike River and encompass most of the floodlands along the main stem. 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 lands for these purposes constitute important means of implementing the recommended watershed plan. It is accordingly recommended that the use of floodland areas for outdoor recreation and related open space activities be encouraged not only to implement the recommended land use plan, but also to minimize the aggravation of existing flood problems and the development of new flood problems in the watershed.

The Wisconsin Floodplain Management Program: The State Statutes require that all counties, cities, and villages 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. Of the communities in the watershed, all but the Village of Elmwood Park contain some existing or potential flood hazard areas. All of these communities have adopted floodland or floodland-related regulations such as wetland, conservancy, or floodplain zoning to protect the floodlands of the Pike River watershed from further encroachment by flood-prone rural and urban land uses. All of these zoning ordinances have been approved or were in mid-1982 in the process of approval by the Wisconsin Department of Natural Resources. It is recommended that, in order to conserve the floodwater storage and conveyance capacity of the existing floodlands, abate future flood hazards and monetary flood damages, reduce the existing hazards to human health and safety caused by unwise occupation of the floodlands, and reduce the expenditures of public funds to secure the health and safety of floodland residents during periods of flooding, the required floodland and floodland-related land use regulations, while designed to accommodate the existing development, be designed to preserve the floodwater conveyance and storage capacity of the floodlands. Floodways should not be delineated and the entire floodplains should be preserved in essentially natural open uses. Only where existing development may warrant should floodways be delineated and any filling and further development of the floodplain fringe area be permitted.

Channel Maintenance: As discussed earlier in this chapter, channel maintenance consisting of periodic removal of sediment deposits, heavy vegetation, and debris, is necessary to: 1) maintain the integrity of the flood stage profiles developed under the watershed planning program; 2) maintain the channel invert below the invert of existing and planned storm water outfalls to allow such outfalls to function properly, and 3) reduce the probability that buoyant objects and debris will be carried downstream by floodwaters and accumulate at bridges and culvert inlets, thereby reducing the conveyance capacity of the bridges and culverts. It is recommended that the operations of the responsible governmental units and agencies be designed to routinely include the conduct of such channel maintenance.

Secondary Measures

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 the communities in the Pike River watershed to participate in the federal flood insurance program.

While the ultimate decision to purchase flood insurance remains with the 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 Federal Emergency Management Agency 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 with sound floodland management practices, including resolutions indicating that flood problems will be continuously monitored and that such problems will be considered in all official actions affecting floodland use.

Based on the hydrologic-hydraulic analyses conducted under the watershed study, existing or potential flood problems have been identified in the watershed portions of the Village of Sturtevant, the Cities of Racine and Kenosha, and the unincorporated areas of Racine and Kenosha Counties. All of these communities have elected to participate in the federal flood insurance program. Insurance rate studies have been completed for the City of Racine, the Village of Sturtevant, and Kenosha and Racine Counties, with the study for the City of Kenosha expected to be completed by the end of 1982. The remaining community in the watershed, the Village of Elmwood Park, has been given a no flood hazard status under the federal flood insurance program.

The analyses conducted under the Pike River watershed planning program were more complete and detailed than those conducted under federal flood insurance studies because of the availability of large-scale topographic mapping over the entire watershed. Therefore, it is recommended that the hydrologic-hydraulic data generated under the watershed planning program be used to update and amend the flood insurance studies where appropriate.

Lending Institution Policies: As a result of the federal 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, whether it requires 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 federal flood insurance program, and that the principal source of flood hazard information within the Pike River watershed be that developed under the watershed planning program and available through the Regional Planning Commission.

Realtor Policies: 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, watermains, 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 Pike 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 Pike River watershed.

Land Use Controls Outside the Floodlands: As described in Chapter XI, about 15 square miles of open land throughout the watershed are proposed for development under the land use plan. In preparing plans for the development of these areas and for the redevelopment of local areas, it is recommended that the potential hydrologic impact of the proposed development or redevelopment be considered in addition to the relationship of such development and redevelopment to soil capabilities, long-established and planned utility systems, and the natural resource base. The alternatives set forth in this chapter are designed to accommodate the plan year 2000 urban development as set forth in the regional land use plans. Development beyond that recommended in the land use plan has not been considered and, thus, onsite storage flood control measures would be needed to accommodate such development.

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 indicate that the urban portions of the Pike 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 an hour 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 urbanized areas of the Pike River watershed for selected recurrence intervals may be expected to be several times larger than those that would occur in the rural areas of similar size, soils, and topography. It is recommended, therefore, that each watershed community where major flooding occurs develop procedures to provide floodland residents and other property owners with information about the location and extent of the flood hazard areas so that residents of these areas can take appropriate flood damage mitigation measures.

ACCESSORY FLOODLAND MANAGEMENT CONSIDERATIONS

During the Pike River watershed planning program there emerged several issues which, although not pertaining directly to the floodland management alternatives set forth in this chapter, did relate to the overall existing and potential flood problems of the Pike River watershed. These matters of concern were considered during the watershed planning process, and the resulting conclusions and recommendations based on that consideration are described below.

Maintenance of Stream Gaging Network

Since 1971, the U. S. Geological Survey has operated, in cooperation with the Kenosha Water Utility and the Regional Planning Commission, a continuous stage recorder gage on the Pike River at the University of Wisconsin-Parkside. Continuous recording stream gaging stations, by monitoring river flows and stages at strategic locations within a watershed, can provide critical data required for the rational management of the surface water resources of the watershed. Discharge-frequency relationships derived from data provided by continuous recording stream gaging stations can be used to periodically refine the hydrologic and hydraulic simulation submodels developed and used in the Pike River watershed study. Such stream gaging records are also useful in bridge and culvert design and in water quality management planning. It is accordingly recommended that the continuous recorder gage installed on the Pike River at the University of Wisconsin-Parkside continue to be operated.

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 Pike 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 synthesized may be broadly subdivided into two categories: structural measures and nonstructural measures. A total of six 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) bridge or culvert modification or replacement, 2) channel modification, 3) dikes, 4) detention reservoirs, 5) onsite storage, and 6) floodwater diversion. Eleven nonstructural measures were identified consisting of: 1) reservation and acquisition of floodlands for recreation and related open space use, 2) floodland use regulation, 3) channel maintenance, 4) federal flood insurance, 5) lending institution policies, 6) realtor policies, 7) community utility policies, 8) regulation of land use outside the floodlands, 9) emergency programs, 10) structure floodproofing, and 11) 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 quantitatively evaluate the response of the Pike River watershed to the plan year 2000 land use on the flood flow behavior of the watershed. The simulation model studies indicated that 100-year recurrence interval peak flood flows may be expected to increase up to 100 percent.

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, indicated that the monetary flood risks for the watershed were estimated, on an average annual basis, at $125,000 under existing land use and existing channel and floodplain conditions, and at $238,000 under plan year 2000 land use and existing channel and floodplain conditions, an increase of about 90 percent. Under existing land use, channel, and floodplain conditions, flood damages to crops and structures of about $806,000 during a 100-year recurrence interval flood could be expected to be incurred and flood damages of about $1,500,000 during a 100-year recurrence interval flood event may be expected to be incurred under plan year 2000 land use and existing channel and floodplain conditions.

After due consideration of the various technical and economic features and other intangible aspects of the alternative floodland management measures discussed above for the 12 individual reaches of the stream system of the watershed and the Pike River estuary, a preliminary recommendation of the most favorable alternative for each portion of the watershed was made. These selected alternatives are as follows:

- Bartlett Branch—onsite detention storage, dike, and structure floodproofing and elevation composite
- Waxdale Creek and tributary to Waxdale Creek—no action except floodland zoning and channel maintenance
- Chicory Creek—no action except floodland zoning and channel maintenance
- Lamparek Ditch—no action except floodland zoning and channel maintenance
- Somers Branch—structure floodproofing and elevation
- Airport Branch and Tributary to Airport Branch—culvert replacement major channelization composite
- Nelson Creek—no action except floodland zoning and channel maintenance
- Sorenson Creek—culvert replacement, and floodland zoning and channel maintenance.
- Kenosha Branch—no action except floodland zoning and channel maintenance
- Pike Creek—channel enlargement
- Upper Pike River—onsite detention storage-channel enlargement composite
- Lower Pike River—diking-structure floodproofing and elevation composite
- Pike River estuary—jetty construction

Utilizing an annual interest rate of 6 percent and an amortization period and project life of 50 years, the total average annual cost of the selected alternatives for the watershed is $298,000, consisting of amortization of the $4,263,500 capital costs and $28,900 in annual operation and maintenance costs.

Analyses conducted under the watershed planning program resulted in the identification of 22 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 under plan year 2000 conditions and existing channel conditions. Of the total number of substandard bridges and culverts so identified, 21 are located on arterial streets and highways other than freeways and expressways, and one is located on a railroad. It is recommended that when these structures are modified or replaced by the responsible highway agencies or by the railroad companies as part of necessary highway and railroad improvement programs, these crossings be designed to provide adequate capacity in accordance with the standards set forth in Chapter X. It is also recommended, in accordance with the adopted standards set forth in Chapter X, that all new or replacement bridges and culverts be designed so as to accommodate the 100-year recurrence interval flood discharge under plan year 2000 conditions without raising the corresponding peak stage by more than 0.1 foot above the peak stage as established in the adopted comprehensive watershed plan.

Of the 11 available nonstructural floodland management measures identified for possible application in the Pike 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) channel maintenance. 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 open space preservation and outdoor recreation plan subelements which seek to preserve recreational, aesthetic, ecological, 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 the Pike River watershed floodlands or new floodland regulations prepared by the communities in the 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. All of the communities located wholly or partly in the Pike River watershed which have been identified as having flood hazard areas have elected to participate in the federal flood insurance program. Insurance rate studies for these communities have been completed or are expected to be completed by the end of 1982. It is recommended that hydrologic-hydraulic data generated under the watershed program be used to amend and update the flood insurance studies. 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 developd 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 to 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 recommendations for the Pike River watershed and the recommended primary environmental corridor protection plan subelement.

The continuous recording stream gaging station located within the Pike River watershed provides critical data required for future rational management of the surface water resources. Discharge-frequency relationships, floodstage profiles, and other information obtained from gaging station records can be used to periodically refine the hydrologic-hydraulic simulation model developed and used in the Pike River watershed study. It is recommended that the continuous streamflow monitoring gage installed on the Pike River near Racine at the University of Wisconsin-Parkside continue to be operated in the immediate vicinity subsequent to completion of this study.

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Chapter XIII

ALTERNATIVE WATER QUALITY MANAGEMENT MEASURES

INTRODUCTION

The inventory and analysis phases of the Pike River watershed planning program identified certain water resource-related problems including flooding and water pollution. The principal objective of the Pike River watershed planning program is to develop a workable plan for the resolution of these problems. The purpose of this chapter is to present alternative plans for water pollution abatement, and to recommend the best plan from among these alternatives for incorporation into the comprehensive plan for the watershed.

More specifically, this chapter analyzes the extent to which various alternative water pollution abatement measures may be expected to mitigate or eliminate the point and nonpoint source pollution problems that exist within the watershed, and, based on evaluation of the technical, economic, and environmental performance of the alternatives considered, recommends a set of water quality management measures for incorporation into the overall plan for the watershed.

In the planning process used by the Commission, the formulation of a set of watershed development objectives, including water use objectives and supporting water quality standards, provides an important basis for alternative plan design and evaluation. An initial set of water use objectives and supporting water quality standards was presented in Chapter X of this report, together with other related objectives and standards. The Commission has always recognized that the formulation of objectives and standards may have to be an iterative process[1] in which, as a result of plan design and evaluation, certain objectives initially proposed may have to be revised or discarded because their satisfaction has been proven unrealistic; new objectives may be suggested; and conflicts between inconsistent objectives may be balanced out. This formulation of objectives and standards must proceed hand in hand with plan design and evaluation.

[1] *See, for example, SEWRPC Planning Report No. 7, The Regional Land Use-Transportation Study, Volume Two, Forecasts and Alternative Plans: 1990, June 1966, page 2.*

The water quality management plan elements prepared under other Commission studies already include recommendations for resolution of water quality problems within the Pike River watershed, namely, for the abatement of the point and nonpoint sources of pollution such as public sewage treatment facility discharges, sanitary sewer overflows, private wastewater treatment plant discharges, industrial wastewater discharges, malfunctioning septic tank system discharges, stormwater runoff from rural and urban lands; soil erosion and livestock waste runoff. The water quality management measures described herein were designed and should be considered as adjuncts to the basic land use development proposal advanced in Chapter XI to facilitate the attainment of regional and watershed development objectives. The water quality management measures are thus intended to be supplementary to the basinwide land use plan element, and the incremental costs of these measures can be separated from that element.

As noted in Chapter X of this report, the evaluation of a particular alternative measure relative to other alternatives intended to resolve identified problems is a sequential process in which the measure is subjected to several types and levels of review, including technical, economic, environmental, financial, legal, and administrative feasibility, and political acceptability. In order to provide for the comparative evaluation of the various alternative water quality management measures, and thus assist in the selection of recommended measures for incorporation in the comprehensive watershed plan, the pertinent technical, economic, and environmental characteristics of each alternative water quality management measure considered are presented in this chapter.

It should again be noted that the water quality management plan element for the Pike River watershed, as described herein, is a systems level plan, and as such, has three functions:

1. Identification of the type and source of existing and probable water pollution problems in the watershed;

2. Evaluation of alternative levels and determination of the optimal overall pollutant reductions required to achieve the desired levels of water quality, and suggestion of methods and techniques for achieving the target reductions; and

3. Identification of the best overall means for abating identified water pollution problems and achieving established water use objectives and supporting water quality standards considering technical practicality, economic feasibility, and environmental impact.

With respect to the organization of the material presented in this chapter, the surface water quality problems of the watershed as identified in Chapter VII are first briefly reviewed, together with the sources of those problems. Next, the steps that have already been taken, or have been committed to be taken, for the resolution of these water quality problems are described. Further measures required to resolve the remaining problems are then explored, and the basis for the selection of a recommended water quality management plan element provided. The techniques used to estimate the extent and severity of the water quality problems are also briefly described, together with the available control measures.

BASIS FOR THE DEVELOPMENT AND ANALYSIS OF ALTERNATIVE WATER QUALITY MANAGEMENT PLAN ELEMENTS

In a combined urban and rural setting similar to the Pike River watershed, man's activities significantly affect, and are affected by, the quality of surface and groundwaters. Waters are defined herein to be polluted when foreign substances caused by, or related to, human activity are present in such form and concentration as to render the water unsuitable for desired beneficial use. Thus, surface water use objectives and supporting water quality standards become an important basis for plan design and evaluation.

Water Use Objectives

For purposes of the water quality analyses set forth in Chapter VII of this report, and for the initial analyses set forth in this chapter, water quality standards were used which were set forth in Chapter X of this report and correspond to the "warm water fishery and aquatic life, recreational use, and minimum standards" water use objective established under the areawide water quality management planning program, in conformance with the national water quality objectives cited in Law 92-500. The standards set forth in Table 80 in Chapter X of this report are intended to permit use of essentially all of the surface waters of the Pike River watershed for full body contact recreation and for the support of a warm water fishery. The water use objectives and supporting water quality standards set forth in Table 80 specify a minimum dissolved oxygen level, a maximum temperature, a maximum fecal coliform count, a maximum residual chlorine content, a maximum ammonia-nitrogen and phosphorus level, and a pH range. In addition, by explicit and implicit reference to other federal and state regulations,[2] the water use objectives and standards incorporate recommended maximum or minimum levels for certain other water quality indicators, including a broad range of toxic and hazardous substances. Based upon the fishery inventory findings set forth in Chapter III, the channel modification alternatives set forth in Chapter XII, and the water quality analyses presented in this chapter, a reevaluation of the water use objectives and supporting standards was conducted, as set forth below.

Historically, water quality standards were developed for application to specified periods of low flow, such as a 7 day-10 year low-flow condition, in order to determine the effects of point sources. Under this historic approach, it was assumed that diffuse sources of pollution had an insignificant effect on water quality conditions and that the worst water quality occurred during periods of low flow. More recent studies, including those conducted by the Commission under its areawide water quality management planning program, however, indicate that the water quality standards may be violated not only during periods of low flow, but also during periods of high flow and during rainfall events following long periods of dry weather during which a buildup of pollutants takes place on the land surface. This finding requires a new approach to the application of water quality standards—an approach which considers the assessment of the proportion of the total time that

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[2] *See U. S. Environmental Protection Agency, Quality Criteria for Water, EPA Report No. 440/9-76-003, Washington, D. C., 1976, and National Academy of Sciences, National Academy of Engineering, Water Quality Criteria-1972, EPA Report No. R3-73-003, Washington, D. C., 1974.*

water quality conditions can be expected to be in compliance with specified standards. Under this approach, statistical analyses were conducted on the results of the continuous water quality simulation model to determine the percent of time a given standard may be expected to be violated, including during periods of low flow. A 95 percent compliance level was selected for those parameters which directly affect aquatic organisms—dissolved oxygen, temperature, ammonia-nitrogen, residual chlorine, and pH. A 90 percent compliance level was selected for those parameters which do not directly affect aquatic organisms, but are primarily related to recreational use—fecal coliforms and phosphorus.

The levels of pollution control which are technically practicable and economically sound also influence the extent to which the "fishable-swimmable" water use objective can be achieved. Point source pollution control measures have historically been given high priority for resolution of surface water quality problems. Point source pollution control measures and practices represent a highly advanced technology, and point sources of pollution and their effects on surface water quality conditions can be quantified more accurately because of the manner in which they are introduced into the surface water systems. Nonpoint source pollution control represents a less advanced technology than point source control, and nonpoint sources and their effects on surface water conditions cannot be quantified as well as point sources. Knowledge of the effectiveness of nonpoint source pollution control measures is limited, and the degree of pollution control which may be expected to be achieved by various methods has been estimated as accurately as possible from recent case studies and reports.[3] It is estimated that technically practicable control measures to reduce the pollutants released and carried by storm water runoff vary in effectiveness from a 5 percent reduction in the release of pollutants for improved leaf and lawn clipping collection and disposal practices, to greater than 75 percent reduction for some rural nonpoint source pollution control practices. On an individual basis, most minimum or low-cost nonpoint source pollution control practices may be expected to attain up to a 25 percent reduction in released pollutants over uncontrolled conditions. Storm water treatment may be expected to attain up to a 50 percent reduction of released pollutants when compared to uncontrolled conditions.

Historic Surface Water Pollution

A careful examination of available water quality data for the Pike River watershed, as described in Chapter VII of this report, indicates that water quality problems exist during both wet and dry weather conditions over much of the watershed. Of the eight possible categories of pollution, six—pathogenic, organic, nutrient, toxic, sediment, and aesthetic—are known to exist in the Pike River watershed. The other two categories of pollution—thermal and radiological—are not known to exist in the watershed.

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 municipal point sources of pollution related to wastewater treatment facilities, and to urban and rural nonpoint sources. Fecal coliform is contributed from urban nonpoint sources in the form of pet waste or from failing septic systems and from rural nonpoint sources in the form of animal wastes. Other less extensive pollution problems include the presence of toxic and hazardous materials, depressed dissolved oxygen levels and excessive nutrient concentrations, particularly phosphorus, under wet weather conditions.

Pollution Sources

The following pollution sources have been identified in the Pike River watershed. As of 1975, the sources of pollution identified as point sources consisted of two municipal sewage treatment facilities, two private wastewater treatment facilities, eight municipal sanitary sewerage system flow relief devices, and eight industrial wastewater discharge outfalls.[4] These point sources were esti-

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[3] *See SEWRPC Planning Report No. 30, A Regional Water Quality Management Plan for Southeastern Wisconsin: 2000, Volume Two, Alternative Plans, February 1979, and SEWRPC Technical Report No. 18, State of the Art of Water Pollution Control in Southeastern Wisconsin, Volume Three, Urban Storm Water Runoff, and Volume Four, Rural Storm Water Runoff, July 1977.*

[4] *The Village of Sturtevant sewage treatment facility and the St. Bonaventure Seminary private sewage treatment facility were abandoned in April 1980 and in December 1979, respectively. The other private wastewater treatment facility was operated by the American Motors Corporation-Transportation Division and was taken out of service in 1978.*

mated to contribute an estimated 4 percent of the nitrogen, 7 percent of the phosphorus, 5 percent of the biochemical oxygen demand, 54 percent of the fecal coliform, and less than 1 percent of the suspended solids contributed annually to the surface waters of the watershed.

Pollutant loading analyses conducted under the areawide water quality management planning program, and confirmed under the watershed study, indicated that nonpoint sources of pollution—both rural and urban—accounted for the majority of pollutants that were transported to the surface water system. Commission inventories indicated that an estimated 96 percent of the nitrogen, 93 percent of the phosphorus, 95 percent of biochemical oxygen demand, 46 percent of the fecal coliform, and virtually all of the suspended solids were contributed to the surface water system of the watershed annually by these nonpoint sources of water pollution. These pollutant loadings will occur during wet weather conditions when surface water runoff acts to transport pollutants to the stream system of the watershed.

About 40 percent of the urban area, and 11 percent of the total area of the Pike River watershed is provided with engineered storm water drainage systems. Therefore, much of the direct runoff from urban areas enters the surface water system through storm sewer outfalls located along the major stream system with the remaining direct runoff entering the surface water system through open storm water channels or as sheet flow—that is, overland flow not occurring in well-defined channels. Direct runoff from rural areas enters the surface water system through open storm water channels, agricultural drainage systems or as sheet flow. Water quality surveys indicate that high concentrations of pollutants, such as biochemical oxygen demand, nitrogen, phosphorus, and fecal coliform bacteria, are most likely to occur during wet weather conditions—that is the conditions in which surface water runoff from urban and rural lands provides the dominant flow and pollutant loading to the river system.

The limited data available also indicate that excessive concentrations of toxic and hazardous substances, including mercury, DDT, DDE, heptachlor epoxide and dieldrin, may exist in the surface water system of the Pike River watershed. The presence of toxic and hazardous materials is also supported by the fishery survey undertaken as part of the watershed study. The survey found a lack of aquatic life in stream reaches with characteristics that should otherwise support warm water species if toxic or other stressful conditions were not present.

The source of toxic and hazardous materials has not been traced to any one particular source or group of sources in the watershed. Potential sources, however, include municipal and industrial wastewater discharges, and nonpoint source contributions such as agricultural application of excessive amounts of pesticides and herbicides and fallout of toxic material from the atmosphere. Such fallout may include lead, chromium, mercury, and nickel. A potential also exists for transmission of toxic and hazardous substances from unconfined leachate that originates in solid waste disposal sites. There are five abandoned landfill sites that are known to exist in the Pike River watershed, of which three are located immediately adjacent to the watershed stream system. These landfills have all been classified by the Department of Natural Resources as having been properly abandoned, however, the potential still exists for surface and groundwater contamination in these areas.

<u>Measures Already Underway, or Committed, to Resolve Pollution Problems</u>

Substantial efforts have already been initiated to abate some of the major sources of water pollution and thereby resolve some of the pollution problems of the Pike River watershed. These efforts are briefly described below and related to the pollution sources described above.

The regulation of point source pollution control sources is effected through the Wisconsin Pollutant Discharge Elimination System. As described in Chapter X of this report, the Wisconsin Pollutant Discharge Elimination System was established by the Wisconsin Legislature in direct response to the requirements of the Federal Water Pollution Control Act of 1972. The system requires a state permit for the discharge of any pollutant into the waters of the State, including the groundwaters. More specifically, permits are required for discharges from municipal sewage treatment plants and associated collection systems, private wastewater treatment facilities and industrial establishments. The permits may specify abatement requirements, and provide a schedule of compliance setting forth dates by which specific elements of the permit must be responded to. The Village of Sturtevant is currently[5] operating a wastewater treatment facility under the provisions of the Wisconsin Pollution Discharge Elimination System and the plant is scheduled to be abandoned in 1980 according to the conditions of the Village of Sturtevant wastewater discharge permit. Abandonment of this facility is expected to result in substantial water quality improvements in Waxdale Creek and in the upper reaches of the Pike River downstream of Waxdale Creek.

Saint Bonaventure Seminary operated a private sewage treatment plant that also discharged to Waxdale Creek upstream of the Village of Sturtevant. The Seminary completed arrangements with the Village of Sturtevant to connect this private facility to the Sturtevant collection system upon completion of the Sturtevant-to-Racine trunk sewer, thereby eliminating this point source. The abandonment of this private sewage treatment plant was completed in December 1979.

The Town of Somers Utility District No. 1 also operates a wastewater treatment facility under the provisions of the Wisconsin Pollution Discharge Elimination System (WPDES). The existing facility was last expanded and upgraded in 1978 and has an average hydraulic capacity of 0.125 million gallons per day. The adopted regional sanitary sewerage system plan recommended that this facility be abandoned and connected to the City of Kenosha wastewater treatment system. This recommendation was also contained in the comprehensive plan for the Kenosha Planning District. The decision to recommend abandonment of the Somers facility was based upon economic analyses that considered alternatives of centralized treatment and treatment at both centralized and remote sites in the Racine and Kenosha urban area. In addition, it was determined that undesirable dissolved oxygen, phosphorus, and ammonia-nitrogen conditions could be expected to result in the Somers Branch of Pike Creek if the plant were not abandoned. With a dilution ratio considerably less than one during low-flow conditions, continued operation of the Somers plant could be expected to result in depleted dissolved oxygen levels along a majority of Somers Branch and in toxic levels of ammonia-nitrogen along the entire length of the stream downstream of the treatment plant. Additional adverse water quality impacts are expected to occur in Pike Creek downstream of the confluence with Somers Branch. In light of this, the abandonment of the Somers sewage treatment plant is determined to be necessary in order to meet even a limited fishery and aquatic life and recreational use category. Therefore, in recognition of previous planning efforts and the economic and water quality considerations attendant thereto, the eventual abandonment of the Town of Somers sewage treatment facility is considered to be committed.

With respect to sanitary sewerage system flow relief devices, it may be assumed that the WPDES discharge permit system will provide means for the elimination of all of these devices over time. As already noted, there were eight sanitary flow relief devices known to exist in the Pike River watershed as of 1975. With the completion of the trunk sewer connection between the City of Racine and the Village of Sturtevant, two of the eight existing flow relief devices have been eliminated. The Village of Sturtevant sewage treatment plant bypass was abandoned along with the treatment plant and the Creuziger lift station bypass in the Town of Mt. Pleasant.[6] With respect to the industrial wastewater discharges, it may also be assumed that WPDES will provide the means for monitoring, regulating, and controlling the industrial discharges to the surface water and groundwater systems of the watershed.

Point source pollution abatement measures were taken in the watershed study as committed measures, based upon previous recommendations of

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[5] *As already noted, the Village of Sturtevant sewage treatment plant was abandoned as of April 1980 upon completion of the trunk sewer connection to the City of Racine.*

[6] *Late in 1982, the City of Kenosha reviewed the status of the six flow relief devices noted to be located in the city's sanitary sewer system. That review indicated that three of the flow relief devices were not needed and were scheduled to be eliminated; two of the flow relief devices function as emergency overflow outlets for pumping stations and accordingly were proposed to be maintained but only utilized in extreme emergencies where the pumping station would be inoperable; and one flow relief device was found to have been connected to a storm sewer which discharges out of the Pike River watershed and will be scheduled for elimination under the city's ongoing sewer rehabilitation program.*

the adopted regional water quality management plan. Commission studies indicated that the abatement of the point sources of water pollution as of 1975 would require an estimated $16,664,000 in capital costs and $902,000 in average annual operation and maintenance costs. It should be recognized, however, that certain point source abatement measures have already been implemented including the Sturtevant-Mt. Pleasant trunk sewer, portions of the Somers-Kenosha trunk sewer as far north as 18th Street, and the abandonment of the private sewage treatment plants at the American Motors Truck Service Facility and St. Bonaventure Seminary. Thus, the remaining measures would require an estimated $8,980,000 in capital costs and $902,000 in average annual operation and maintenance cost. These costs are expressed in January 1980 dollars, on the basis of an "Engineering News Record" construction cost index of 3131.

With regard to nonpoint source pollution control, the Commission recently assisted Racine and Kenosha Counties in the completion of a farmland preservation plan in order to identify the prime agricultural lands in these counties. [7] The Wisconsin Farmland Preservation Act provided grants-in-aid to assist the two counties in preparation of the plans and in the mapping of the prime agricultural lands. The plans delineated prime agricultural lands into appropriate exclusive agricultural zoning districts. It is anticipated that these plans will encourage the agricultural community to provide the nonpoint source pollution control measures necessary to meet the water use objectives and standards. Such willingness and ability should result from the long-term land use stability provided by the public preservation actions, the return which this stability will make possible on investment in agricultural soil erosion control measures, and the effect which the removal of urban development pressures should have.

As a part of the agricultural land preservation planning effort, refined and detailed primary environmental corridor boundaries within the Pike River watershed have also been delineated. These corridor lands are generally associated with surface water drainage systems and their preservation in essentially natural open uses will provide valuable nonpoint source pollution abatement through preservation of wetlands, woodlands, and other open lands that provide positive water quality impacts by retaining fecal coliform bacteria and soil nutrients, and by reducing soil erosion and sediment contributions to surface water systems.

Finally, both Racine and Kenosha Counties have prepared and adopted countywide sanitary ordinances in 1980 as a basis for resolving existing public health and pollution problems associated with malfunctioning of private onsite sewage disposal systems.

ANALYSIS OF THE ALTERNATIVE WATER QUALITY MANAGEMENT PLAN ELEMENTS

Analytic Framework and Assumptions

The data regarding water pollution problems and pollution sources in the Pike River watershed, and the review of efforts underway to abate or eliminate those sources and thereby mitigate the pollution problems, indicate that substantial progress is being made toward the abatement of pollution in the Pike River watershed. In consideration of the basic pollution abatement program already in progress, the water quality analyses conducted under the Pike River watershed planning program, including stream water quality simulation modeling studies, were conducted within the framework of the committed actions and related assumptions set forth below.

Municipal Sewage Treatment Plants: The water quality analysis conducted under the Pike River watershed planning program accepted as committed, the eventual abandonment of the Village of Sturtevant and Town of Somers sewage treatment plants as recommended in the adopted regional water quality management plan. It was, however, deemed necessary to conduct simulation studies of the impact on existing water quality of the removal of these two plants from the watershed stream system. This analysis was considered necessary as a first step in determining if additional pollution abatement measures directed primarily at diffuse sources of pollution will be required in the Pike River watershed between now and the plan design year 2000.

It is important to understand the degree to which the eventual abandonment of the two municipal sewage treatment plants in the watershed is a com-

[7] *See SEWRPC Community Assistance Planning Report No. 45, A Farmland Preservation Plan for Kenosha County, Wisconsin, and SEWRPC Community Assistance Planning Report No. 46, A Farmland Preservation Plan for Racine County, Wisconsin.*

mitted decision. The major trunk sewer connecting the Village of Sturtevant sanitary sewerage system to the City of Racine sewage treatment plant was under construction and scheduled to be completed during 1980. The Town of Somers wastewater treatment plant is recommended to be abandoned in the adopted regional sanitary sewerage system plan and the adopted regional water quality management plan. The City of Kenosha has completed approximately 5.7 miles, or 48 percent, of the total of 11.8 miles of connecting sewers necessary in order to abandon the Town of Somers plant. The connecting sewer is also designed to serve portions of the City of Kenosha and the University of Wisconsin-Parkside, prior to extension to the Town of Somers treatment facility, and ultimately to serve proposed development in the Town of Somers west of the City of Kenosha.

At the present time (November 1980), the Town of Somers is engaged in a sanitary sewer service area refinement process in cooperation with the City of Kenosha and the Regional Planning Commission. Agreement has been reached upon a preliminary refined year 2000 sanitary sewer service area for Township 2 North, Range 22 East and Township 2 North, Range 23 East (see Map 75). The proposed sewer service area is intended to be served ultimately in its entirety by the City of Kenosha sewage treatment plant, with the exception of about 400 acres of land lying along CTH KR in the Town of Somers which is proposed to be served by the City of Racine sewage treatment plant through the Sturtevant-Mt. Pleasant trunk sewer.

Given the low priority in terms of federal and state grants attached to the completion of the Parkside trunk sewer, as well as the immediate needs of the Town of Somers Utility District No. 1 and the desirability of abandoning the Somers treatment facility as soon as possible in order to enhance water quality on the Pike River, all parties concerned have agreed that an interim connection of the existing Somers utility district sewerage system to the City of Kenosha sewerage system would afford the earliest possible means of abandonment of the Somers sewage treatment plant, and would be feasible and desirable prior to the completion of the Parkside trunk sewer. The sewers necessary to effect abandonment of the Somers sewage treatment facility on an interim basis, as well as the proposed alignment of the Parkside trunk sewer in its entirety, are also shown on Map 75. As indicated on the map, immediate abandonment of the Somers sewage treatment facility would be effected by constructing the following segments of sewer:

1. A permanent gravity flow trunk sewer from the Somers sewage treatment facility east along CTH E to the Pike Creek.

2. A permanent gravity flow trunk sewer west along CTH L or 18th Street from the current terminus of the Parkside trunk sewer to about STH 31.

3. A temporary sewage pumping station located along CTH E at Pike Creek.

4. A temporary sewage force main from the sewage pumping station at the Pike Creek to the end of the gravity flow trunk sewer in CTH L.

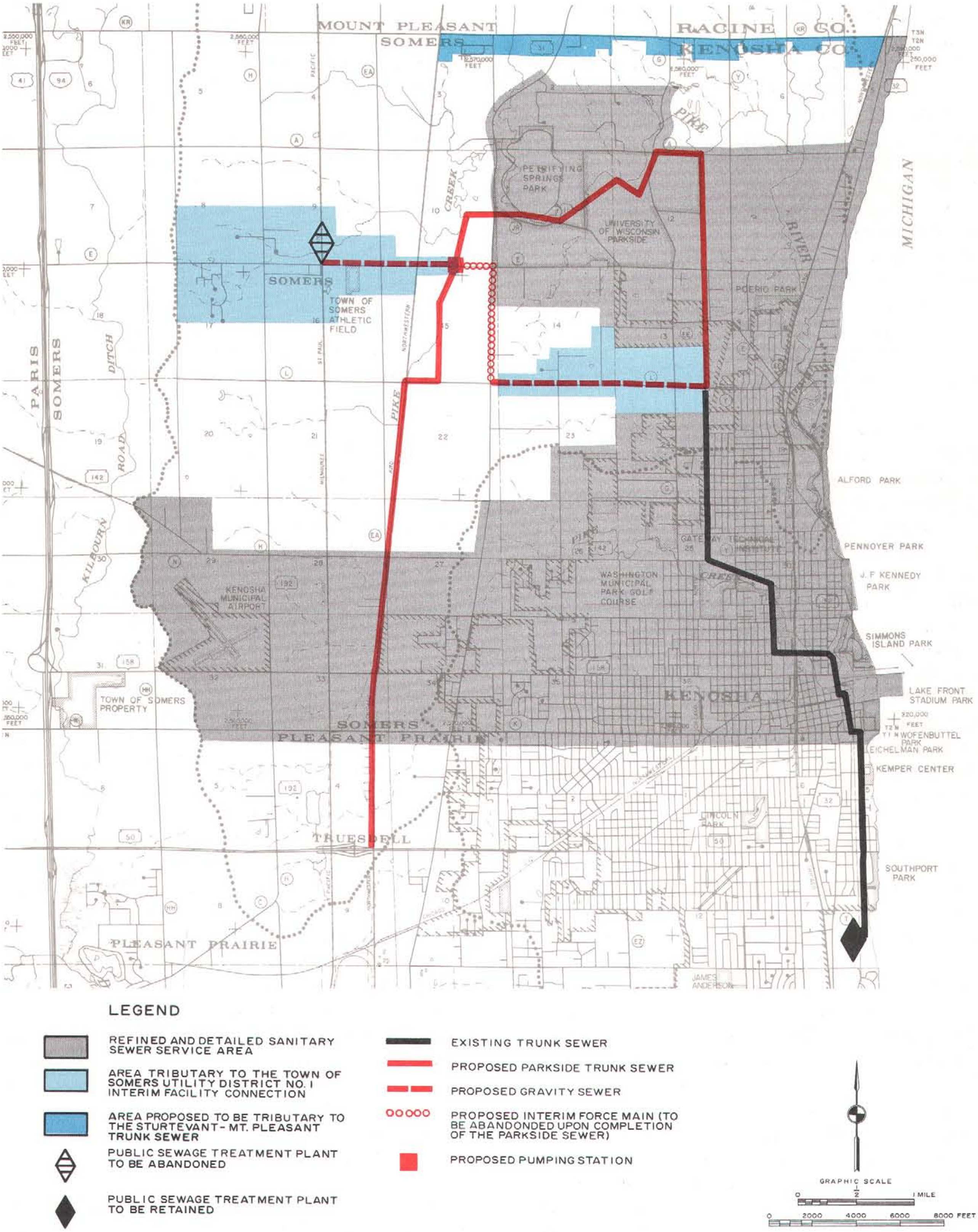
Upon the ultimate completion of the Parkside trunk sewer, the sewage pumping station and force main would be abandoned. The area that could be served by the interim sewer connection is also shown on Map 75.

Flow Relief Devices: In Chapter VII of this report, a comparative analysis of the pollution loads contributed by sanitary sewerage system flow relief devices, and washoff from the land surface was conducted. The results indicated that flow relief devices contribute a small proportion of the total pollution load on the Pike River system. Consequently, these devices were omitted in the simulation of existing conditions and were considered to be eliminated under future conditions. Although the analysis indicated that the flow relief devices contribute small quantities of pollution to the surface water, relative to those quantities contributed by storm water runoff, pollutant contribution from flow relief devices may constitute serious public health hazards and create objectionable aesthetic conditions. Therefore, efforts should be continued to eliminate the discharge of any raw sanitary sewerage through flow relief devices. As previously noted two of the identified eight sanitary sewage flow relief devices have been abandoned as of 1980 and plans for properly dealing with the remaining six flow relief devices located in the City of Kenosha are in place.

The watershed plan recognizes the basically local nature of the decisions which dictate the specific means of eliminating these flow relief devices, and thus does not include an explicit analysis of alternative ways of eliminating sanitary sewerage

Map 75

PROPOSED TRUNK SEWER SYSTEM TO ENABLE ABANDONMENT OF THE SOMERS UTILITY DISTRICT NO. 1 SEWAGE TREATMENT PLANT



The abandonment of the single remaining sewage treatment plant in the watershed serving the Town of Somers Utility District No. 1 and connection of its service area to the City of Kenosha sanitary sewerage system would be effected by an interim connection using a combination gravity flow sewer and pumping station and force main system, as shown on the above map. At such time as the proposed Parkside trunk sewer is extended, the proposed interim force main would be abandoned. In 1980, the City of Kenosha sewage treatment plant provided secondary waste treatment with conventional advanced waste treatment for phosphorus removal, and auxiliary waste treatment for effluent disinfection with the discharge of treated effluent to Lake Michigan. The areawide water quality management plan recommended continuation of that level of treatment for the Kenosha treatment plant.

Source: SEWRPC.

system flow relief devices such as crossovers and bypasses. The Pike River watershed plan accepts, as committed, the ultimate elimination of discharge from flow relief devices as recommended in the adopted regional sanitary sewerage system plan and as locally planned for.

Private Wastewater Treatment Plants: As of 1980, there is one known private wastewater treatment plant in operation in the Pike River watershed. This facility which serves the St. Bonaventure Seminary in the Village of Sturtevant has been abandoned and the wastewater flow diverted to the Village of Sturtevant collection system. The entire flow from the Sturtevant system is planned to be connected to the City of Racine sewerage system. As previously mentioned this connection was scheduled to take place in 1980, and thus may be regarded as a committed action under the plan year 2000 conditions.

Industrial Discharges: The water quality management plan element of the Pike River watershed plan also assumes that pollutants that are transported through industrial wastewater outfalls to the surface water system of the watershed will be controlled through regulation under the Wisconsin Pollutant Discharge Elimination System. Currently, industrial discharges in the Pike River watershed consist of cooling, process, and backwash waters that do not contain significant amounts of pollutants and that do not have notable water quality impacts. The estimated existing and year 2000 discharges of the existing industrial wastewater outfalls in the Pike River watershed, are presented in Table 98.

Existing and Plan Year 2000 Land Use Conditions: The existing land use conditions and plan year 2000 land use conditions in the Pike River watershed, as described in Chapter III and Chapter XI of this report, respectively, provided the basis for estimating the extent and probable surface water quality consequences of land use changes in the watershed and, more importantly, for examining the diffuse source pollution problem and alternate solutions thereto under the water quality management plan element.

Extent and Severity of Existing and Anticipated Future Water Quality Problems

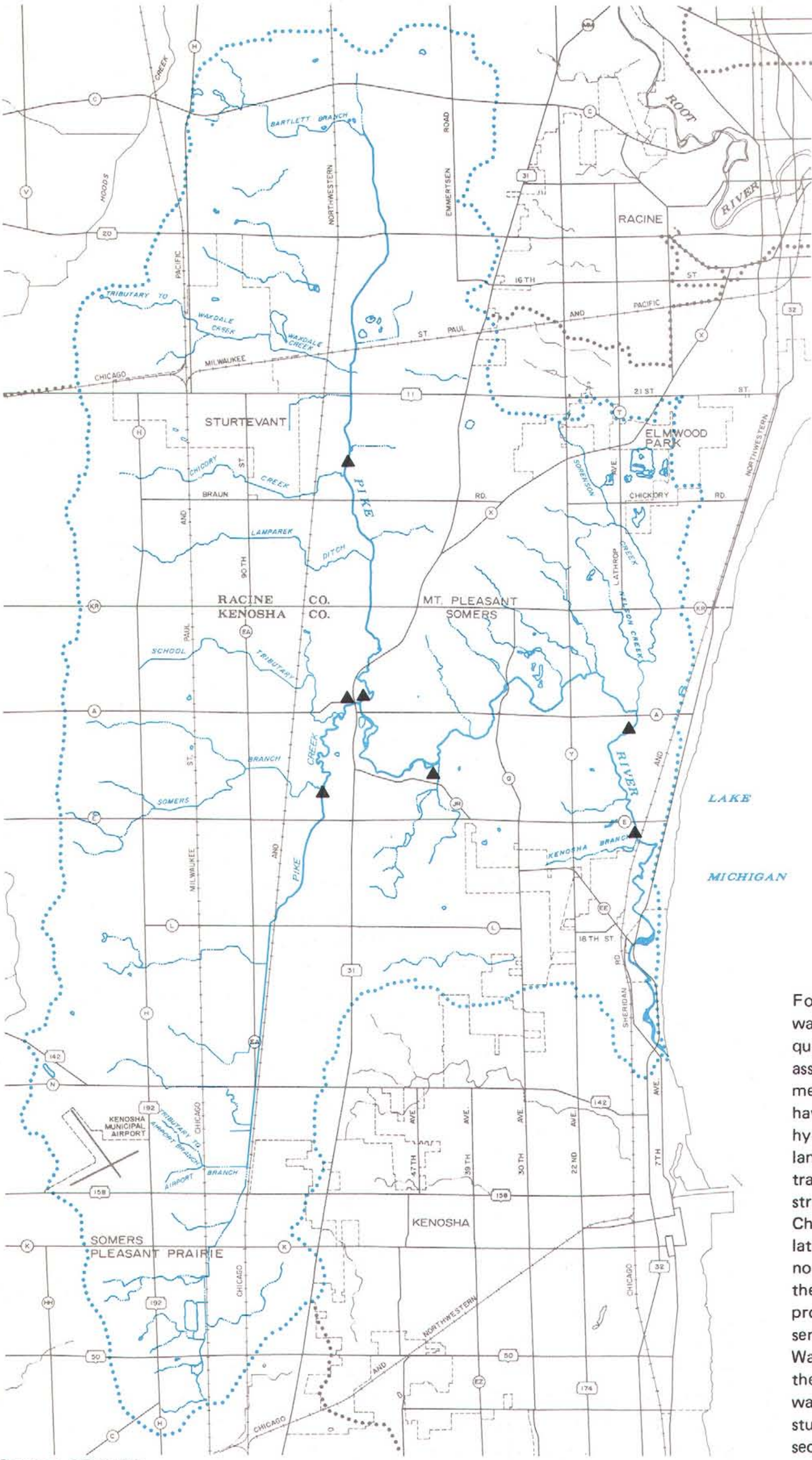
The development, test, and evaluation of alternative water quality control measures requires an assessment of probable future, as well as existing, water quality problems in the watershed. Identification of the probable future pollution problems and attendant sources was based upon the historic data presented in Chapter VII and on the results of stream water quality simulation modeling studies. The historic water quality information provided data on various types of pollution not assessable by simulation, such as toxic substances and sediment. Although standards have not been developed for these pollutants, their presence does affect the use of the surface water resources. The water quality simulation model was used to quantify both existing and probable future water quality conditions and to assess the impact of implementing the recommended year 2000 land use plan together with various alternative pollution control measures. The simulation model results were assessed against the water quality standards representing the intended water uses in order to identify and define the pollution problems and probable sources.

Use of the Simulation Model: As noted in Chapter VIII of this report, the principle purpose of developing and calibrating the water resource simulation model under the Pike 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 Pike River watershed are discussed in the following section.

In using the water quality submodel to analyze the impact of the year 2000 land use plan and alternative pollution abatement measures on water quality conditions, the watershed land surface and stream system were represented as shown on Map 39 of this report for existing (1975) conditions, and for the year 2000 planned land use-floodland development conditions. The watershed land surface was represented by 39 water quality land segments. Each of the 39 land segments was assigned one of 18 hydrologic water quality land segment types developed for the watershed—each type having specified land use, meteorological station, and hydrologic soil group characteristics. Water quality simulation results were obtained at seven locations within the watershed as shown on Map 76. Input data base development and the calibration of the water quality submodel are described in Chapter VIII of this report. Streamflow was continuously simulated for the three-year period beginning January 1, 1969, and ending December 31, 1971, through application of the hydrologic-hydraulic water quality simulation model. This time period was selected as being representative of, and repli-

Map 76

SIMULATED WATER QUALITY OUTPUT LOCATIONS IN THE PIKE RIVER WATERSHED



For purposes of water quality simulation modeling, the watershed land surface was represented by 39 water quality land segments. Each of the 39 land segments was assigned one of 18 hydrologic water quality land segment types developed for the watershed—each type having specified land use, meteorological station, and hydrologic soil group characteristics. The water quality land segments types were the basis for simulating the transport of pollutants from the land surface to the stream system via surface runoff or groundwater flow. Characteristics of each land segment were used to simulate the accumulation and transport of both point and nonpoint source pollutants in the channel system and the resulting instream biological, chemical, and physical processes. The water quality simulation results are presented for seven locations, as shown on the above map. Water quality simulation results are not presented for the Pike River estuary because accurate simulation of water quality conditions in the estuary requires further study of the complex hydraulic, water quality, and sediment interactions occurring in this environment.

Source: SEWRPC.

Table 98

EXISTING AND FORECAST YEAR 2000 INDUSTRIAL WASTEWATER DISCHARGE QUANTITIES IN THE PIKE RIVER WATERSHED

Name	Receiving Stream	Civil Division	Number of Cooling Water Outfalls	1975 Reported Average Hydraulic Discharge Rate (gallons/day)	Projected Year 2000 Average Hydraulic Discharge Rate (gallons/day)
Ametek-Lamb Electric	Sorenson Creek via storm sewer	Town of Mt. Pleasant	2	--[a]	--[a]
Rexnord, Inc. Hydraulic Component Division.	Pike River	Town of Mt. Pleasant	1	130,000	260,000
J. I. Case Company Transmission Plant	Pike River	Town of Mt. Pleasant	1	50,000	100,000
S. C. Johnson & Son, Inc. . . .	Waxdale Creek	Town of Mt. Pleasant	3	2,155,000	2,160,000
Metal-Lab, Inc.	Pike River via storm sewer	Town of Mt. Pleasant	1	--[a]	--[a]

[a] *These flow quantities were determined not to be significant in the simulation modeling.*

Source: Wisconsin Department of Natural Resources and SEWRPC.

cating the hydrologic characteristics of a longer 10-year period, beginning in January 1965 and used in previous Commission studies.

In order to further define and quantify the water quality problems which currently exist in the Pike River watershed as described in Chapter VII of this report, the instream water quality conditions were simulated using input data representing the existing land use and channel conditions, and municipal and industrial point source discharges as set forth in Table 69 in Chapter VIII, and Table 98 in this chapter. The simulation results for existing conditions provided a basis of comparison for the simulation of probable future conditions and for determining the effects of future land use, channel conditions, and alternative point source controls and land management measures on water quality.

Continuous water quality simulation produces sufficient water quality data to allow water quality constituent-duration relationships to be developed. These relationships may be used to quantitatively evaluate the impact of the full spectrum of hydrologic-hydraulic water quality phenomena on instream water quality conditions, and to provide a comparison to water quality standards for existing conditions as well as planned or projected future conditions.

Simulation Results Under Existing and Planned Year 2000 Conditions: Review of the simulation model study results, as summarized in Table 99 verifies the conclusion derived from the inventory data that water quality under existing conditions in the Pike River watershed generally does not meet recommended water use objectives and supporting water quality standards for warmwater fishery and aquatic life and recreational use. Existing condition simulation results indicate that fecal coliform, ammonia-nitrogen, and phosphorus levels generally do not meet recommended standards nearly throughout the watershed with depressed dissolved oxygen levels occurring at output locations downstream of the Sturtevant sewage treatment plant. Temperature levels are within the specified standard of 89°F throughout the watershed. The resultant water use conditions in the Pike River watershed are shown on Map 77, and indicate that none of the stream miles studied met all of the recommended water quality standards for support of warmwater fish and aquatic life and recreational use.

Simulation of water quality conditions of the Pike River watershed was carried out under design year 2000 planned conditions including planned land use, and implementation of committed and planned point source abatement measures. The plan year

Table 99

SUMMARY OF SIMULATED WATER QUALITY CONDITIONS IN THE PIKE RIVER WATERSHED UNDER EXISTING AND ALTERNATIVE FUTURE CONDITIONS

Water Quality Parameter and Alternative Condition[b]	Percent of Time Simulated Value Achieves the Recommended Standard						
	Pike River Upstream of Chicory Creek Output Site No. 1	Pike River Upstream of Pike Creek Output Site No. 2	Pike Creek Upstream of Somers Branch Output Site No. 3	Pike Creek at the Confluence with the Pike River Output Site No. 4	Pike River Downstream of Petrifying Springs Park Output Site No. 5	Pike River Downstream of the Confluence with Sorenson Creek Output Site No. 6	Pike River Downstream of CTH E Output Site No. 7
Dissolved Oxygen							
Existing	37[a]	40[a]	98	99	92[a]	94[a]	97
2000.	49[a]	96	98	99	94[a]	94[a]	97
Alternative 1	74[a]	98	99	99	98	97	98
Alternative 2	97	99	99	99	99	99	99
Orthophosphate							
Existing	54[a]	66[a]	96	94	78[a]	83[a]	78[a]
2000.	99	98	96	96	97	97	96
Alternative 1	99	99	98	98	98	98	98
Alternative 2	99	99	99	99	99	99	99
Ammonia-Nitrogen							
Existing	40[a]	67[a]	91[a]	90[a]	80[a]	85[a]	88[a]
2000.	97	97	84[a]	90[a]	95	94[a]	94[a]
Alternative 1	98	98	91[a]	93[a]	97	96	96
Alternative 2	99	99	96	97	99	99	98
Fecal Coliform							
Existing	2[a]	27[a]	56[a]	60[a]	40[a]	41[a]	54[a]
2000.	50[a]	74[a]	48[a]	58[a]	70[a]	68[a]	69[a]
Alternative 1	61[a]	82[a]	50[a]	64[a]	80[a]	77[a]	81[a]
Alternative 2	82[a]	97	66[a]	76[a]	94	90	92

[a] *Indicates that the applicable standard is not achieved for the recommended percent of time.*

[b] *The existing condition represents 1975 conditions. The 2000 condition represents planned year 2000 land use, recommended point source controls, and no nonpoint source control. Alternative 1 represents year 2000 planned land use conditions with recommended point source controls plus a 25 percent reduction in nonpoint source pollutant loadings. Alternative 2 represents year 2000 planned land use conditions with recommended point source controls plus a 50 percent reduction in nonpoint source pollutant loadings.*

Source: SEWRPC.

2000 conditions assume elimination of the two existing (1975) municipal wastewater discharges and one existing private wastewater discharge, elimination of all sanitary sewage flow relief devices in the watershed, and increased flow volumes from the industrial waste discharges. This increased flow volume from industrial waste discharges, because it consists entirely of spent cooling and other clear waters, is not expected to have an adverse water quality impact. Under plan year 2000 conditions, the simulation data indicate substantially improved water quality conditions may be expected downstream of the abandoned Sturtevant and Somers sewage treatment plants. However, reduced pollutant loadings from treatment facilities may be expected to be partially offset by increased urbanization that would tend to increase nonpoint source contributions to the surface water system. Thus, the resultant water quality conditions may be expected to be improved in particular with respect to phosphorus, ammonia-nitrogen, and dissolved oxygen levels. However, the conditions would still generally not satisfy the recommended water use objectives, because, as shown in Table 99, occasional violations of the ammonia-nitrogen and dissolved oxygen standards would continue to occur, as would violations of the fecal coliform standard.

The water quality simulation results for future land use and plan year 2000 point source controls but without nonpoint source control beyond existing levels are summarized on Map 77, which indicates that none of the stream miles studied would fully meet the fishable-swimmable criteria. The simulated water quality conditions summarized in Table 99 also show the effects of a 25 percent reduction in pollutant loadings from nonpoint sources, and a 50 percent reduction in pollutant loadings from nonpoint sources.

ALTERNATIVE NONPOINT SOURCE WATER QUALITY MANAGEMENT PLAN ELEMENTS

Based upon measured historic and simulated water quality data, the problems to be addressed in the development of alternative water quality management plan elements include excessive fecal coli-

Map 77

WATER QUALITY SIMULATION RESULTS FOR THE PIKE RIVER WATERSHED EXISTING (1975) LAND USE CONDITIONS, AND FORECAST (2000) LAND USE CONDITIONS ASSUMING PLANNED POINT SOURCE POLLUTION ABATEMENT MEASURES

Water quality simulation modeling study data supported by water quality sampling data indicate that under existing conditions none of the stream reaches within the watershed met the national goal of "fishable and swimmable" waters in 1975. Under planned year 2000 land use conditions and with point source control, but without nonpoint source control, the simulation results indicate that significant water quality improvements may be expected. However, due to the predominantly nonpoint source nature of fecal coliform bacterial pollution throughout the watershed and the resultant high instream fecal coliform bacterial levels shown by the simulation data, no significant advancement in achievement of water use objectives may be expected.

Source: SEWRPC.

form counts, depressed dissolved oxygen levels, excessive nutrient concentrations and the presence of toxic and hazardous substances. Historic water quality sample data and simulation results under existing conditions indicate fecal coliform bacteria to be the most prevalent and potentially dangerous form of water pollution in the watershed. The assumed abandonment of the Somers and Sturtevant sewage treatment plants under planned year 2000 conditions resulted in large reductions in orthophosphate and ammonia-nitrogen levels, but in only modest reductions in fecal coliform bacteria levels. These results indicate that the primary sources of fecal coliform bacteria are urban and rural nonpoint sources rather than point source contributions. This was attributed in large part to direct discharge from malfunctioning private onsite sewage disposal systems. Commission studies have indicated that about 40 percent of the onsite sewage disposal systems in the watershed may be malfunctioning or improperly installed.[8] For toxic and hazardous substances, the limited data indicate that unreported point source discharge of such substances may be occurring within the watershed. The planned point source controls will also substantially improve dissolved oxygen levels except at output site number 1, where sediment oxygen demand continues to result in substandard levels of dissolved oxygen. This sediment oxygen demand, produced by historic point and nonpoint sources of pollution, may be reduced over time, or sediment removal may be required to satisfy the dissolved oxygen standard.

Alternative Reductions in Nonpoint Source Loadings

A wide variety of management measures are available for controlling nonpoint sources of water pollution. The task of formulating a plan element for the abatement of these diffuse sources of pollution requires a somewhat different approach than would be used for the abatement of point source pollution problems or flooding problems. Different physical measures for nonpoint source pollution abatement exist and should be properly combined to provide an effective combination of measures in specific geographic subareas of the watershed. However, at the areawide systems level of planning, the examination of alternative water pollution abatement plans must, as a practical matter, be limited to the degree of control necessary to meet the standards for each water quality analysis area. The development of site-specific practices requires a detailed consideration of a great many factors including among others, land use, soils, subsurface characteristics, existing management practices, property ownership, property use and management goals, public works equipment and practices, investment policies, available technical and financial resources, and the extent to which and methods whereby public agencies may desire to seek plan implementation

The development and evaluation of alternative diffuse source control measures was accomplished by evaluating various levels of diffuse source pollutant reductions upstream of each simulation output site under plan year 2000 land use conditions. Because of the site-specific nature of diffuse sources, recommendation of specific measures at specific locations could not be made at the systems planning level. Rather, the required level of reduction in pollutant loading was used as the basis for the development of alternative combinations of nonpoint source control measures. The control measures used to attain these approximate levels of reduction in surface runoff loadings were selected from the spectrum of possible management measures as developed by the Commission under its areawide water quality planning program.[9]

Use of Simulation Model: Simulation model studies were used to determine the impact on surface water quality conditions of the reductions in diffuse source land surface loadings. The simulation model inputs representing plan year 2000 land use conditions and channel modifications were altered to represent the reduction in land surface loading rates and in the resultant runoff loadings. This was accomplished by reducing the pollutant loading rates for both impervious and pervious surfaces, as well as concentrations of pollutants in subsurface flow, by a factor consistent with the reduction desired. The subsurface flow concentrations were reduced accordingly to reflect the expected reduction in concentration of these potential pollutants in the groundwater as the result of implementation

[8] *See SEWRPC Technical Report No. 21, Sources of Water Pollution in Southeastern Wisconsin: 1975, p. 336.*

[9] *See SEWRPC Technical Report No. 18, State of the Art of Water Pollution Control in Southeastern Wisconsin, Volume Three, Urban Storm Water Runoff and Volume Four, Rural Storm Water Runoff.*

of land management practices. The reduction factor was applied equally to all simulated water quality constituents because the current state of the art of nonpoint source pollution control measurement did not permit any greater precision.

Alternative Simulation Results: Simulated water quality under plan year 2000 conditions were described in the previous section and indicated that substandard water quality conditions could be expected for fecal coliform organisms, dissolved oxygen, and ammonia-nitrogen at various locations throughout the watershed. The simulation model studies indicated that a 25 percent reduction in nonpoint source pollutant loads, applied to both the rural and urban areas of the watershed under plan year 2000 conditions, may be expected to result in overall reductions in fecal coliform bacteria, biochemical oxygen demand, ammonia-nitrogen and phosphorus levels. Dissolved oxygen levels were generally found to increase as a result of the reduction in biological and chemical oxygen demanding materials and dissipation of bottom sediment oxygen demand that is attributed to long-term deposition of organic material from point and nonpoint sources.[10] Of the five constituents for which standards were adopted—temperature, dissolved oxygen, ammonia-nitrogen, phosphorus, and fecal coliform—only two were found to be within the recommended levels of water quality achievement with a 25 percent reduction in nonpoint source loadings. These constituents are temperature and phosphorus. However, although the simulation model results indicated that values for ammonia-nitrogen and dissolved oxygen may not be within acceptable levels, an additional review of the relationship of these pollutants with other stream parameters such as pH and temperature, indicated that the expected violations of the dissolved oxygen and ammonia-nitrogen standards would not be significant. The simulation model study results are interpreted and discussed in the following sections and are summarized on Map 78, which indicates the full achievement of the recommended water use objectives and supporting standards in all 39 miles of stream studied in the watershed.

[10] *It should be noted that the reach of the Pike River from CTH KK to STH 11 was dredged in 1977 by the Town of Mt. Pleasant for purposes of drainage maintenance. This dredging should have benefited dissolved oxygen concentrations in this reach by removing oxygen-demanding benthic sediments.*

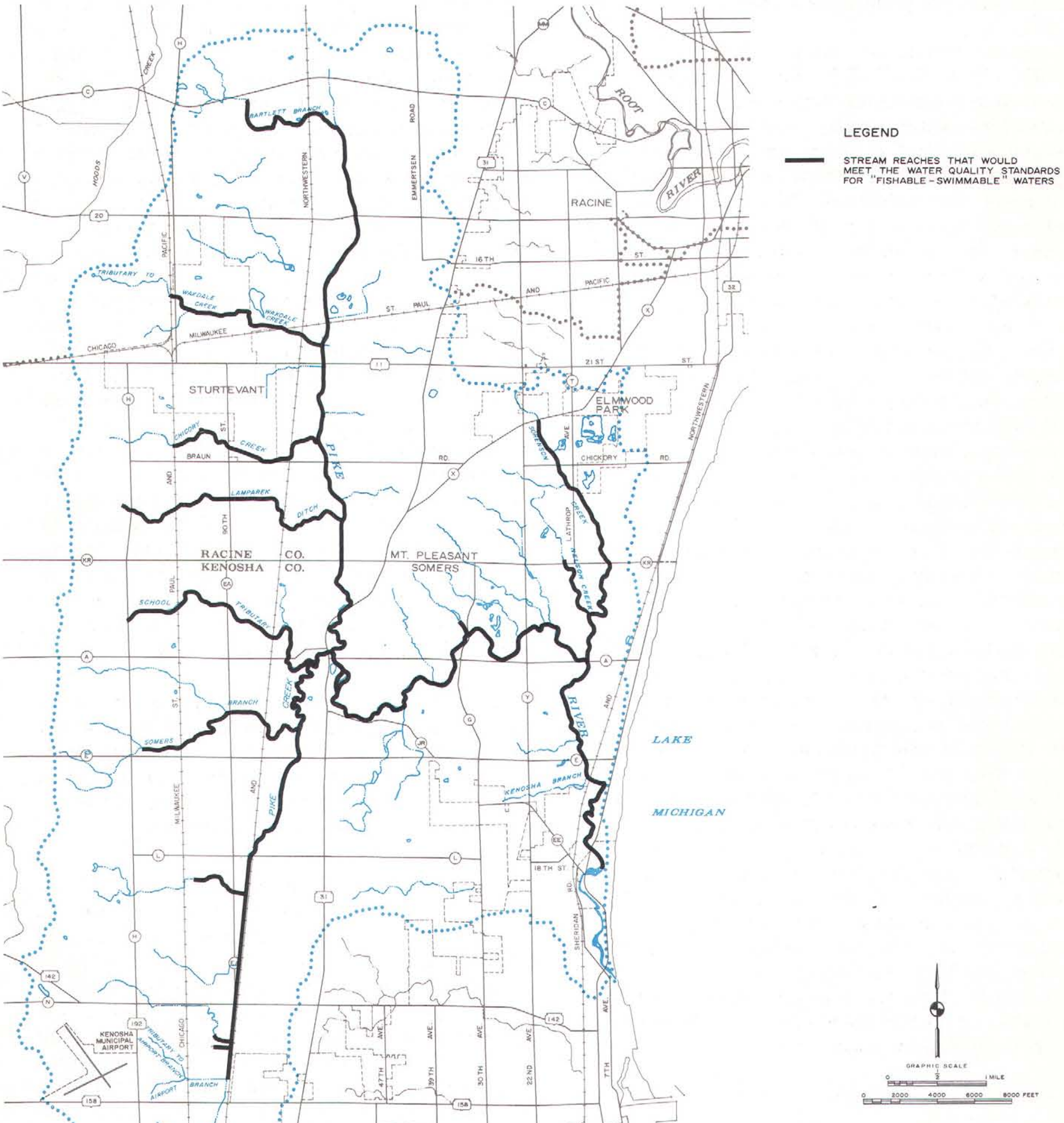
Dissolved oxygen levels at only one of the seven output locations showed achievement levels of significantly less than the recommended 95 percent level. This output location is on the Pike River downstream of the abandoned Sturtevant sewage treatment plant and upstream of Chicory Creek. An investigation of the input data and the calculations that affect simulated instream dissolved oxygen indicated that the level of dissolved oxygen at this site is substantially dependent upon the reduction in sediment oxygen demand which would be associated with reduced point and nonpoint source loadings. Sediment oxygen demand for this reach of stream was reduced in proportion to the reduction of nonpoint source loadings; however, the removal of a substantial point source load from the Sturtevant sewage treatment plant may be expected to result in a substantially higher reduction in sediment oxygen demand not reflected in the simulation results since there is no precise method of estimating the reduction in sediment oxygen demand. Based upon the frequency analyses, it was concluded that a 25 percent reduction in nonpoint source pollutant loadings may be expected to achieve the dissolved oxygen standard at output site number 1. Further site-specific investigation of the effects of abandonment of the Sturtevant sewage treatment plant on sediment oxygen demand would be required before additional practices for nonpoint source pollution control could be responsibly recommended.

Simulation results, supported by historic water quality sample data, indicate that there are excessive nutrient concentrations in the Pike River main stem. However, under plan year 2000 conditions with point source control, all output locations showed acceptable levels of phosphorus.

As noted in Chapter X, the level of ammonia-nitrogen that is considered to be toxic to fish and other aquatic life is based upon the un-ionized form of ammonia-nitrogen. The concentration of un-ionized ammonia is dependent upon instream pH and temperature conditions, as well as the concentration of total ammonia. The level of un-ionized ammonia decreases with decreasing pH, temperature, or total ammonia concentration. The recommended total ammonia-nitrogen standard of 0.40 mg/l used in this evaluation is based on the estimate that a toxic level of un-ionized ammonia-nitrogen of 0.02 mg/l will occur at this total ammonia concentration at a pH of 8.0 standard units and temperature of 75°F. An investigation of historic pH levels that have been measured for various locations along Pike Creek indicates

Map 78

WATER QUALITY SIMULATION RESULTS FOR THE PIKE RIVER WATERSHED: FORECAST YEAR (2000) LAND USE CONDITIONS ASSUMING PLANNED POINT SOURCE POLLUTION ABATEMENT MEASURES AND THE REQUIRED LEVEL OF NONPOINT SOURCE POLLUTION ABATEMENT



Source: SEWRPC.

Simulation model studies were conducted to estimate the probable future water quality conditions in the watershed by the year 2000 if a combined point source and nonpoint source pollution control effort was implemented. The alternative identified a practical and cost-effective combination of both point and nonpoint source controls. Under this alternative, it is estimated that water quality conditions throughout the watershed could support the fishable-swimmable water quality criteria.

that average pH levels are somewhat less than the estimated regional average pH values of 8.0 standard units. This slightly lower pH value, known to exist in Pike Creek, would allow concentrations of total ammonia greater than 0.40 mg/l without imposing toxic levels of un-ionized ammonia-nitrogen on fish and other aquatic life. Thus the 0.40 mg/l standard for ammonia-nitrogen is in this case considered to be a conservative level of control indicating that the simulated 91 and 93 percent achievement levels for total ammonia should more than satisfy the recommended standard of 0.02 mg/l of un-ionized ammonia 95 percent of the time.

It has been established that fecal coliform levels are consistently high throughout the watershed. Simulation results indicate that although nonpoint source control substantially reduces levels of fecal coliform bacteria, reduction in nonpoint source loads will not satisfy the recommended 90 percent achievement level at three of the seven output sites. Based on these results it would be necessary, in order to meet the agreed-upon water use objectives, to design the specific nonpoint source management practices to assure very high levels of control of nonpoint sources of fecal coliform bacteria. The high levels of control required are achievable by the control of malfunctioning private sewage disposal systems and livestock wastes. These are the predominant sources of fecal coliform bacteria and, therefore, basic controls of these sources would achieve a very high level of reduction in bacteria levels.

Based on the foregoing, it is apparent that for dissolved oxygen, phosphorus, and ammonia-nitrogen, only a 25 percent reduction in nonpoint source loadings would be required to achieve the applicable standards. In excess of a 50 percent reduction in fecal coliform bacteria from nonpoint sources is required in order to achieve the fecal coliform standard.

Other Considerations: In addition to those constituents represented in the water quality submodel, the application of diffuse source control measures may be expected to result in the reduction of other constituents, including toxic substances and sediment which accumulate on the land surface and are washed off during rainfall or snowmelt events. Since some toxic substances form an association with fine soil particles in a manner similar to phosphorus, it is estimated that the reduction in toxic substances from diffuse sources would be similar to that of phosphate-phosphorus, as shown in Table 99. Much of the sediment transported in the Pike River watershed originates from agricultural areas where the soil is periodically exposed, from streambed erosion, and from construction sites where the land surface has been disturbed. Agricultural soil conservation measures and construction erosion control measures are quite effective in reducing sediment contributions from these sources. Reductions in excess of 50 percent may be achieved from these measures.

Alternative Nonpoint Source Control Measures

The selection of nonpoint source pollution control measures at the systems planning level involves consideration of the character, extent, and severity of the identified water quality problems in relation to the available control measures. Measures must be selected to assure the necessary level of control at the least cost. Control measures that are available for nonpoint sources in the Pike River watershed are summarized in Table 100. Costs of the diffuse source pollution control measures were estimated based on the information presented in SEWRPC Technical Report No. 18, State of the Art of Water Pollution Control in Southeastern Wisconsin, Volume Three, Urban Storm Water Runoff, and Volume Four, Rural Storm Water Runoff.

The simulation model studies indicated that a substantial improvement in the surface water quality can be achieved under the design year 2000 planned land use conditions through: 1) abandonment of two municipal sewage treatment plants in the Pike River watershed, and 2) a 25 percent reduction in the runoff rates of various potential pollutants through implementation of nonpoint source management measures. The simulation model results indicate that a 25 percent nonpoint source pollutant reduction will allow the achievement of the water quality standards for ammonia-nitrogen, phosphorus, and dissolved oxygen, and that a 50 percent reduction is required to achieve the fecal coliform standard. Relatively higher levels of control specific to the reduction of fecal coliform bacteria, accordingly, may be expected as a result of the application of septic tank system management and livestock waste control minimum practices. Continuous flow simulation under the postulated future conditions in the watershed indicated that implementation of the "minimum practices" set forth in Table 100 may be expected to result generally in the achievement of the temperature standard all of the time, the dissolved oxygen and ammonia-nitrogen standards at least

Table 100

ALTERNATIVE GROUPS OF NONPOINT SOURCE WATER POLLUTION CONTROL MEASURES PROPOSED FOR STREAM WATER QUALITY MANAGEMENT IN THE PIKE RIVER WATERSHED UNDER THE AREAWIDE WATER QUALITY MANAGEMENT PLAN

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

[a] *The required level of nonpoint source reduction is identified from the water quality analyses. The percent reduction refers to the portion of pollutant runoff from urban or rural land which can be controlled by the implementation of those practices.*

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

[c] *Includes urban stormwater runoff detention and storage, and infiltration measures.*

[d] *On the average, sweep all streets in urban areas an equivalent of once or twice a week with vacuum street sweepers; require parking restrictions to permit access to curb areas; sweep all streets at least eight months per year; sweep commercial and industrial areas with greater frequency than residential areas.*

[e] *The provision of bench terraces would render unnecessary the application of other conservation practices.*

Source: SEWRPC.

95 percent of the time, and the phosphorus standard at least 90 percent of the time. In addition, Commission staff analyses indicate that the fecal coliform standard should be achieved about 90 percent of the time by application of minimum practices.

The purpose of this section of the chapter is to identify and briefly describe practical land management measures capable of achieving the necessary minimum levels of nonpoint source pollution control, thus reducing the transport of pollutants from the land surface to the watershed system. Land management measures are closely related to land use in that there is one set of land management measures generally suitable for urban lands and another, quite different, set of land management measures generally suitable for agricultural or rural lands.

Control of Runoff from Urban Lands: The 10 urban nonpoint source pollution control measures referred to as minimum practices in Table 100—public education programs, litter and pet waste control, restricted use of fertilizers and pesticides, construction erosion control, septic tank system management, critical area protection, improved timing and efficiency of street sweeping, leaf collection, catch basin cleaning, and industrial and commercial material storage facilities and runoff control[11]—are applicable to existing and proposed urban areas of the Pike River watershed. Since substantial urban development may be expected to occur within the watershed over the next two decades, control of the erosion from construction areas will be, in particular, an effective measure. Effective management of the remaining septic tank systems is also anticipated to be of importance due to the excessive instream concentrations of fecal coliform bacteria that are known to exist in the stream system of the watershed.

Control of Runoff from Rural Lands: The nine rural nonpoint source pollution control measures referred to as minimum practices in Table 100—public education programs, fertilizer and pesticide management, critical area protection, crop residue management, conservation tillage, pasture management, contour plowing, livestock waste control, and construction erosion control—are applicable to rural areas of the Pike River watershed. Again, due to the high levels of fecal coliform bacteria that are known to exist throughout the stream system of the watershed, particular emphasis should be given to livestock waste control measures.

Other Pollution Control Measures: Although reductions in diffuse source loadings, through measures described above, may be expected to provide the necessary surface water quality improvement for most pollutants, some additional control measures will be necessary in order to achieve water use objectives for the Pike River watershed. These measures include additional nonpoint source controls more specific than the minimum practice measures suggested above. The elimination of toxic and hazardous substances from surface waters in the Pike River watershed is essential to the development of any fishery. The implementation of diffuse source pollution control measures discussed above will provide some reduction of the pesticides and sediment-associated urban toxic substances broadly distributed over the land surface. Accidental spills with attendant intermittent discharges through surface runoff, as well as floor drains connected to surface water and surface drainage systems, however, are another source of toxic and hazardous substances which should be controlled. The establishment of spill prevention and control plans should be developed for all situations under which such spills could occur. Floor drains and drainage pumps in industrial facilities which collect grease, oil, chemical, and other toxic and hazardous substances, should be altered, as necessary, to eliminate discharge to storm sewers and surface water courses. Possible alternatives include discharge to sanitary sewer systems for treatment at, and disposal through, public sewage treatment plants, pretreatment prior to discharge, or elimination of the discharge entirely through process modifications.

Costs: The full implementation of the minimum levels of nonpoint source control, as set forth in Table 100, is estimated to have a total capital cost of about $8.5 million, and an average annual operating and maintenance cost of about $152,000, for a total average annual cost of $577,000 over the 20-year planning period. Of this total, $422,000, or 73 percent, is related to construction erosion control. Capital and operation and maintenance costs for the proposed nonpoint source control measures are set forth in Table 101. The estimated capital operation and maintenance costs for the abatement of the point sources of water pollu-

[11] *Runoff control refers to the conveyance, detention, or infiltration of storm water runoff from these areas so as to minimize the discharge of pollutants to surface waters.*

Table 101

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

Diffuse Source Pollution Control Measures	Estimated Cost[a] Total Capital (1980-2000)	Estimated Cost[a] Average Annual Operation and Maintenance
Urban		
Septic System Management[b]	$ --	$ --
Low-Cost Urban Diffuse Source Controls[c]	Minimal	24,000
Industrial and Commercial Material Storage Facilities and Runoff Control Measures	1,128,000	Minimal
Construction Erosion Control Practices	7,261,000	59,000
Subtotal	$8,389,000	$ 83,000
Rural		
Minimum Conservation Practices[d]	$ 10,000	$ 60,000
Livestock Waste Control	110,000	9,000
Subtotal	$ 120,000	$ 69,000
Total	$8,509,000	$152,000

[a] *Costs expressed in January 1980 dollars; "Engineering News Record" cost construction index of 3131.*

[b] *The proper maintenance and replacement of the remaining septic tank systems are recommended to help improve the water quality of the Pike River watershed. However, because septic tank systems management is an existing function necessary for the preservation of public health and the protection of private drinking water supplies, this cost is not included in the water quality management plan. The estimated expenditures for septic system management for the stream plan element include a capital cost over the period of 1980-2000 of $1,583,000, and an average annual operation and maintenance cost of $49,000.*

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

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

Source: SEWRPC.

tion—including abandonment of public and private sewage treatment plants, elimination of separate sanitary sewer flow relief devices, and control of sources of industrial wastewater—as well as for the abatement of nonpoint sources, are not included in the comprehensive watershed plan costs because the water quality management costs were developed and are set forth in the regional water quality management plan.

WATER QUALITY MONITORING PROGRAM

As discussed in Chapter VII of this report, a variety of surface water quality monitoring programs have been carried out within the Pike River watershed. These monitoring programs include, but are not limited to, periodic basin surveys by the Wisconsin Department of Natural Resources, beginning in 1955; a Commission water quality study conducted in 1964 to 1965; a Commission continuous water quality monitoring program conducted from 1968 to 1976; and a survey of toxic and hazardous substances conducted by the Wisconsin Department of Natural Resources in 1975 and 1976. These studies were conducted for several specific purposes and include samples of specific constituents as indicators of water quality conditions.

A well-planned and executed water quality monitoring program can serve two important functions for the water quality management plan element of a comprehensive plan for the Pike 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 pollutants and help to determine the probable source and thereby facilitate corrective action. Second, the water quality monitoring effort, using historic and existing data as a benchmark, can be used to demonstrate and document improvements in the water quality of the Pike River watershed as recommended plan elements are implemented. As part of the Commission's continuing regional water quality management planning program, a prospectus for water quality monitoring in the Region is scheduled for preparation in 1983, relying upon the guidance of a special advisory body including technical water quality monitoring expertise, as well as potential financial support agencies.

SUMMARY

A careful examination of the available water quality data for the Pike River watershed stream system for the period from 1955 through 1977 indicates that polluted conditions exist or have existed over extended periods of time for virtually all of the watershed. Toxic, organic, nutrient, pathogenic, sediment and aesthetic pollution are all known to exist in the surface waters of the Pike River watershed. These problems are attributed primarily to five sources: municipal sewage treatment facilities, sanitary sewerage system flow relief devices, industrial wastewater discharges, urban nonpoint sources, and rural nonpoint sources. As of 1975 municipal sewage treatment plants accounted for about 4 percent of the total nitrogen, 6 percent of the total phosphorus, 5 percent of the biochemical oxygen demand, 51 percent of the fecal coliform and less than 1 percent of the sediment. Sanitary sewerage system flow relief devices accounted for about 2 percent of the fecal coliform, and a negligible fraction of the other four pollutants studied. Industrial wastewater discharges contributed a very small fraction of the five conventional pollutants studied. Urban nonpoint sources accounted for about 19 percent of the total nitrogen, 67 percent of the total phosphorus, 50 percent of the total of the biochemical oxygen demand, 22 percent of the fecal coliform, and 50 percent of the total sediment. Rural nonpoint sources accounted for about 77 percent of the total nitrogen, 26 percent of the total phosphorus, 44 percent of the total of the biochemical oxygen demand, 25 percent of the total fecal coliform, and 50 percent of the total sediment.

Substantial efforts have already been initiated to abate these sources of pollution. In accordance with the recommendations contained within the adopted regional water quality management plan for southeastern Wisconsin, the two municipal sewage treatment plants located within the watershed are recommended to be abandoned, as is one private sewage treatment plant. These facilities are proposed to be connected to the public sewage treatment facilities of the Cities of Racine and Kenosha. In addition, it is recommended that all sanitary sewerage system flow relief devices be abandoned through the institutional mechanism of the Wisconsin Pollutant Discharge Elimination System (WPDES). That system also is expected to provide the institutional means to monitor and control wastewater discharges from industrial sources. Progress has also been made with regard to nonpoint source pollution control through the farmland preservation planning efforts of Racine and Kenosha Counties and concerning the development of countywide sanitary ordinances. These efforts include the refined delineation of primary environmental corridor lands within the two counties. The various local efforts are expected to result in long-term positive benefits for nonpoint source pollution control.

The water quality management plan element of the Pike River watershed planning program was conducted within the framework of several overall guiding assumptions. First, the water quality analyses and water quality management plan design efforts accept as committed actions the eventual abandonment of two municipal and one remaining private sewage treatment plants. Second, the water quality analyses and plan design efforts accept as committed actions the eventual elimination of all sanitary sewerage system flow relief devices in the watershed, since their elimination may be expected to occur in an orderly way under the provisions of WPDES. Third, the water quality analyses and plan design efforts accept as committed the continued discharge of noncontact cooling waters from industrial wastewater sources to the surface water system, discharges which presently have a very small impact on water quality. Accordingly, all excessive pollutant loads from industrial sources are eliminated in the analysis.

A series of water quality simulation model studies were conducted under existing and various possible future development conditions and water quality management measures in the watershed. This approach served to demonstrate quantitatively the likely consequence of committed and alternative future water quality management measures. The simulation model studies indicate that elimination of the two municipal sewage treatment plants and one private sewage treatment plant under the year 2000 land use conditions, without any further nonpoint pollution abatement measures, may be expected to yield the following water quality impacts. Temperature levels throughout the watershed which presently meet standards may be expected to remain essentially unchanged. Dissolved oxygen levels on the Pike River upstream of the confluence of Pike Creek may be expected to exhibit significant increases due to elimination of the Sturtevant and St. Bonaventure sewage treatment plant discharges. Dissolved oxygen levels may also be expected to be slightly improved in the downstream reaches of the Pike River. Orthophosphate-phosphorus concentrations are also expected to be substantially reduced throughout the watershed. Substantial decreases of ammonia-nitrogen concentrations may be expected in the Pike River immediately downstream of the abandoned municipal treatment facilities, with some lesser decreases expected in the lower reaches of the Pike River. Fecal coliform levels may be expected to slightly improve throughout the watershed. Despite these very significant point source-related water quality improvements, it is not expected that the surface water system of the Pike River watershed would fully achieve the applicable water quality standards in the absence of nonpoint source control measures.

The simulation model studies further indicated that nonpoint source control measures are needed to achieve the water quality standards attendant to the water use objectives for maintenance of a warmwater fishery and full recreational uses of all the streams of the watershed. The analyses indicated that minimum practices for nonpoint source pollution control in urban and rural areas would be required throughout the watershed in order to meet water use objectives and supporting water quality standards set forth in this report. Particular emphasis must be placed upon control measures that abate fecal coliform bacteria pollution. In urban areas, such emphasis will require public education programs, litter and pet waste control, sound use of fertilizers and pesticides, construction erosion control, septic tank system management, critical area protection, improved timing and efficiency of street sweeping, leaf collection and catch basin cleaning, materials storage facilities and storm water runoff control. With respect to nonpoint source pollution control from rural areas, it is recommended that emphasis be placed upon public education programs, fertilizer and pesticide management, critical area protection, crop residue management, conservation tillage, pasture management, contour plowing, and livestock waste control.

A water quality monitoring program should be developed for the watershed within the context of the regional water quality monitoring program to be developed by the Commission as part of its continuing water quality management planning effort. The monitoring program should seek to determine and document actual changes in surface water quality in response to plan implementation actions, and to provide surveillance data to detect and locate continued undesirable levels of pollution.

Based upon the analyses conducted as part of the Pike River watershed study, it may be concluded that the application of the committed and planned point source pollution abatement measures, together with the application of minimum nonpoint source pollution abatement measures, can result in the full attainment of the fishable-swimmable water use objectives and supporting water quality standards in all of the 39 stream-miles studied within the Pike River watershed. The nonpoint source pollution control measures along with the abatement of point source pollution would assure the achievement of safe and healthful water quality conditions to support the protection and maintenance of a sound aquatic habitat, as well as the assurance of a safe and healthful human environment within the Pike River watershed.

Chapter XIV

RECOMMENDED COMPREHENSIVE PLAN

INTRODUCTION

The comprehensive plan for the Pike River watershed is comprised of three major elements: 1) a land use base element, including open space preservation and outdoor recreation subelements; 2) a supporting floodland management element composed of structural and nonstructural subelements; and 3) a supporting water quality management element composed of various point and diffuse source pollution abatement subelements. The land use base element is based upon and refines and details the adopted regional land use plan and the adopted regional park and open space plan. The water quality management plan element is based upon and refines and details the adopted regional water quality management plan. The floodland management plan element was synthesized by selecting from among the alternatives considered the best floodland management measures. This selection was based upon careful evaluation of the tangible and intangible factors involved, with primary emphasis upon the degree to which the various alternatives met the established watershed development objectives in the most cost-effective manner.

This chapter presents a description of the recommended comprehensive watershed development plan as synthesized from the best of the alternatives considered, together 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 watershed development objectives and standards and discusses the likely consequences of not implementing the plan. It should be noted that this chapter presents the recommended plan as presented for public hearing. The public reaction to this recommended plan and the subsequent action of the Pike River Watershed Committee to adjust the plan as necessary are discussed in Chapter XVI of this report.

BASIS FOR PLAN SYNTHESIS

The watershed development objectives which the comprehensive plan for the Pike River watershed is designed to meet are set forth in Chapter X of this report. 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.

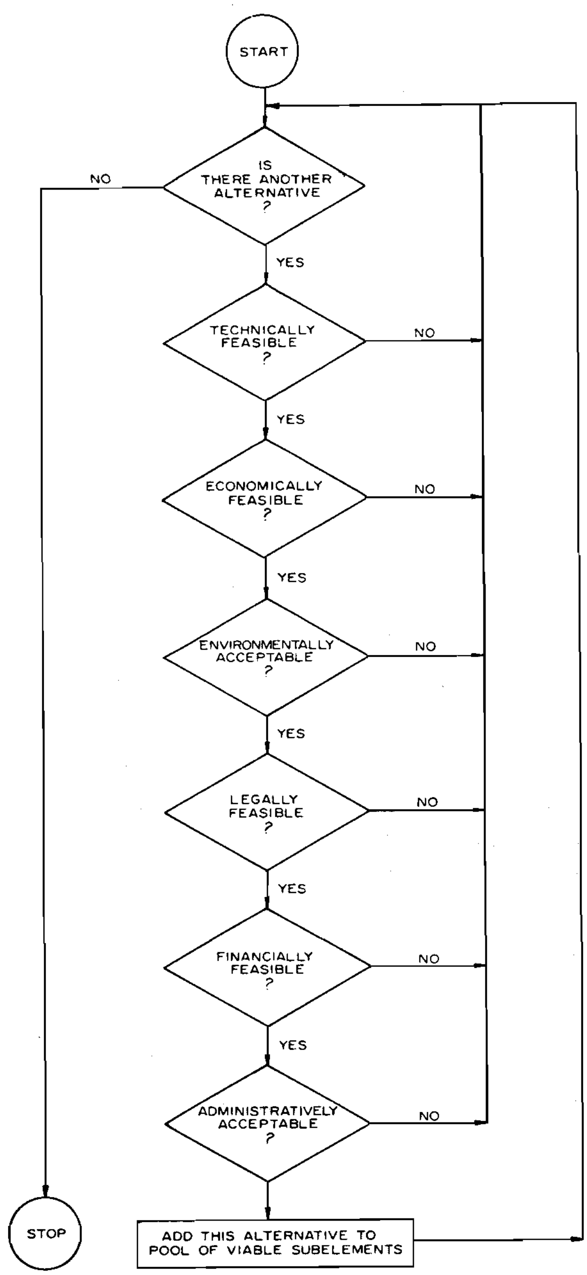
The three preceding chapters describe the alternative proposals considered for the resolution of the water-related problems of the watershed, and identify the best land use, floodland management, and water quality management alternative for inclusion in the comprehensive watershed plan. This identification was based upon careful evaluation of the various alternative plan elements of technical, economic, environmental, legal, financial, and administrative feasibility, as well as on the basis of the ability to meet the applicable watershed development objectives and supporting standards. Figure 62 illustrates the manner in which a plan element or subelement was 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 actually test and evaluate alternative subelements ranged from the mathematical models used to simulate river performance to informal interagency meetings and formal public hearings.

No single 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 elements, with each plan element contributing to the extent practicable toward the satisfaction of the development objectives. It should be noted that many of the alternative plan elements were specifically designed to satisfy certain watershed development objectives, and therefore the selection from among the alternatives depended largely upon analysis of the attendant costs. The various recommended plan alternatives, as set forth in Chapters XI, XII, and XIII of this report, are complementary in nature, and the recommended comprehensive watershed plan represents a synthesis of carefully coordinated individual plan elements which together should achieve most of the adopted watershed development objectives.

This synthesis of the individual plan elements into a comprehensive plan required further test and evaluation, including further simulation model applications and, in some cases, adjustment of the individual plan elements. 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 economic analyses of certain of the individual plan elements and subelements, however, as set forth in previous chapters of this report, comprise important inputs to the plan selection process, particularly where the alternative plan elements or subelements were specifically designed to meet certain development objectives.

Figure 62

TEST AND EVALUATION OF A PLAN SUBELEMENT



Source: SEWRPC.

RECOMMENDED PLAN

Based upon the results of the analyses of the ability of the various plan elements to satisfy watershed development objectives and to exhibit an acceptable benefit-cost ratio, as described in previous chapters of this report, the specific plan elements set forth below are recommended for inclusion in the comprehensive plan for the Pike River watershed.[1]

Recommended Land Use Plan Element

Overall Land Use: The adopted regional land use plan, as refined and detailed under the watershed study, is recommended for adoption as the land use base element in the Pike River watershed plan (see Map 44 in Chapter XI). This land use plan element envisions use of a combination of public acquisition and public regulation of private holdings of land to guide and shape the spatial distribution of land uses within the watershed in order to achieve a safer, more healthful, more pleasant, and more efficient land use pattern while meeting the forecast land use demand requirements. 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.

[1] *A fishery development plan element was prepared and presented to the watershed committee. The Committee determined not to include the staff recommendations pertaining to fishery development in the recommended plan. In order to fully document the work conducted, however, the fishery development element has been reproduced in Appendix I..*

Urban Development: Forecasts indicate that the population of the Pike River watershed may be expected to increase from the 1970 level of about 24,200 persons to a plan year 2000 level of about 56,300 persons, a 132 percent increase.[2] Employment may be expected to reach approximately 25,200 jobs by 2000, an increase of about 16,900 jobs, or about 240 percent over the 1970 level. Although the Pike River watershed is still primarily occupied by rural land uses, with about 37 square miles, or 72 percent of the watershed devoted to such uses in 1975, an additional 15 square miles of land are forecast to be converted from rural to urban use over the next two to three decades, a 105 percent increase.

As indicated in Table 81 in Chapter XI of this report, the recommended land use plan proposes to add about 8.6 square miles of land to the existing stock of residential land within the watershed in order to meet the housing needs created by anticipated shifts in the distribution as well as growth of population within the watershed, and by decreasing household size and attendant increase in the number of dwelling units needed. This new urban development is proposed to occur primarily at medium population densities, with gross residential population densities ranging from about 2,900 to about 8,000 persons per square mile. The new residential development would be located in areas served, or proposed to be served, by a full range of public utilities and essential urban services. The remaining 6.4 square miles of land proposed to be converted from rural to urban use within the watershed by the year 2000 would be used for commercial, industrial, governmental and institutional, transportation, communication, and utility land uses as required to meet the gross demand for land generated by the anticipated resident population and employment levels within the watershed.

Agricultural and Other Open Land Use: As noted above, the recommended watershed land use plan would require the conversion to urban use of about 15 square miles of land presently devoted to agricultural and other open land uses within the watershed. The existing stock of such land within the watershed could, therefore, be expected to decrease from about 37 square miles in 1975 to about 22 square miles in the year 2000, a decrease of 40 percent.

Park and Open Space Plan: As discussed earlier in this report, a regional park and open space plan was completed and adopted by the Commission in 1978 and includes recommendations affecting the Pike River watershed. The regional park and open space plan is composed of two principal elements—an open space and natural resource base preservation plan element, and an outdoor recreation plan element.

The open space preservation plan element recommends the continued maintenance and preservation in essentially open uses of all remaining primary environmental corridor lands within the Region and the watershed. The preservation of the primary environmental corridor 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 Region and the watershed. As shown on Map 44 in Chapter XI of this report, those corridor lands consist of about 1,189 acres located along the Pike River from the mouth upstream to and within Petrifying Springs County Park, along the Sorenson Creek from the confluence with the Pike River upstream to the Kenosha-Racine county line, and along the Pike Creek from the confluence with the Pike River upstream to CTH E. Of this total, 439 acres, or about 37 percent, are already publicly owned. An additional 138 acres, or about 12 percent, are held in compatible nonpublic outdoor recreation uses. The plan recommends that the remaining 612 acres, or 51 percent, ultimately be publicly acquired through purchase, dedication, or gift.

The outdoor recreation plan element for the Region and the watershed is composed of: 1) a resource-oriented outdoor recreation component containing recommendations as to the number and location of large parks, proposed recreation corridors to accommodate trail-oriented activities, and water access facilities; and 2) an urban-oriented outdoor recreation component containing recommendations to guide the public provision of needed local parks and nonresource-oriented recreation facilities within urban areas. More specifically, with respect to the watershed, and as shown on Map 44 in Chapter XI, the outdoor recreation plan element recommends:

[2] *Results of the 1980 federal census—which became available as this plan was nearing completion—indicate that approximately 30,500 persons were residing in the watershed in 1980, an increase of about 6,300 persons, or about 26 percent, over the 1970 level.*

- Continued maintenance of Petrifying Springs County Park—a large, general use outdoor recreation site;

- Development of a seven-mile recreation corridor along the main stem of the Pike River from Petrifying Springs County Park to Lake Michigan to be linked to a five-mile Kenosha-Racine county bike trail, and to the proposed recreation corridor along the Root River in Racine County;

- Expansion of Sanders Park in the Town of Mt. Pleasant through acquisition of 40 additional acres;

- Development of facilities at Sam Poerio Park in the City of Kenosha;

- Continued maintenance of the four existing community and neighborhood parks in the watershed, and the acquisition and development of 12 new community and neighborhood parks as the need for such parks becomes evident; and

- Development of urban outdoor recreation facilities for community and neighborhood parks, the type and quantity of which would be determined through a joint effort by county agencies, school districts, and local community recreation agencies.

The estimated costs for the development and acquisition of the proposed parks and related open spaces, including the cost of acquisition of the primary environmental corridor lands, are reflected in the total cost of the regional park and open space plan and are not, therefore, included in the implementation cost of the Pike River watershed plan. The recommended park and open space plan element would achieve the park, outdoor recreation, and open space preservation objectives and standards formulated under the watershed study, meeting the existing and anticipated future recreation needs within the watershed in an efficient and effective manner.

Recommended Floodland Management Plan Element

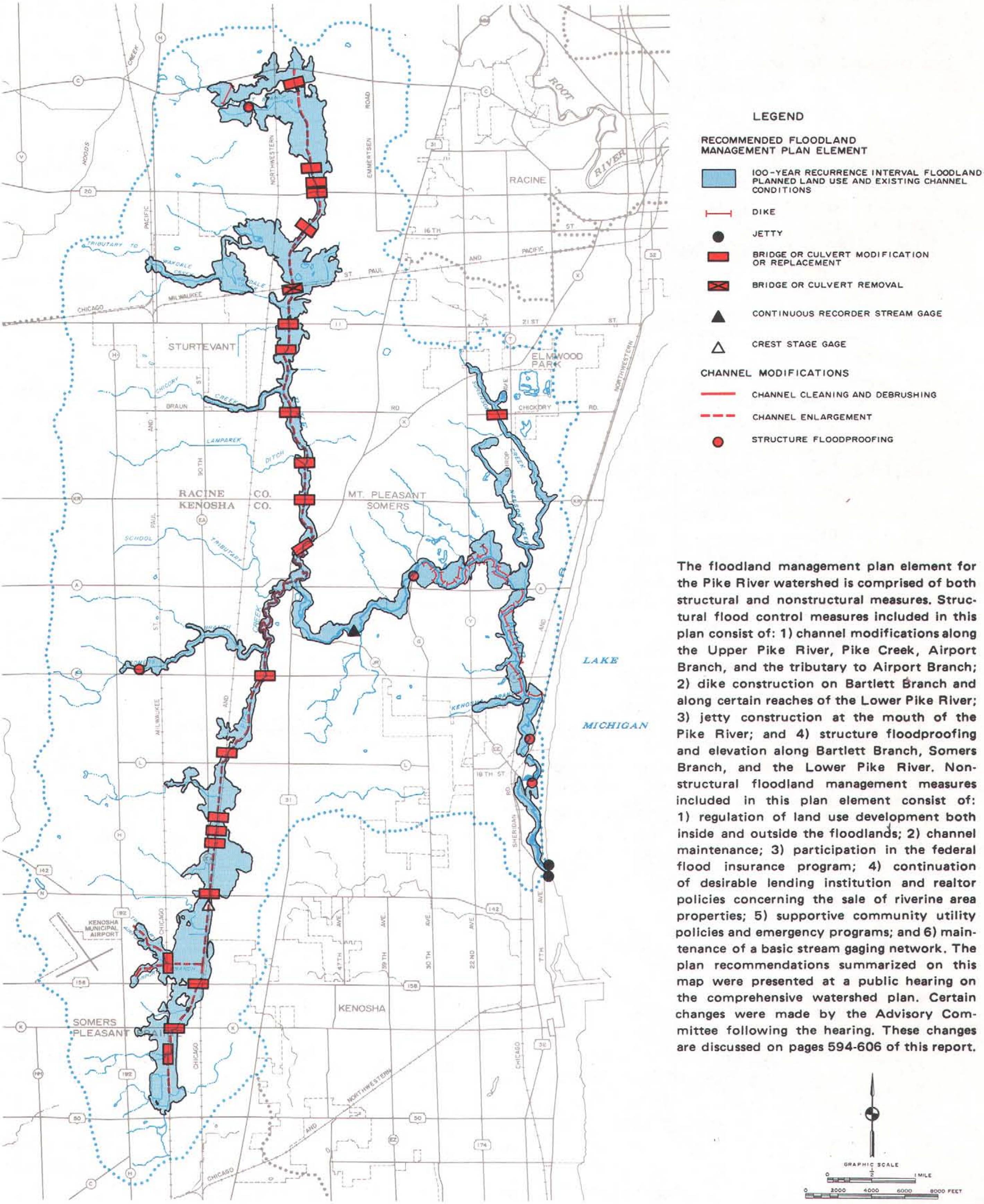
The basic floodland management plan element recommended for inclusion in the Pike River watershed plan is nonstructural, consisting of the land use development proposals contained in the land use element of the watershed plan. The extent and placement of incremental urban development over the next two decades is critical if intensification of the existing flooding problems and the creation of new flooding problems in the watershed are to be avoided, since such extent and placement directly affects the hydrologic and hydraulic behavior of the watershed. In this respect, preservation of the primary environmental corridors is of particular importance and affects not only the hydrologic and hydraulic behavior of the stream system but also water quality conditions. Preservation of all remaining undeveloped floodlands in natural open uses is critical along those stream reaches where structural flood improvements are not recommended. These nonstructural floodland management plan elements are graphically summarized in the recommended land use and park and open space plan for the watershed as shown on Map 44 in Chapter XI.

The recommended structural floodland management plan element for the Pike River watershed—which complements but is subordinate to the nonstructural element—is graphically summarized for the entire watershed on Map 79. Structural measures are recommended—in some cases with conditions described below—for Bartlett Branch, Somers Branch, Airport Branch and the Tributary to Airport Branch, Sorenson Creek, Pike Creek, the Pike River, and the Pike River estuary. No structural measures are recommended for Waxdale Creek and the tributary to Waxdale Creek, Chicory Creek, Lamparek Ditch, Nelson Creek, and the Kenosha Branch. As reported in Chapter XII, analyses indicated that relatively minor flood damages occur along these tributaries to the Pike River. No practical, cost-effective flood control plans could be developed to resolve these minor flooding problems and, accordingly, no structural measures are recommended along these streams. It is important, however, that public land use controls be exercised so as to prohibit the location of new flood-damage-prone land use development in the floodlands concerned.

The Pike River Watershed Committee gave careful consideration to the relationship between the recommended watershed land use plan and the recommended watershed flood control plan. As a matter of policy, the Watershed Committee recommended that all flood control works be designed based upon anticipated flood flows and stages under land use development conditions as reflected in the watershed land use plan. The Committee further recommended that, should any local unit of government subsequently determine to permit new urban development in those

Map 79

RECOMMENDED FLOODLAND MANAGEMENT PLAN ELEMENT FOR THE PIKE RIVER WATERSHED: 2000



The floodland management plan element for the Pike River watershed is comprised of both structural and nonstructural measures. Structural flood control measures included in this plan consist of: 1) channel modifications along the Upper Pike River, Pike Creek, Airport Branch, and the tributary to Airport Branch; 2) dike construction on Bartlett Branch and along certain reaches of the Lower Pike River; 3) jetty construction at the mouth of the Pike River; and 4) structure floodproofing and elevation along Bartlett Branch, Somers Branch, and the Lower Pike River. Nonstructural floodland management measures included in this plan element consist of: 1) regulation of land use development both inside and outside the floodlands; 2) channel maintenance; 3) participation in the federal flood insurance program; 4) continuation of desirable lending institution and realtor policies concerning the sale of riverine area properties; 5) supportive community utility policies and emergency programs; and 6) maintenance of a basic stream gaging network. The plan recommendations summarized on this map were presented at a public hearing on the comprehensive watershed plan. Certain changes were made by the Advisory Committee following the hearing. These changes are discussed on pages 594-606 of this report.

Source: SEWRPC.

portions of the watershed not recommended for urban development in the watershed land use plan, as a matter of policy such development should be permitted only upon the condition that stormwater runoff from the developed land not exceed runoff under predevelopment conditions.

In making the foregoing policy recommendation, the Watershed Committee considered the policy of the Town of Mt. Pleasant to utilize onsite storage to ensure that runoff from developing areas in the Town not exceed such runoff under predevelopment conditions. The analyses conducted under the watershed study indicated that, while such a policy may, in some site specific situations, have local stormwater drainage benefits, the flood control benefits were marginal. In this respect, as indicated in Table 102, with the exception of one location each on the Bartlett Branch, Nelson Creek, and Waxdale Creek—all streams with small catchment areas—increases in flood stages attendant to undetained flows from incremental urban development may be expected to be limited to less than one foot, well within the limits of the normal freeboard provisions attendant to flood control works. Moreover, the Committee believed that the preparation of a floodland management plan element, under an assumption that flood flows in the Upper Pike River subwatershed—which is comprised largely of the Town of Mt. Pleasant—would not exceed flood flows under current development conditions, would entail an unacceptable risk for the following reasons:

1. The long-term commitment of the Town of Mt. Pleasant—or any other local unit of government—to an onsite detention policy must be considered uncertain. While the current officials may favor such a policy, there is no assurance to downstream communities that future governing bodies will be similarly inclined.

2. The practicality of applying an onsite detention policy to each and every increment of urban land development in the watershed is unlikely. While such a policy is relatively easy to apply to large development proposals, it is much more difficult to apply to smaller increments of land development. Accordingly, as a practical matter, it is likely that, despite the best efforts of the local unit of government concerned to apply an onsite detention policy uniformly throughout a community, flood flows may be expected to increase. The extent of such an increase cannot be determined in advance in a systems planning effort. Rather, the systems planning effort can only assume that future flood flows will reflect planned land use development conditions absent any such policy.

3. Analyses conducted under the watershed study indicated that the recommended flood control works on that reach of the Upper Pike River through the Town of Mt. Pleasant would not differ significantly whether designed with or without onsite detention. The channel improvement and bridge replacement recommendations for the Upper Pike River would be only marginally more costly—about 12 percent—under an assumption that onsite detention is not provided. Given the uncertainties attendant to the future application of an onsite detention policy and its applicability to each and every increment of new urban development, it was the judgment of the Watershed Committee that the plan should be set forth under an assumption of increased flood flows from areas proposed for urban development in the upper watershed.

The foregoing findings and recommendations from the Watershed Committee relative to this matter are not intended to inhibit the Town of Mt. Pleasant or any other watershed municipality from implementing a policy of onsite detention on a site-specific basis. Rather, it simply means that the Watershed Committee recommends that the policy be applied on a case-by-case, site-specific basis and that individual benefit-cost analyses be undertaken in each instance to determine whether or not it is economically and fiscally viable to apply the policy. There may be instances where application of the policy will from a drainage, as opposed to a flood control, perspective be cost-effective. On the other hand, there may be instances where the application of the policy would not be cost-effective in terms of decreasing the cost of drainage improvements, in which case the policy should not be applied.

Specific Recommended Structural Measures for Flood Damage Abatement: The following specific structural measures are recommended for inclusion in the Pike River watershed plan. These measures are presented by the three subwatersheds identified in the planning process: Pike Creek, Upper Pike River, and Lower Pike River.

Table 102

100-YEAR RECURRENCE INTERVAL FLOOD DISCHARGES AND STAGES AT SELECTED LOCATIONS IN THE PIKE RIVER WATERSHED: EXISTING LAND USE AND EXISTING CHANNEL CONDITIONS AND PLANNED LAND USE AND PLANNED CHANNEL CONDITIONS

Location	Existing Land Use and Channel Conditions		Planned Land Use and Planned Channel Conditions (Assuming No Provision of Onsite Stormwater *Detention Facilities in* the Town of Mt. Pleasant)		Planned Land Use and Planned Channel Conditions (Assuming the Provision of Onsite Stormwater Detention Facilities in the Town of Mt. Pleasant)	
	Peak Flood Discharge (cfs)	Peak Flood Stage (feet, NGVD)	Peak Flood Discharge (cfs)	Peak Flood Stage (feet, NGVD)	Peak Flood Discharge (cfs)	Peak Flood Stage (feet, NGVD)
Lower Pike River						
Confluence with Lake Michigan. . .	3,720	581.0	4,120	581.0	4,120	581.0
CTH E/12th Street	3,880	595.7	4,210	595.3	4,210	595.3
CTH A/7th Street.	3,650	600.4	4,500	601.8	4,500	601.8
CTH G/Wood Road.	3,080	617.1	4,490	618.1	4,490	618.1
Downstream of Confluence with Pike Creek.	3,320	644.4	4,200	645.3	4,310	645.4
Upper Pike River						
Upstream of Confluence with Pike Creek.	2,550	644.7	3,260	645.6	3,410	645.7
CTH KR/County Line Road.	2,440	657.7	3,475	652.4	3,210	652.1
Braun Road	2,020	666.6	3,800	662.2	2,920	661.9
STH 11/Durand Avenue	1,660	669.2	3,330	667.3	2,465	667.3
STH 20/Washington Avenue.	980	680.6	1,605	675.8	1,130	676.4
Upstream of Confluence with Bartlett Branch	450	684.9	420	680.8	560	680.8
Pike Creek						
Upstream of Confluence with Pike River	1,150	644.7	2,750	645.0	2,750	645.0
CTH E/12th Street	1,250	664.0	2,750	662.2	2,750	662.2
CTH L/Lichter Road	1,250	672.5	2,650	670.3	2,650	670.3
STH 142/S. 43rd Street	740	676.9	2,650	672.8	2,650	672.8
CTH K/60th Street.	610	682.5	1,600	676.4	1,600	676.4
Bartlett Branch						
Upstream of Confluence with Pike River	365	684.9	590	685.6	365	684.9
Stuart Road	465	687.3	800	689.1	465	687.3
Spring Street	285	689.0	610	692.7	285	689.0
Waxdale Creek						
Upstream of Confluence with Pike River	270	669.4	295	670.7	270	669.4
Chicago, Milwaukee, St. Paul & Pacific Railroad Company	570	677.4	720	677.7	570	677.4
90th Street	420	690.9	630	691.6	420	690.9
Chicory Creek						
Upstream of Confluence with Pike River	140	668.2	140	668.2	140	668.2
Chicago & North Western Transportation Company	140	674.7	140	674.7	140	674.7
90th Street	115	686.0	115	686.0	115	686.0
Lamparek Ditch						
Upstream of Confluence with Pike River	220	659.6	220	659.8	220	659.8
90th Street	170	683.0	170	683.0	170	683.0
Chicago, Milwaukee, St. Paul & Pacific Railroad Company	140	703.2	140	703.2	140	703.2

Table 102 (continued)

Location	Existing Land Use and Channel Conditions		Planned Land Use and Planned Channel Conditions (Assuming No Provision of Onsite Stormwater Detention Facilities in the Town of Mt. Pleasant)		Planned Land Use and Planned Channel Conditions (Assuming the Provision of Onsite Stormwater Detention Facilities in the Town of Mt. Pleasant)	
	Peak Flood Discharge (cfs)	Peak Flood Stage (feet, NGVD)	Peak Flood Discharge (cfs)	Peak Flood Stage (feet, NGVD)	Peak Flood Discharge (cfs)	Peak Flood Stage (feet, NGVD)
Somers Branch						
Upstream of Confluence with Pike Creek.	215	658.6	320	659.3	320	659.3
CTH EA/90th Street	220	675.1	280	675.8	280	675.8
Chicago, Milwaukee, St. Paul & Pacific Railroad Company.	160	693.4	560	695.3	560	695.3
Airport Branch						
Upstream of Confluence with Pike Creek.	355	676.9	1,570	668.8	1,570	668.8
Chicago, Milwaukee, St. Paul & Pacific Railroad Company.	655	679.3	1,570	674.9	1,570	674.9
Nelson Creek						
Upstream of Confluence with Sorenson Creek	145	601.1	235	601.3	145	601.1
CTH KR/County Line Road.	130	617.6	255	619.3	130	617.6
Sorenson Creek						
Upstream of Confluence with Pike River	860	600.6	1,080	600.6	860	600.6
Upstream of Confluence with Nelson Creek	900	601.1	1,130	601.3	900	601.1
CTH KR/County Line Road.	940	617.0	1,240	617.2	940	617.0
Chicory Road	740	637.2	835	637.2	740	637.2
Kenosha Branch						
Upstream of Confluence with Pike River	310	586.5	440	586.9	440	586.9
CTH Y/22nd Avenue.	395	617.3	735	620.9	735	620.9

Source: SEWRPC.

Pike Creek Subwatershed: Within this subwatershed structural measures for flood control are recommended for the Pike Creek, for the Somers Branch, and conditionally recommended for the Airport Branch and Tributary to Airport Branch. Summary data pertaining to the costs and benefits of the recommended flood control measures in the Pike Creek subwatershed are set forth in Table 103. These measures are as follows:

1. Channel cleaning and debrushing activities along the 1.8-mile reach of Pike Creek extending from the confluence with the Pike River upstream to the confluence with Somers Branch as indicated on Map 80. This reach of the Pike Creek begins in Petrifying Springs County Park and extends west and south of STH 31 through the Hawthorne Hollow Nature Preserve. This stream reach is included within a primary environmental corridor. The channel cleaning and debrushing activities recommended to be undertaken can be accomplished in a manner compatible with preserving and protecting the natural environment in that corridor.

2. Major channel improvements, including channel widening and deepening, along that reach of Pike Creek extending from the confluence with Somers Branch upstream to STH 158, a distance of about 4.1 miles (see Map 80). The channel would be lowered by an average of about five feet, would have a bottom width of about 20 feet, and would have side slopes of one on three. The new channel would be turf lined. Except for a very short segment between the confluence with Somers Branch and CTH E, these channel improvements do not lie within a primary environmental corridor, nor would any significant wetlands be destroyed.

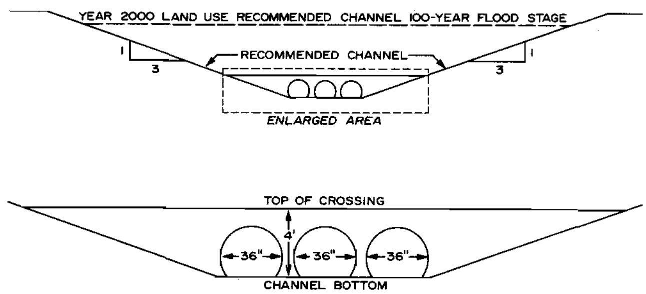
3. Major channel improvements, including channel widening and deepening, along that reach of Pike Creek extending from STH 158 upstream to CTH K, a distance of about 0.6 mile as indicated on Map 80. The channel would be lowered by an average of about eight feet, would have a bottom width of about 10 feet, and would have side slopes of one on three. The channel would be turf lined. No primary environmental corridor nor significant wetlands lie along this reach.

4. The construction of a defined channel for that reach of the Pike Creek extending upstream of CTH K for nearly one mile as indicated on Map 80. This newly defined turf-lined channel would have a bottom width of about 10 feet from CTH K upstream to the Chicago, Milwaukee, St. Paul & Pacific railroad bridge and side slopes of one on three. The existing drainageway would be deepened by an average of about 11 feet. Upstream of the Chicago, Milwaukee, St. Paul & Pacific railroad bridge the channel would have a bottom width of five feet and side slopes of one on three. The existing drainageway would be deepened by an average of about 13 feet. While no primary environmental corridor lands are involved, wetlands lying south of STH 50 and west of the Chicago, Milwaukee, St. Paul & Pacific railroad would be affected.

5. The replacement of nine existing bridges across the Pike Creek. Three of these bridges consist of farm access bridges upstream of STH 142. These three farm bridges would be replaced in the manner identified in Figure 63. These three farm crossings would be placed in the proposed new channel by laying multiple culverts across the channel bottom. The three farm crossings would be dry most of the time, but could be expected to be under water during major flood events. The remaining six bridges would be replaced in order to provide adequate hydraulic capacity under planned land use and channel conditions. Three of these bridges—CTH E, STH 142, and CTH K—located on arterial highways are old and should be replaced as a normal step in the reconstruction of the arterial highway system. The cost of these three bridge replacements is assumed to be charged to the regional transportation plan since the bridges would have to be replaced irrespective of any plan for flood control

Figure 63

TYPICAL FARM CROSSING STRUCTURE PROPOSED FOR THE PIKE CREEK AND UPPER PIKE RIVER CHANNELS



Source: SEWRPC.

measures. The remaining three bridges—the Town of Somers solid waste transfer station site bridge upstream of CTH L, the Chicago, Milwaukee, St. Paul & Pacific railroad bridge upstream of CTH K, and the STH 158 culvert—would have to be reconstructed in a manner coordinated with the proposed channel improvements in order to provide adequate hydraulic capacity. The cost of replacing these three bridges, as well as the three aforementioned farm bridges, is assumed to be charged to the total watershed plan costs since they would not have to be replaced for transportation purposes alone.

6. Structure floodproofing and elevation along the Somers Branch upstream of the Chicago, Milwaukee, St. Paul & Pacific railroad crossing. Under this proposal, three structures would be floodproofed and two structures elevated in order to substantially abate flood damages. The location of these structures is shown on Map 81.

7. Major channel improvements, including channel widening and deepening, along both the Airport Branch and the Tributary to Airport Branch. Along the Tributary to Airport Branch such channelization would extend for about 0.4 mile and would consist of a turf-lined channel having a bottom width of 10 feet and side slopes of one on three. The existing drainageway would be deepened by an average of about six feet. Along the Airport Branch such channelization would extend both upstream and downstream of the Chicago, Milwaukee, St. Paul & Pacific

Table 103

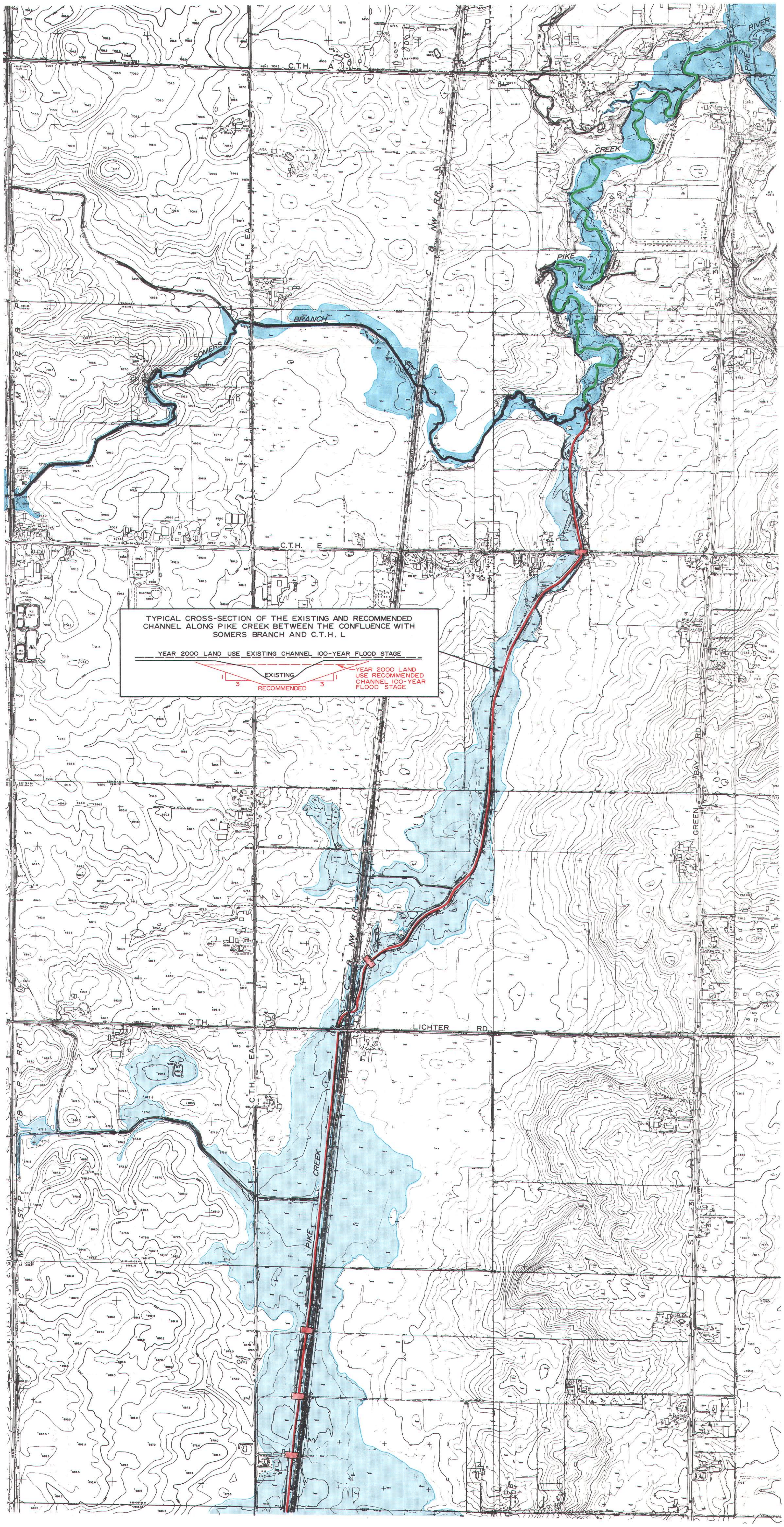
SUMMARY OF CAPITAL AND OPERATION AND MAINTENANCE COSTS OF THE RECOMMENDED FLOODLAND MANAGEMENT PLAN FOR THE PIKE CREEK SUBWATERSHED: PIKE CREEK, SOMERS BRANCH, AIRPORT BRANCH, AND TRIBUTARY TO AIRPORT BRANCH

Stream	Plan Element	Estimated Cost: Capital	Estimated Cost: Annual Operation and Maintenance
Pike Creek	Channel improvement		
	Cleaning and debrushing—confluence with Pike River to confluence with Somers Branch (1.8 miles)	$ 32,700	$2,000
	Channel widening and deepening—confluence with Somers Branch to STH 158 (4.1 miles)	538,000	4,500
	Channel widening and deepening—STH 158 to CTH K (0.6 mile)	116,000	600
	Channel construction—upstream of CTH K (1.0 mile)	56,000	1,000
	Subtotal	$ 742,700	$8,100
	Bridge replacement—required for flood control and charged to watershed plan		
	Somers Solid Waste Transfer Station upstream of CTH L	$ 80,000	$ --
	Three farm bridges upstream of STH 142	9,000	--
	Chicago, Milwaukee, St. Paul & Pacific railroad upstream of CTH K	54,000	--
	STH 158	240,000	--
	Subtotal	$ 383,000	$ --
	Bridge replacement—required for transportation and flood control and charged to transportation plan		
	CTH E	$ 240,000	$ --
	STH 142	270,000	--
	CTH K	210,000	--
	Subtotal	$ 720,000	$ --
	Cost summary		
	Charged to watershed plan and included in benefit-cost analysis	$1,125,700	$8,100
	Charged to transportation plan and not included in benefit-cost analysis	720,000	--
	Total	$1,845,700	$8,100
	Benefit-cost analysis		
	Average annual benefits		
	Structural damages	$ 31,500	
	Crop damages	56,300	
	Total	$ 87,800	
	Average annual costs		
	At 6 percent rate of return	$ 79,500	
	At 10 percent rate of return	120,700	
	Benefit-cost ratio		
	At 6 percent rate of return	1.10	
	At 10 percent rate of return	0.73	

Table 103 (continued)

Stream	Plan Element	Estimated Cost: Capital	Estimated Cost: Annual Operation and Maintenance
Somers Branch	Structure floodproofing and elevation		
	Floodproofing of three structures	$ 11,400	$
	Elevation of two structures	42,100	- -
	Total	$ 53,500	- -
	Benefit-cost analysis		
	Average annual benefits		
	Structural damages	$ 4,200	
	Average annual costs		
	At 6 percent rate of return.	$ 3,400	
	At 10 percent rate of return	5,400	
	Benefit-cost ratio		
	At 6 percent rate of return.	1.24	
	At 10 percent rate of return	0.78	
Airport Branch and Tributary to Airport Branch	Channel improvements		
	Channel widening and deepening along Tributary to Airport Branch upstream from confluence with Airport Branch (0.4 mile) and diversion channel from Kenosha Municipal Airport east of STH 192 (0.3 mile).	$ 118,000	$ 300
	Channel widening and deepening along Airport Branch upstream from Chicago, Milwaukee, St. Paul & Pacific railroad (0.5 mile)	99,000	400
	Channel widening and deepening along Airport Branch downstream of Chicago, Milwaukee, St. Paul & Pacific railroad to confluence with Pike Creek (0.4 mile).	142,000	300
	Subtotal	$ 359,000	$1,000
	Bridge replacement		
	Chicago, Milwaukee, St. Paul & Pacific railroad	$ 498,000	$
	Total	$ 857,000	$1,000
	Benefit-cost analysis		
	No benefit-cost analysis was conducted for this element of the watershed plan. Any benefits attendant to these flood control measures would be associated with the future development of an industrial park east of the Kenosha Municipal Airport. Any decision to undertake these proposed improvements would necessarily have to consider such benefits at the time development of the industrial park was imminent		

Source: SEWRPC.



Map 80

RECOMMENDED STRUCTURAL FLOODLAND MANAGEMENT MEASURES ALONG THE PIKE CREEK

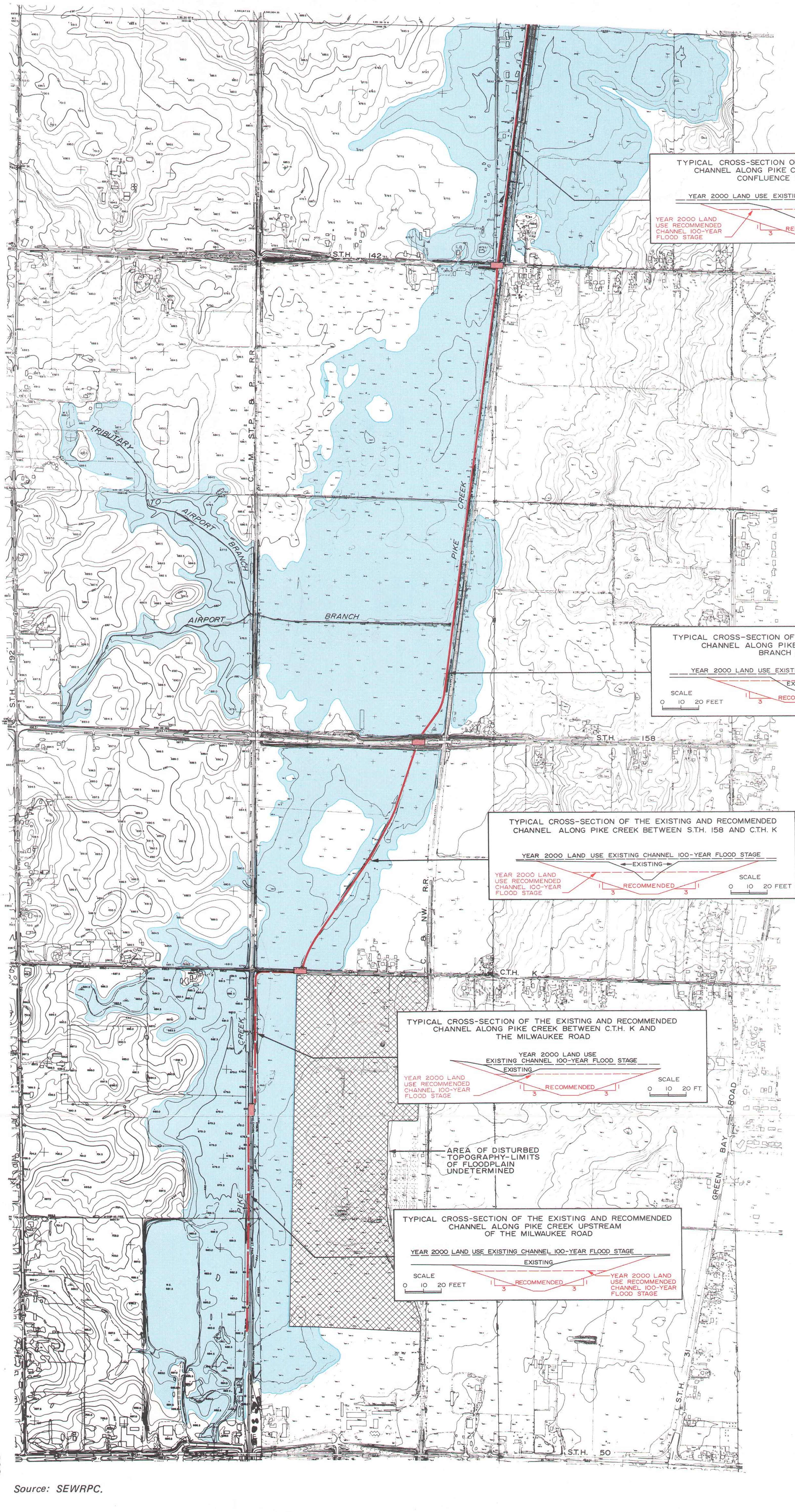
LEGEND

- 100-YEAR RECURRENCE INTERVAL FLOODLANDS--PLANNED LAND USE AND PLANNED CHANNEL CONDITIONS
- 100-YEAR RECURRENCE INTERVAL FLOODLANDS UNDER PLANNED LAND USE AND EXISTING CHANNEL CONDITIONS THAT WOULD BE ELIMINATED UNDER PLANNED CHANNEL CONDITIONS
- EXISTING CHANNEL
- PROPOSED CHANNEL ENLARGEMENT
- PROPOSED MAJOR CHANNELIZATION
- PROPOSED CHANNEL CLEARING AND DEBRUSHING
- PROPOSED BRIDGE OR CULVERT MODIFICATION OR REPLACEMENT

GRAPHIC SCALE

0 400 800 1200 FEET

Map 80 (continued)

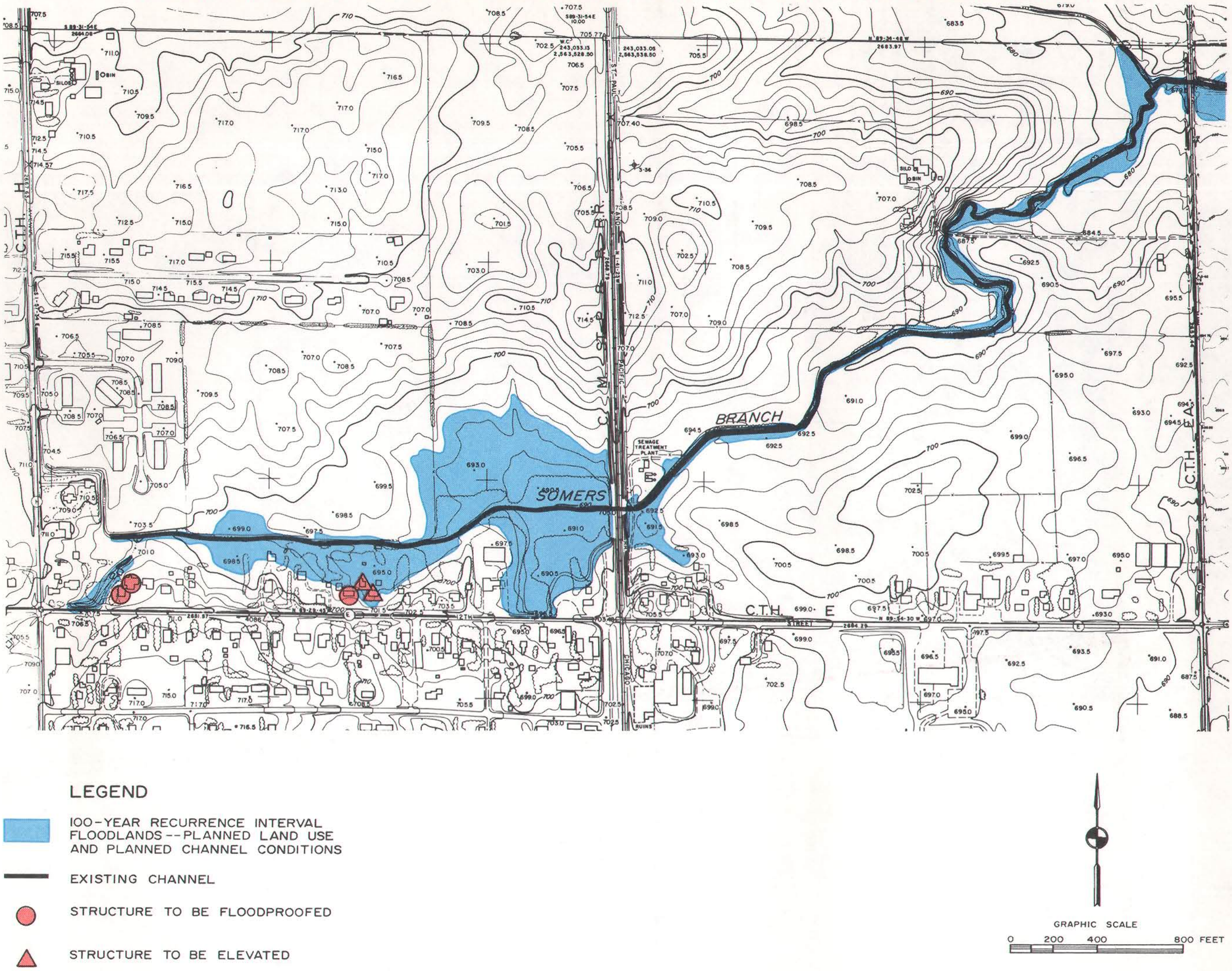


Source: SEWRPC.

The channel enlargement alternative was selected as the recommended flood control plan to alleviate the flood problem along the Pike Creek. Under this flood control plan, the existing channel would be modified beginning at the confluence with Somers Branch and extending upstream to approximately one-quarter mile north of STH 50. Channel clearing and debrushing would be carried out beginning at the confluence with the Pike River and extending upstream to the confluence with Somers Branch. In addition, nine bridges would be replaced to accommodate the larger channel. Under this flood control plan, damages would be prevented from floods up to and including the 100-year recurrence interval event.

Map 81

RECOMMENDED STRUCTURAL FLOODLAND MEASURES ALONG THE SOMERS BRANCH



The structure floodproofing and elevation alternative was selected as the recommended flood control plan to alleviate the flood problem along the Somers Branch. Under this flood control plan, three structures would be floodproofed and two structures would be elevated. Damages would be prevented from floods up to and including the 100-year recurrence interval event.

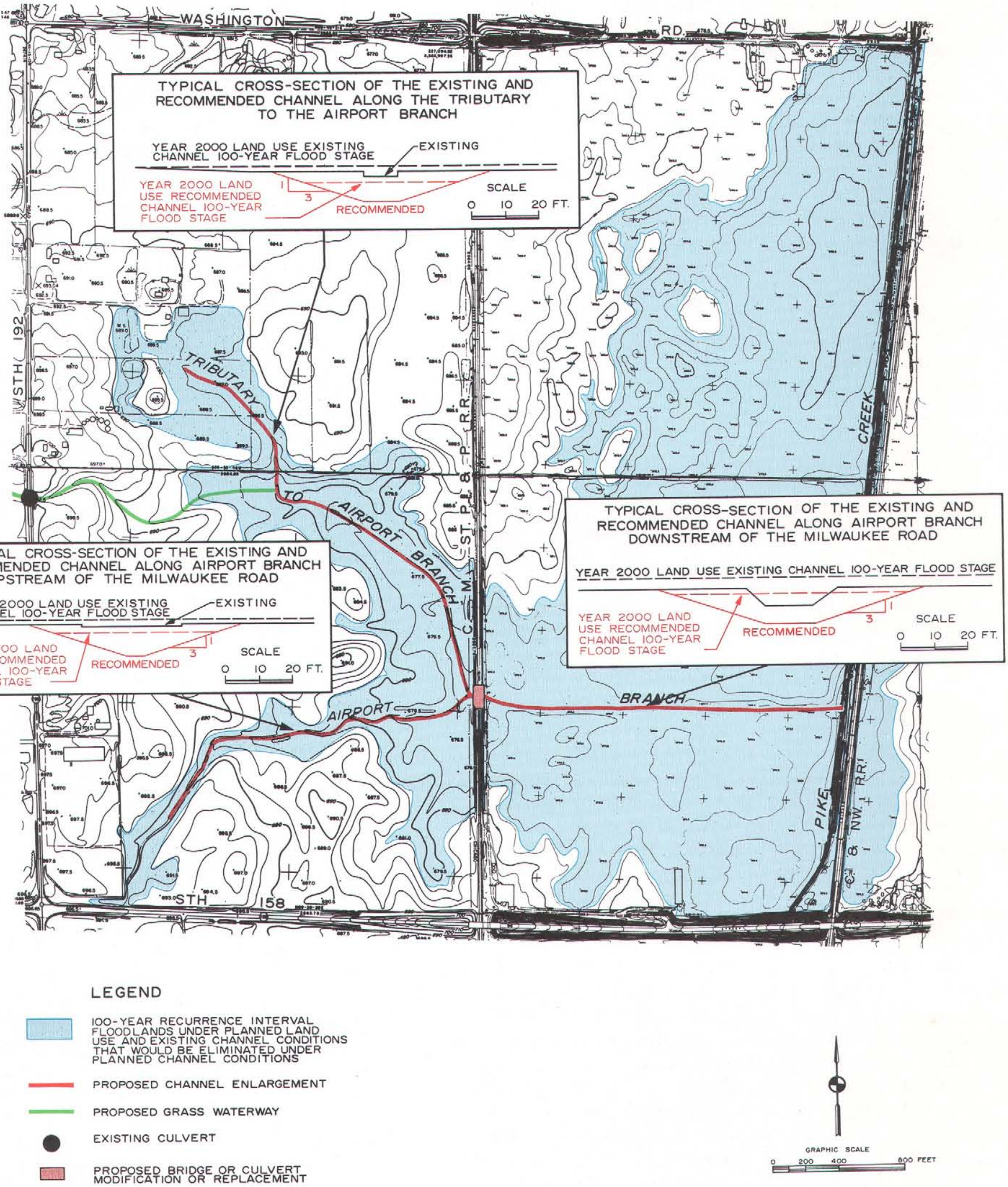
Source: SEWRPC.

railroad crossing. For about 0.5 mile upstream of that crossing, the turf-lined channel would have a bottom width of about five feet and side slopes of one on three. The existing drainageway would be deepened by an average of about five feet. Downstream of the crossing, the turf-lined channel would have a bottom width of about 15 feet and side slopes of one on three for a distance of about 0.4 mile. The existing channel would be deepened by an average of about five feet. These channelization projects do not lie in a primary environmental corridor nor are significant wetlands involved. This channelization would also require the replacement of two four-foot diameter culverts and one three-foot diameter culvert currently carrying the Airport Branch under the Milwaukee Road right-of-way with a new bridge having a clear span of about 40 feet. This recommendation is summarized on Map 82.

The foregoing recommendations attendant to the Airport Branch and the Tributary to the Airport Branch would permit continuation of industrial land use development between STH 31 and the

Map 82

RECOMMENDED STRUCTURAL FLOODLAND MANAGEMENT MEASURES ALONG THE AIRPORT BRANCH AND THE TRIBUTARY TO AIRPORT BRANCH



The culvert modification and major channelization alternative was selected as the recommended flood control plan to alleviate the flood problem along the Airport Branch and the tributary to Airport Branch. Under this flood control plan, 1.3 miles of major channelization would be carried out and the conveyance capacity of the existing Milwaukee Road crossing would be increased. In addition, 0.3 mile of storm water diversion channel would be constructed from the Kenosha Municipal Airport to the tributary to Airport Branch under this alternative. Damages would be prevented from floods up to and including the 100-year recurrence interval event.

Source: SEWRPC.

Kenosha Municipal Airport north of STH 158 unconstrained by flood hazard considerations. Should it ultimately be determined to develop the area for industrial land use purposes without filling the floodplain, none of the structural flood control measures on the Airport Branch and Tributary to Airport Branch would be required. In this respect, it should be noted that any future determination to not undertake the structural flood control measures on the Airport Branch and the Tributary to Airport Branch would not significantly change any of the downstream structural flood control recommendations on the Pike Creek. Conversely, however, it would not be possible to undertake the channel improvements envisioned on the Airport Branch and the Tributary to the Airport Branch without having implemented the channelization recommendations on the Pike Creek downstream from the confluence with the Airport Branch.

During the formulation of the recommended floodland management plan for the Airport Branch and the Tributary to Airport Branch, the Regional Planning Commission was requested by the Town Board of the Town of Somers to evaluate the impacts of proposed improvements to the Kenosha Municipal Airport on stormwater drainage flows in the vicinity of the airport. This evaluation was set forth in a letter report dated July 30, 1982, from the Commission to the Town of Somers. In order to resolve existing and probable future drainage problems associated with the expansion of the Kenosha Municipal Airport, which expansion is recommended in the adopted regional airport system plan, for those storm events up to and including a 10-year recurrence interval, recommendations were made to the Town of Somers and the City of Kenosha concerning diversion of stormwater from one subbasin to another in the manner shown on Map 83. Under this proposal, stormwater from about 52 acres of developed airport land would be diverted from an unnamed tributary to the Pike Creek lying to the north of the Airport Branch drainage basin to the Tributary to Airport Branch. The 10-year recurrence interval flood flow on the Tributary to Airport Branch about 0.4 mile upstream of the Milwaukee Road under existing land use conditions is about 140 cubic feet per second (cfs). Under the proposed land use and stormwater diversion conditions, that flow would increase to about 155 cfs, or by about 11 percent. It was determined that such an increase in flow would have no significant effect upon the 100-year recurrence interval flood flows and stages along the Airport Branch and, furthermore, would not substantially affect the design of the aforenoted channel improvements along the Airport Branch should a decision ultimately be made to proceed with those channel improvements.

Upper Pike River Subwatershed: Within this subwatershed structural measures for flood control are recommended for the Pike River and Bartlett Branch. Summary data pertaining to the costs and benefits of the recommended flood control measures in the Upper Pike River subwatershed are set forth in Table 104. These measures are as follows:

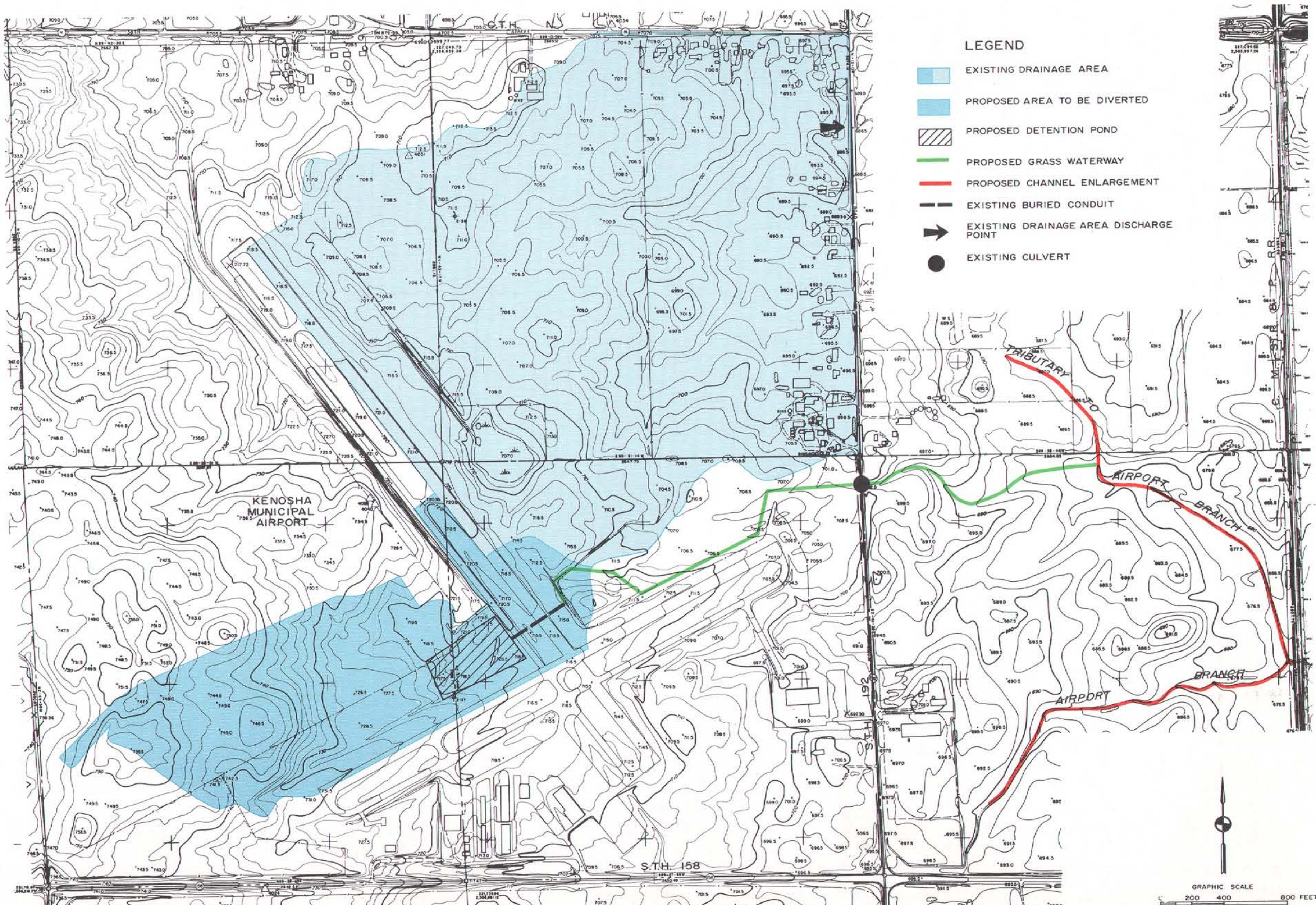
1. Channel enlargement, defined to consist of the widening and deepening of the channel along that two-mile reach of the Upper Pike River extending from CTH C downstream to Oakes Road as indicated on Map 84. The existing channel would be lowered by an average of about one foot, would have a bottom width of about 10 feet, would be turf lined, and would have side slopes of one on three. No primary environmental corridor nor significant wetlands lie along this reach.

2. Major channel improvements, including channel widening and deepening, along that 3.4-mile reach of the Upper Pike River extending from Oakes Road downstream to CTH KR as indicated on Map 84. Along this reach, the channel would be lowered by an average of about four feet, would have a bottom width of about 10 feet, would be turf lined, and would have side slopes of one on three. No primary environmental corridor nor significant wetlands lie along this reach.

3. Major channel improvements, including channel widening, deepening, and realignment, along that 1.5-mile reach of the Upper Pike River extending from CTH KR downstream to the confluence with the Pike Creek in Petrifying Springs Park as indicated on Map 84. The existing stream channel bottom would be lowered in this reach by an average of about five feet, would have a bottom width of about 20 feet, would be turf lined, and would have side slopes of one on three. The southernmost reach of this stream segment does lie within a primary environmental corridor extending north through Petrifying Springs Park along the Upper Pike River to a point about one-quarter mile upstream of STH 31. Accordingly, great care would have to be taken in

Map 83

PROPOSED STORMWATER DIVERSION IN THE VICINITY OF THE KENOSHA MUNICIPAL AIRPORT



In order to resolve existing and probable future drainage problems associated with the expansion of the Kenosha Municipal Airport for runoff events having up to and including a 10-year recurrence interval, recommendations were made concerning the diversion of stormwater from one subbasin to another. Under this proposal, stormwater from about 52 acres of developed airport land would be diverted from an unnamed tributary to the Pike Creek, to the tributary to Airport Branch.

Source: SEWRPC.

Table 104

SUMMARY OF CAPITAL AND OPERATION AND MAINTENANCE COSTS OF THE RECOMMENDED FLOODLAND MANAGEMENT PLAN FOR THE UPPER PIKE RIVER SUBWATERSHED: PIKE RIVER AND BARTLETT BRANCH

Stream	Plan Element	Estimated Cost: Capital	Estimated Cost: Annual Operation and Maintenance
Pike River[a]	Channel improvement		
	Channel widening and deepening—CTH C to Oakes Road	$ 162,000	$2,200
	Channel widening and deepening—Oakes Road to CTH KR	410,000	3,700
	Channel widening and deepening—CTH KR to confluence with Pike Creek	129,000	1,700
	Subtotal	$ 701,000	$7,600
	Bridge modification or replacement—required for flood control and charged to watershed plan		
	Farm bridge downstream of confluence with Lamparek Ditch	$ 2,000	$ --
	Farm bridge downstream of STH 11	2,000	--
	STH 11	70,000	--
	Chicago, Milwaukee, St. Paul & Pacific Railroad upstream of STH 11	4,000	--
	Oakes Road	100,000	--
	STH 20	186,000	--
	Two private bridges upstream of STH 20	174,000	--
	Spring Street	147,000	$ --
	Subtotal	$ 685,000	$ --
	Bridge replacement—required for transportation and flood control and charged to transportation plan		
	STH 31	$ 297,000	$ --
	CTH KR	297,000	--
	Braun Road	297,000	--
	Subtotal	$ 891,000	$ --
	Summary		
	Charged to transportation plan	$ 891,000	$ --
	Charged to watershed plan	1,386,000	7,600
	Total	$2,277,000	$7,600
	Benefit-cost analysis		
	Average annual benefits		
	Structural damages	$ 33,100	
	Crop damages	14,000	
	Total	$ 47,100	
	Average annual costs		
	At 6 percent rate of return	$ 95,500	
	At 10 percent rate of return	146,000	
	Benefit-cost ratio		
	At 6 percent rate of return	0.49	
	At 10 percent rate of return	0.32	
	NOTE: Costs identified as chargeable to the transportation plan are not included in the benefit-cost analysis		

Table 104 (continued)

Stream	Plan Element	Estimated Cost	
		Capital	Annual Operation and Maintenance
Bartlett Branch[a]	Dike upstream of Spring Street	$ 37,900	$ 300
	Structure floodproofing and elevation		
	Floodproofing of seven structures.	$ 27,600	$ --
	Elevation of four structures.	68,900	--
	Subtotal	$ 96,500	$ --
	Summary		
	Charged to watershed plan	$ 134,400	$ 300
	Benefit-Cost analysis		
	Average annual benefits		
	Structural damages	$ $25,600	
	Crop damages	--	
	Total	$ 25,600	
	Average annual costs		
	At 6 percent rate of return.	$ 8,800	
	At 10 percent rate of return	13,700	
	Benefit-cost ratio		
	At 6 percent rate of return.	2.91	
	At 10 percent rate of return	1.87	

[a]Costs associated with the potential application in the Town of Mt. Pleasant of an onsite stormwater detention policy were not included in the watershed plan but were estimated in the watershed study. These costs are $4,860,000 (capital) and $107,900 (operation and maintenance) for the Upper Pike River; and $280,800 (capital) and $6,200 (operation and maintenance) for the Bartlett Branch.

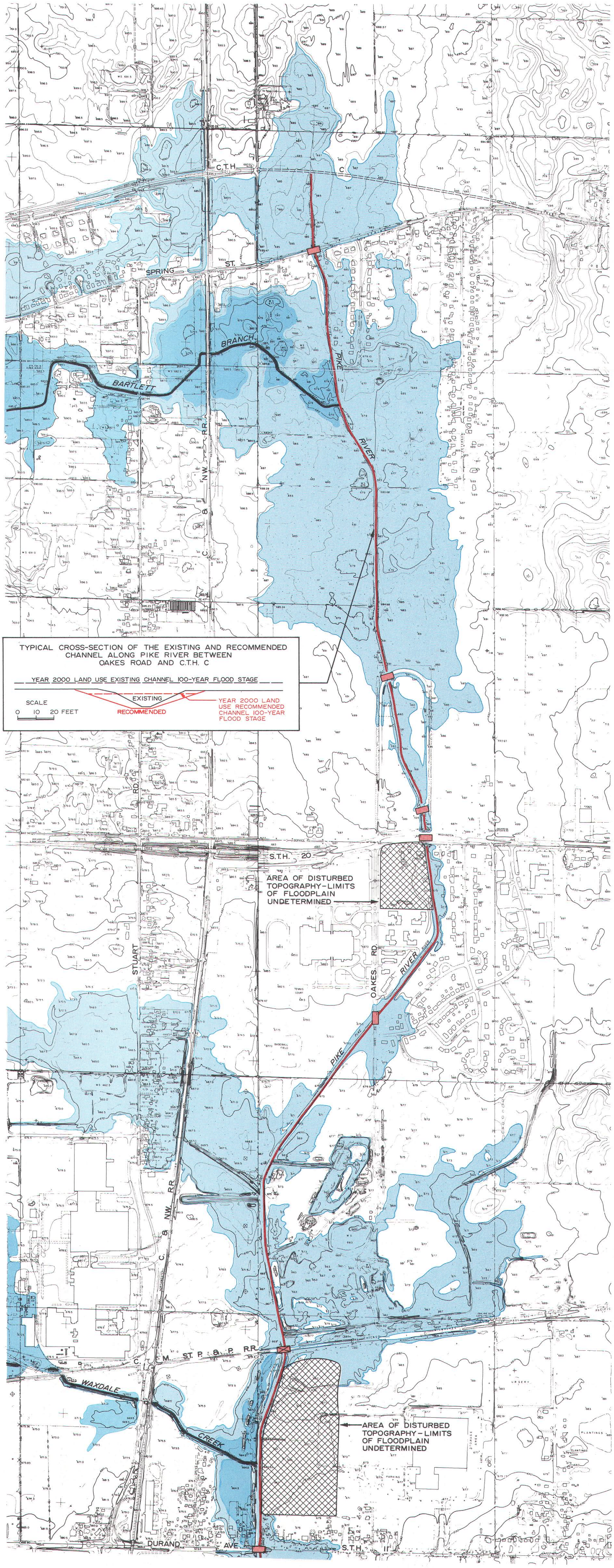
Source: SEWRPC.

the engineering and design of this particular segment of the proposed channel improvement to ensure that the improvements are made in a manner compatible with preservation to the maximum extent practicable of the natural environment.

4. The replacement of 12 existing bridges across the Upper Pike River. Two of these bridges consist of farm access bridges—one located immediately downstream of STH 11, and one downstream of the confluence with Lamparek Ditch. These two farm bridges would be replaced in the manner identified in Figure 63 by laying multiple culverts across the channel bottom. These two farm crossings may be expected to be dry most of the time but may be expected to be under water during major flood events. The remaining 10 bridges would be replaced in order to provide adequate hydraulic capacity under planned land use and channel conditions. Three of these bridges—those carrying STH 31, CTH KR, and Braun Road—are located on arterial highways, are from 30 to 50 years old, and may be expected to be replaced as a normal part of the maintenance and reconstruction of the arterial highway system. The cost of these three bridge replacements is accordingly assumed to be charged to the regional transportation plan since the bridges may be expected to be replaced within the plan design period irrespective of any plan for flood control measures. Of the remaining seven bridges, four—STH 11, STH 20, Oakes Road, and Spring Street—would have to be reconstructed in a manner coordinated with the proposed

Map 84

RECOMMENDED STRUCTURAL FLOODLAND MANAGEMENT MEASURES ALONG THE UPPER PIKE RIVER



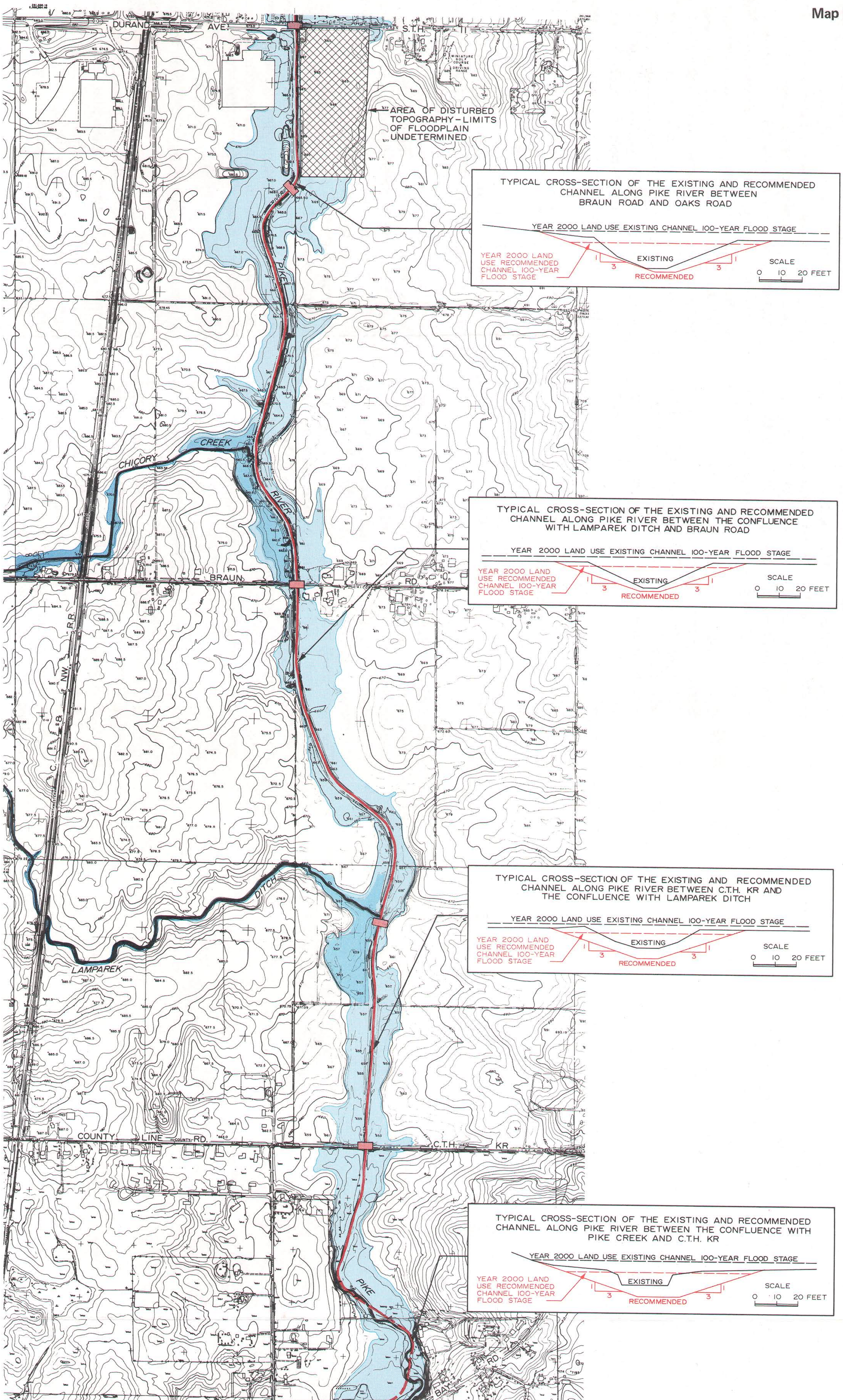
LEGEND

- 100-YEAR RECURRENCE INTERVAL FLOODLANDS—PLANNED LAND USE AND PLANNED CHANNEL CONDITIONS
- 100-YEAR RECURRENCE INTERVAL FLOODLANDS UNDER PLANNED LAND USE AND EXISTING CHANNEL CONDITIONS THAT WOULD BE ELIMINATED UNDER PLANNED CHANNEL CONDITIONS
- EXISTING CHANNEL
- PROPOSED CHANNEL ENLARGEMENT
- PROPOSED MAJOR CHANNELIZATION
- PROPOSED BRIDGE OR CULVERT MODIFICATION OR REPLACEMENT
- PROPOSED BRIDGE REMOVAL

GRAPHIC SCALE

0 400 800 1200 FEET

Map 84 (continued)



Source: SEWRPC.

The channel enlargement alternative was selected as the recommended flood control plan to alleviate the flood problem along the Upper Pike River. Under this flood control plan, the existing channel would be modified beginning at the confluence with the Pike Creek and extending upstream to CTH C. In addition, 12 bridges would have to be replaced to accommodate the larger channel. Under this flood control plan, damages would be prevented from floods up to and including the 100 year recurrence interval event.

channel improvements in order to provide adequate hydraulic capacity. The cost of replacing these four bridges, as well as the two aforereferenced farm bridges, are accordingly assumed to be charged to the total watershed plan costs since they would not have to be replaced for transportation purposes within the plan design period. The Chicago, Milwaukee, St. Paul & Pacific railroad bridge north of STH 11 is to be removed and not replaced since this line has recently been abandoned.[3] The remaining two bridges are private bridges on lands lying upstream of STH 20. These two bridges could be either removed and not replaced, or replaced with adequate structures. The plan cost identified in Table 104 assumed that it would be necessary to replace both bridges.

5. The construction of a dike upstream of Spring Street to protect existing residential development from flooding along the Bartlett Branch. This dike would have a total length of about 500 feet, an average height of about four feet, and a maximum height of about six feet. The location and alignment of this dike is shown on Map 85, together with a typical cross-section of the dike. No special drainage facilities would be required with this particular dike configuration since the Town Engineer has determined that any water impounded behind the dike may be permitted to be dissipated slowly through infiltration into the groundwater reservoir.

6. The floodproofing of seven structures and the elevation of four structures currently located in the floodplain of the Bartlett Branch downstream of Spring Street. The location of these structures is shown on Map 85.

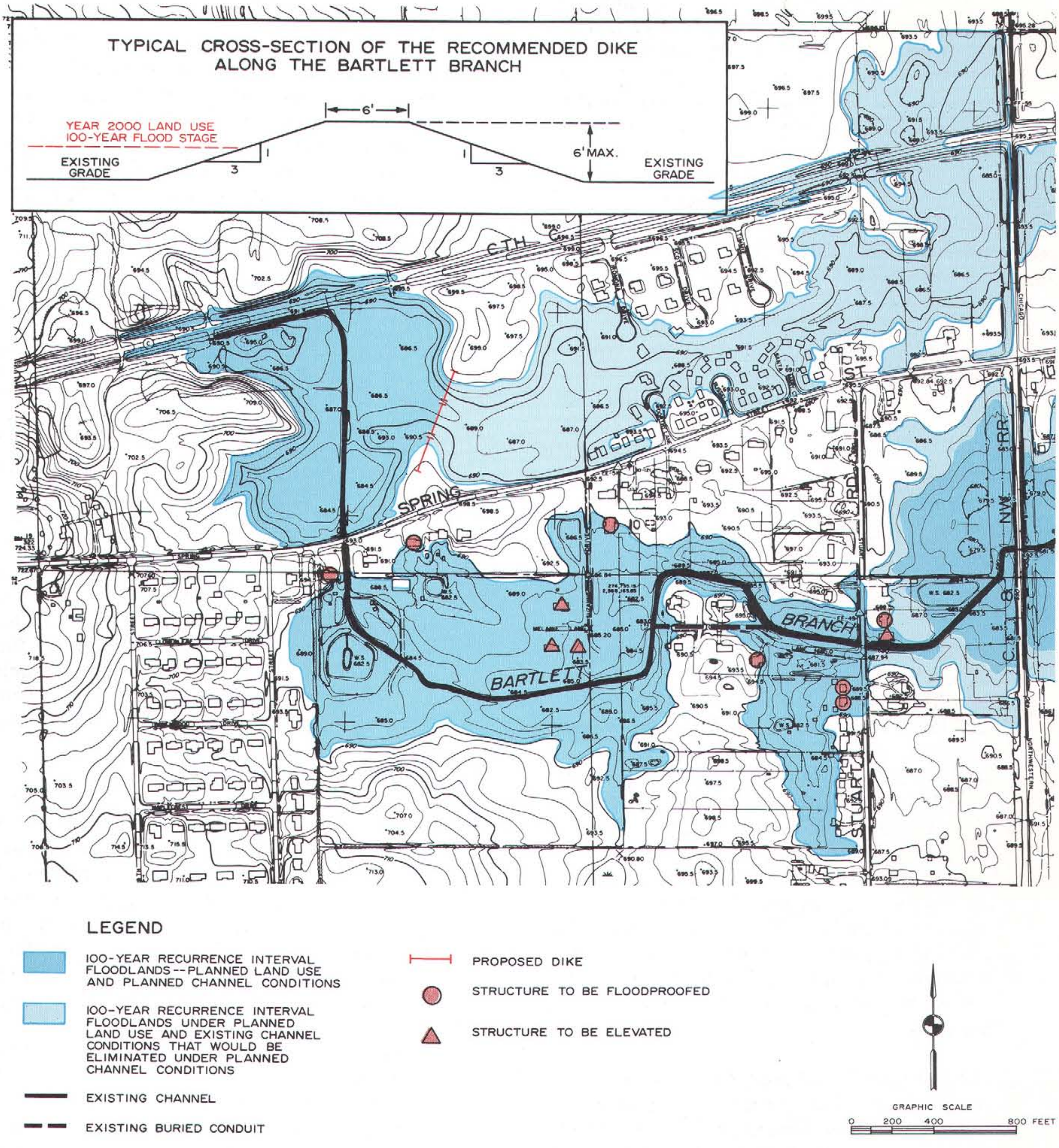
The foregoing recommendations attendant to channel improvements along the Upper Pike River and to dike and structure floodproofing and elevation along the Bartlett Branch have been made based upon an assumption, as discussed earlier in this chapter, that future land use development in the watershed would occur in accordance with the watershed land use plan, and without onsite detention to limit increases in flood flows and stages along downstream reaches of the Pike River system. The analyses conducted under the watershed study indicated that full implementation of an onsite stormwater detention policy by the Town of Mt. Pleasant with respect to each increment of urban development may be expected to have only a modest impact on the design of the recommended flood control improvements. For example, the dikes upstream of Spring Street could be made up to four feet lower depending upon the amount of freeboard provided, the structure floodproofing and elevation measures along the Bartlett Branch could be carried out to a regulatory elevation of up to two feet lower, the channel improvements along the Upper Pike River from CTH C downstream to Oakes Road could be maintained at the existing grade rather than be lowered by about one foot, and the channel improvements from Oakes Road downstream to CTH KR could be carried out by lowering the channel an average of about three feet instead of four feet. Such differences in the extent of the recommended flood control measures and the costs attendant thereto were, however, considered to be marginal, affecting the costs of the recommended flood control works by about 12 percent.

In addition, it should be noted that the benefit-cost ratio attendant to the proposed channel improvements on the Upper Pike River approximates 0.5, indicating that the direct benefits would be less than the direct, or tangible, costs associated with the project. This benefit-cost ratio must, however, be viewed in a broader context that takes into account the long-term indirect, or intangible, benefits associated with providing an improved

[3] *The Chicago, Milwaukee, St. Paul & Pacific railroad right-of-way traversing the Pike River watershed in this location was the subject of a potential reuse analysis conducted by the Regional Planning Commission for Racine County in the fall of 1982. The reuse analysis concluded that there were a sufficient number of potential public uses for this abandoned right-of-way so as to warrant its acquisition by one or more public bodies. Should this right-of-way eventually be publicly acquired and agreement reached on a reuse plan for the right-of-way, it may be necessary to eventually rebuild the Pike River crossing. In that event, the cost of replacing the bridge would have to be borne as a part of the reuse project and, accordingly, was not charged to the Pike River watershed plan. The reuse analysis is set forth in a SEWRPC Community Assistance Staff Memorandum entitled, "Analysis of Redevelopment Alternatives for Abandoned CMStP&P Railroad (Milwaukee Road) Right-of-Way in the City of Racine and Town of Mt. Pleasant," and dated October 4, 1982.*

Map 85

RECOMMENDED STRUCTURAL FLOODLAND MANAGEMENT MEASURES ALONG THE BARTLETT BRANCH



The combination dike and structure floodproofing and elevation alternative was selected as the recommended flood control plan to alleviate the flood problem along the Bartlett Branch. Under this flood control plan, about 500 feet of earthen dike would be constructed about 500 feet east of, and approximately parallel to, the Bartlett Branch between CTH C and Spring Street. In addition, seven structures would have to be floodproofed and four structures would have to be elevated. Under this flood control plan, damages would be prevented from floods up to and including the 100-year recurrence interval event.

Source: SEWRPC.

urban stormwater drainage system throughout the Upper Pike River watershed. The landscape within the upper watershed is relatively flat, and as that watershed is gradually converted from rural to urban use over time, means must be found to facilitate urban stormwater drainage even given an approach that might foster the construction of onsite stormwater detention facilities. Within the context of a systems level watershedwide planning effort designed primarily to consider direct flood control benefits, it was not possible to assess the land use development and stormwater drainage benefits that might be attendant to a stream course improvement project that would permit the operation of a more efficient areawide drainage system.

Lower Pike River Subwatershed: Within this subwatershed, structural measures for flood control are recommended for certain locations along the Pike River and along Sorenson Creek, and conditionally recommended for other locations along the Lower Pike River. Summary data pertaining to the costs and benefits of the recommended flood control measures in the Lower Pike River subwatershed are set forth in Table 105. These measures are as follows:

1. The floodproofing of three existing structures currently subject to flood damages along the Lower Pike River. These structures consist of a residence located just upstream of CTH G, the former Valley Restaurant and Supper Club located just upstream of Sheridan Road, and the Carthage College Field House located just downstream of Sheridan Road (see Map 86). The plan recommends that the residence be elevated. With respect to the larger structures, it is recommended that detailed studies be made of the means by which these two structures can be floodproofed and flood damages thereby substantially abated. Floodproofing represents the only feasible way in which to approach resolution of these isolated flooding problems.

2. A large part of the grounds of the Kenosha Country Club lies within the 100-year recurrence interval floodplain of the Pike River. The Club extends along the Pike River from 22nd Avenue on the upstream end to the former Chicago, Northshore & Milwaukee Railroad right-of-way on the downstream end. Flooding along the Pike River through the Country Club can disrupt normal golfing activities; damage tees, greens, and traps; cause maintenance problems over the course, including the deposition of debris; and contribute to increased problems of drainage even when the flood peaks pass. Accordingly, it is recommended that, should the members of the Kenosha Country Club wish to take measures to abate these flooding problems, consideration be given to the construction of a system of earthen dikes along the shoreline of the Pike River to provide protection against floods up to the 10-year recurrence interval flood. Such dikes could be located generally as shown on Map 87.

   The system of dikes would approximate about 5,900 feet in length and would average about four feet in height. As shown on Map 87, the dikes or berms could either be of traditional design, or could be constructed in such a manner so as to extend back to a point where the dike elevation intersects with the golf course fairways. The construction of this dike system might also require that each of the 10 existing golf course bridges across the Pike River be raised and lengthened so as to permit golf course operation during flood events. Any consideration of such a diking alternative on the Kenosha Country Club grounds would require careful, detailed design by a skilled landscape architect, since the fairways for eight of the holes cross the Pike River. Some tees and greens may have to be elevated or relocated to permit construction of the dike system.

   Under this approach, floods up to and including the 10-year recurrence interval flood would be contained within the dikes. The regulatory 100-year recurrence interval flood, however, would occupy its normal floodplain. This diking system could be undertaken by the Kenosha Country Club without any adverse effects on flows upstream or downstream of the Country Club site and without any loss of floodplain storage during the regulatory flood. The costs associated with these potential flood control measures at the Kenosha Country Club are summarized in Table 105. No benefit-cost analysis was made since the benefits that may be attributable to such a system of dikes would be limited to those perceived by the members of the Country Club in terms of the increased number of days of the year in which play is possible and in terms of decreased maintenance costs.

Table 105

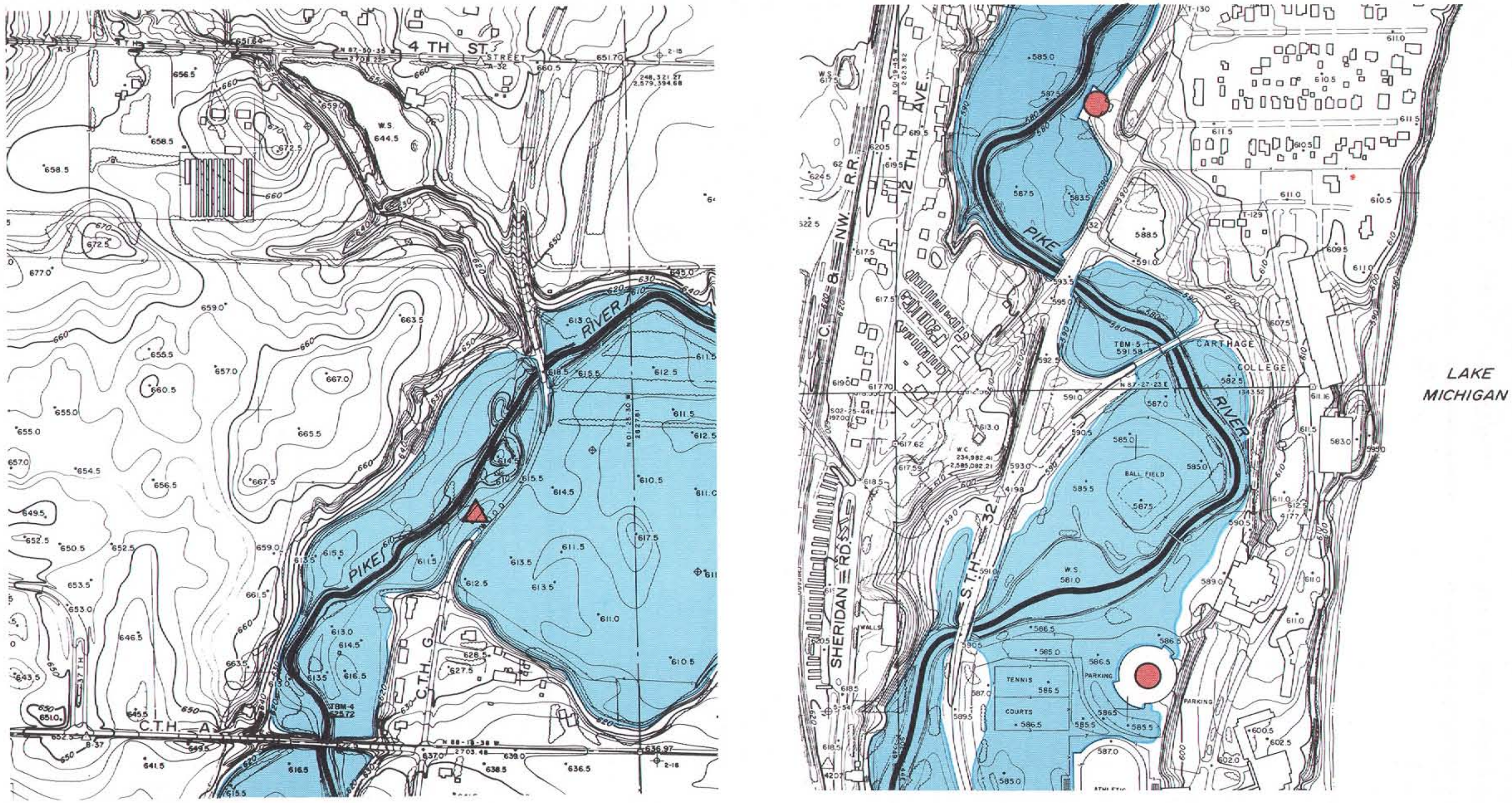
SUMMARY OF CAPITAL AND OPERATION AND MAINTENANCE COSTS OF THE RECOMMENDED FLOODLAND MANAGEMENT PLAN FOR THE LOWER PIKE RIVER SUBWATERSHED: PIKE RIVER AND SORENSON CREEK

Stream	Plan Element	Estimated Cost: Capital	Estimated Cost: Annual Operation and Maintenance
Pike River	Dikes for agricultural land protection		
	Upstream of Kenosha Country Club	$ 236,000	$ 3,100
	Downstream of Kenosha Country Club	647,000	6,200
	Subtotal	$ 883,000	$ 9,300
	Dikes for recreational land protection at Kenosha Country Club	$ 363,000	$ 3,500
	Structure floodproofing and elevation		
	Floodproofing of two structures	$ 62,000	$ --
	Elevation of one structure	22,400	--
	Subtotal	$ 84,400	$ --
	Summary: Charged to watershed plan	$1,330,400	$12,800
	Benefit-cost analysis		
	Average annual benefits		
	Structural damages	$ 9,900	
	Crop damages	27,100	
	Total	$ 37,000	
	Average annual costs		
	At 6 percent rate of return	$ 70,600	
	At 10 percent rate of return	106,000	
	Benefit-cost ratio		
	At 6 percent rate of return	0.52	
	At 10 percent rate of return	0.35	
	NOTE: Costs and benefits associated with the dike system at the Kenosha Country Club are not included in the benefit-cost analysis		
Sorenson Creek	Bridge replacement: Chicory Road	$ 90,300	$ --
	Summary: Charged to watershed plan	$ 90,300	$ --
	Benefit-cost analysis		
	Average annual benefits		
	Structural damages	$ 4,300	
	Crop damages	--	
	Total	$ 4,300	
	Average annual costs		
	At 6 percent rate of return	$ 5,700	
	At 10 percent rate of return	9,000	
	Benefit-cost ratio		
	At 6 percent rate of return	0.75	
	At 10 percent rate of return	0.48	
Pike River Estuary	Jetties and dredging at mouth of Pike River	$ 95,000	$ 1,100

Source: SEWRPC.

Map 86

LOCATION OF STRUCTURES ALONG THE LOWER PIKE RIVER WHERE FLOODPROOFING MEASURES ARE RECOMMENDED



LEGEND

- 100-YEAR RECURRENCE INTERVAL FLOODLAND--PLANNED LAND USE AND PLANNED CHANNEL CONDITIONS
- EXISTING CHANNEL
- STRUCTURE TO BE FLOODPROOFED
- STRUCTURE TO BE ELEVATED

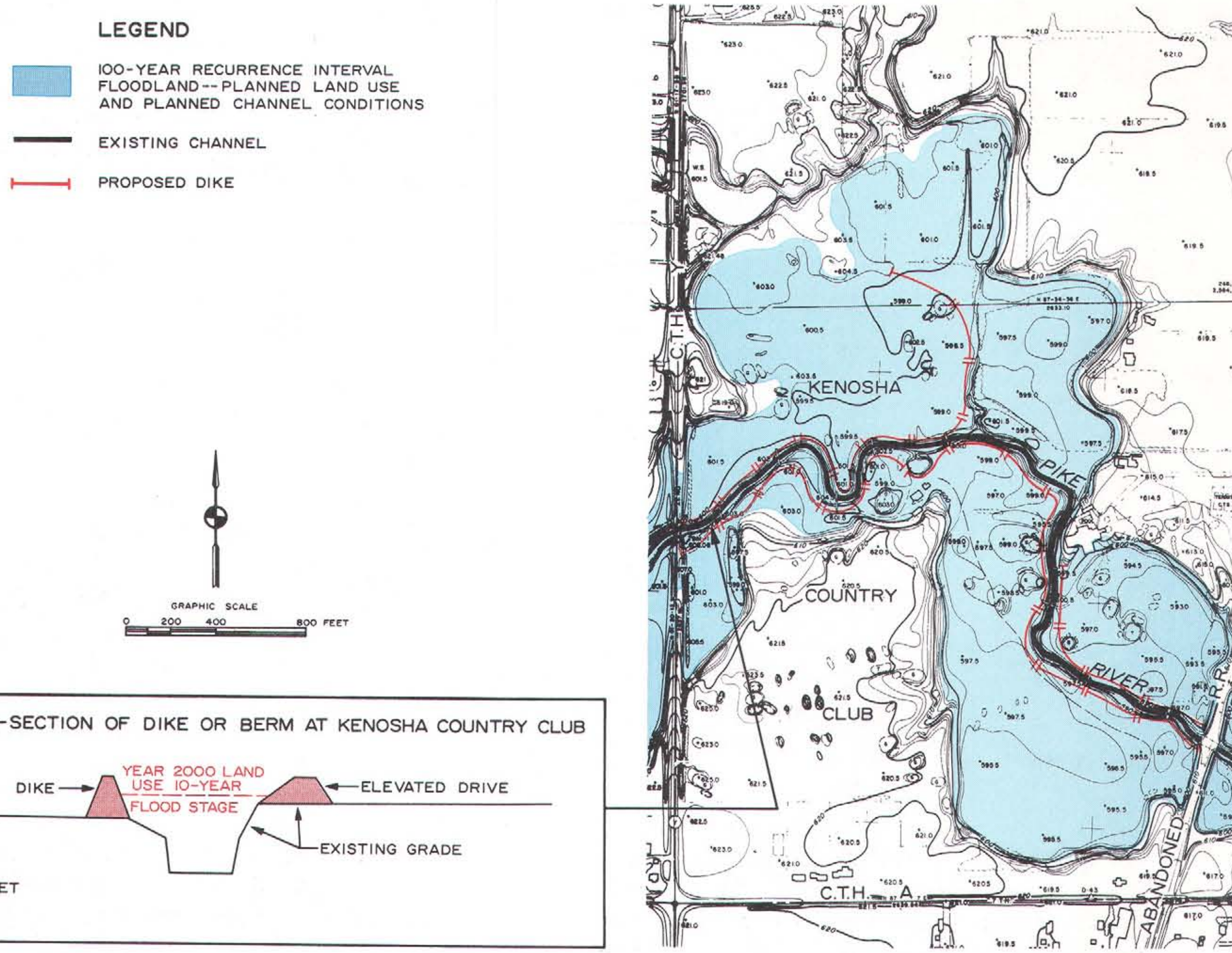
GRAPHIC SCALE
0 200 400 800 FEET

The recommended structural floodland management measures along the Lower Pike River include structure floodproofing and elevation. Under this flood control plan element, two structures would have to be floodproofed and one structure would have to be elevated. Damages would be prevented from floods up to and including the 100-year recurrence interval event.

Source: SEWRPC.

Map 87

POTENTIAL SYSTEM OF DIKES AND BERMS TO ABATE FLOODING PROBLEMS ON THE GROUNDS OF THE KENOSHA COUNTRY CLUB



Initially recommended structural floodland management measures along the Lower Pike River included the construction of about 5,900 feet of dikes on the grounds of the Kenosha Country Club. In addition, 10 golf course bridges would have to be raised and lengthened so as to permit golf course operation during flood events. Under this flood control plan element, damages to the golf course would be prevented from floods up to and including the 10-year recurrence interval event.

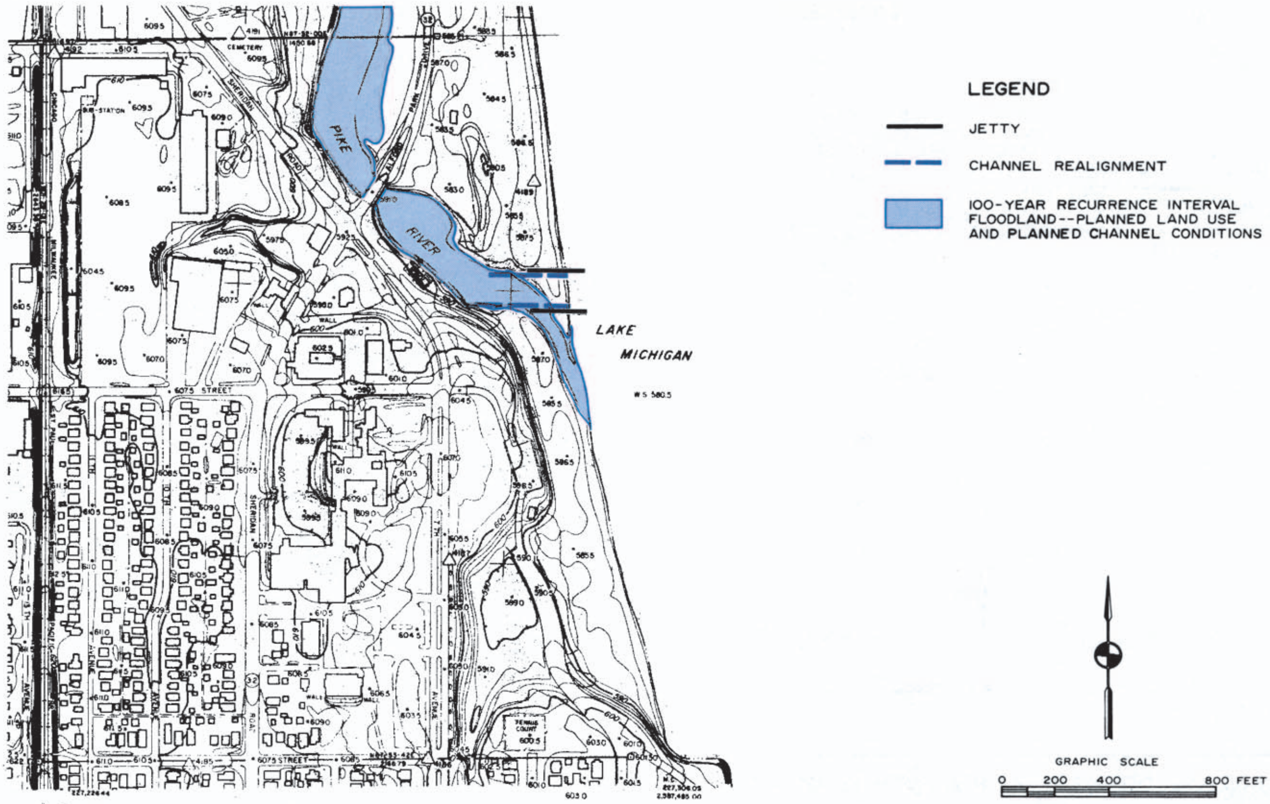
Source: SEWRPC.

3. The remaining problems along the main stem of the Lower Pike River consist of agricultural flood damages, both upstream and downstream of the Kenosha Country Club. The watershed land use plan envisions that the lands downstream of the Kenosha Country Club will be urbanized over the next two decades. At such time as these lands urbanize, it is recommended that the entire 100-year recurrence interval floodplain be maintained in essentially natural open uses. Along certain stream reaches downstream of the Kenosha Country Club, this will help to reestablish wetlands along the stream and the consequent enrichment of the primary environmental corridor along the Pike River.

Although the plan does not specifically recommend that any measures be taken to abate agricultural crop damages either upstream or downstream of the Kenosha Country Club because of the long-term commitment to urban development in this area of the watershed, the plan should not be construed to prohibit farmers along these stream reaches from individually or collectively undertaking the construction of low-level dikes to abate flooding problems so long as the land continues to be farmed.

Figure 64

RECOMMENDED SYSTEM OF JETTIES AT THE MOUTH OF THE PIKE RIVER ON THE LAKE MICHIGAN SHORELINE



Source: SEWRPC.

A system of low-level agricultural dikes designed to prevent flooding from floods up to and including the 10-year recurrence interval flood along the Lower Pike River both upstream and downstream of the Kenosha Country Club is indicated on Map 88, and the costs attendant to such diking systems are set forth in Table 105. It should be noted that these dikes would not have a benefit-cost ratio of greater than one. Nevertheless, the farmers involved may wish to individually or collectively consider such measures.

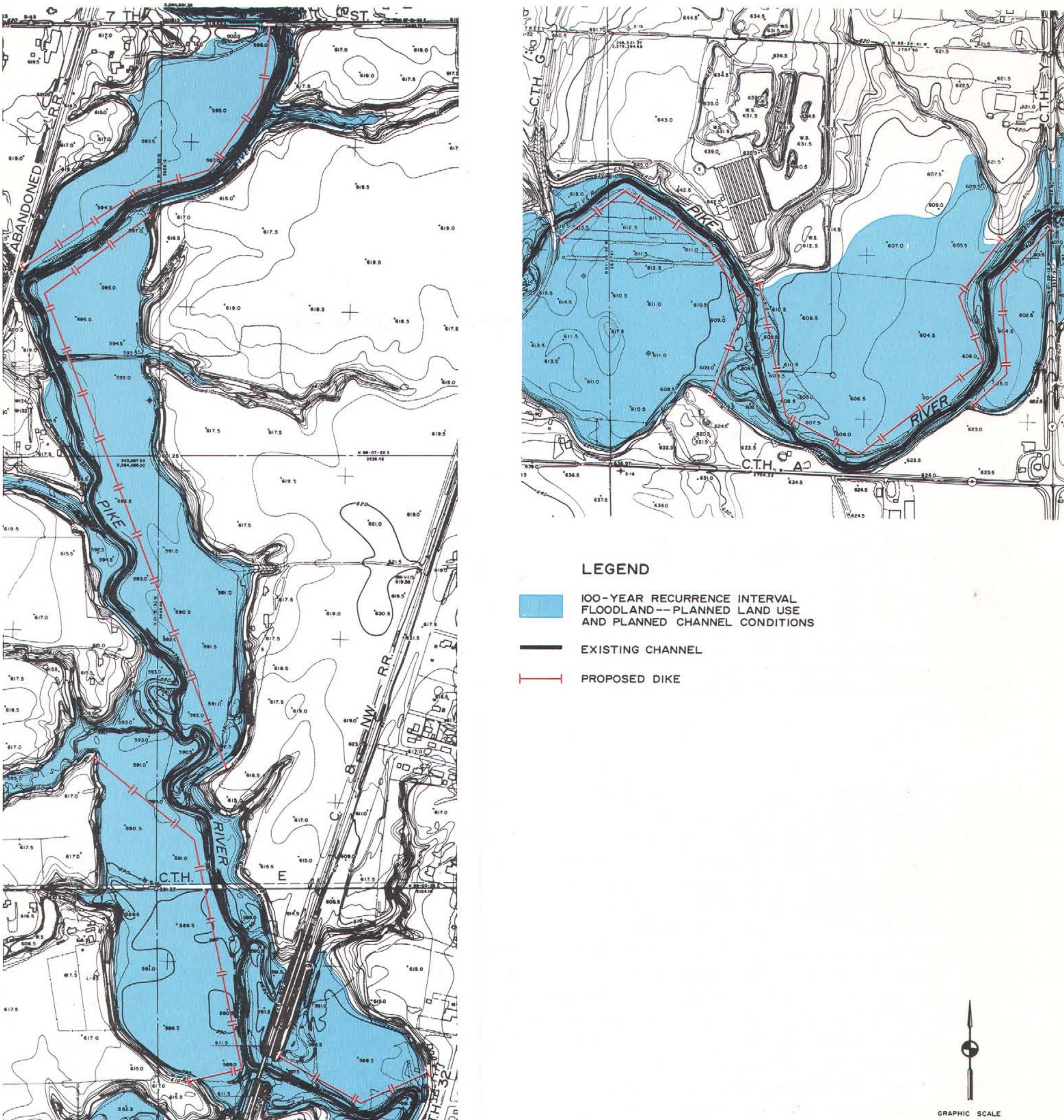
4. The replacement of the Chicory Road crossing of Sorenson Creek as shown on Map 89. The current crossing consists of dual six-foot diameter culverts. The plan recommends that a new clear span bridge with an opening of about 30 feet be provided in order to eliminate the backwater effects of the existing hydraulically inadequate crossing.

5. The construction of two parallel jetties and the dredging of the channel bottom between the jetties to maintain channel flow capacity at the mouth of the Pike River on the shoreline of Lake Michigan. These measures are essential to resolve the flooding problems that are caused by the frequent formation of a sandbar across the mouth of the Pike River. An annual maintenance effort will be required to ensure that the mouth is kept free from accumulated sand. The type of jetty construction envisioned is shown in Figure 64.

An alternative to the parallel sheet-pile jetties would be placement of rip-rap or gabion revetments. Parallel revetments could be installed, or one revetment could be installed on the north side of the channel with the existing natural bluff on the south side of the channel containing the flow of the Pike River for most of the reach between Lake Michigan and the Alford Park Drive bridge. Suitable subsurface foundation conditions for the placement of revetments must exist and could be determined by soil borings. These alternative construction techniques should be evaluated as part of the detailed design of the structure.

Map 88

POTENTIAL SYSTEM OF AGRICULTURAL DIKES ALONG THE LOWER PIKE RIVER

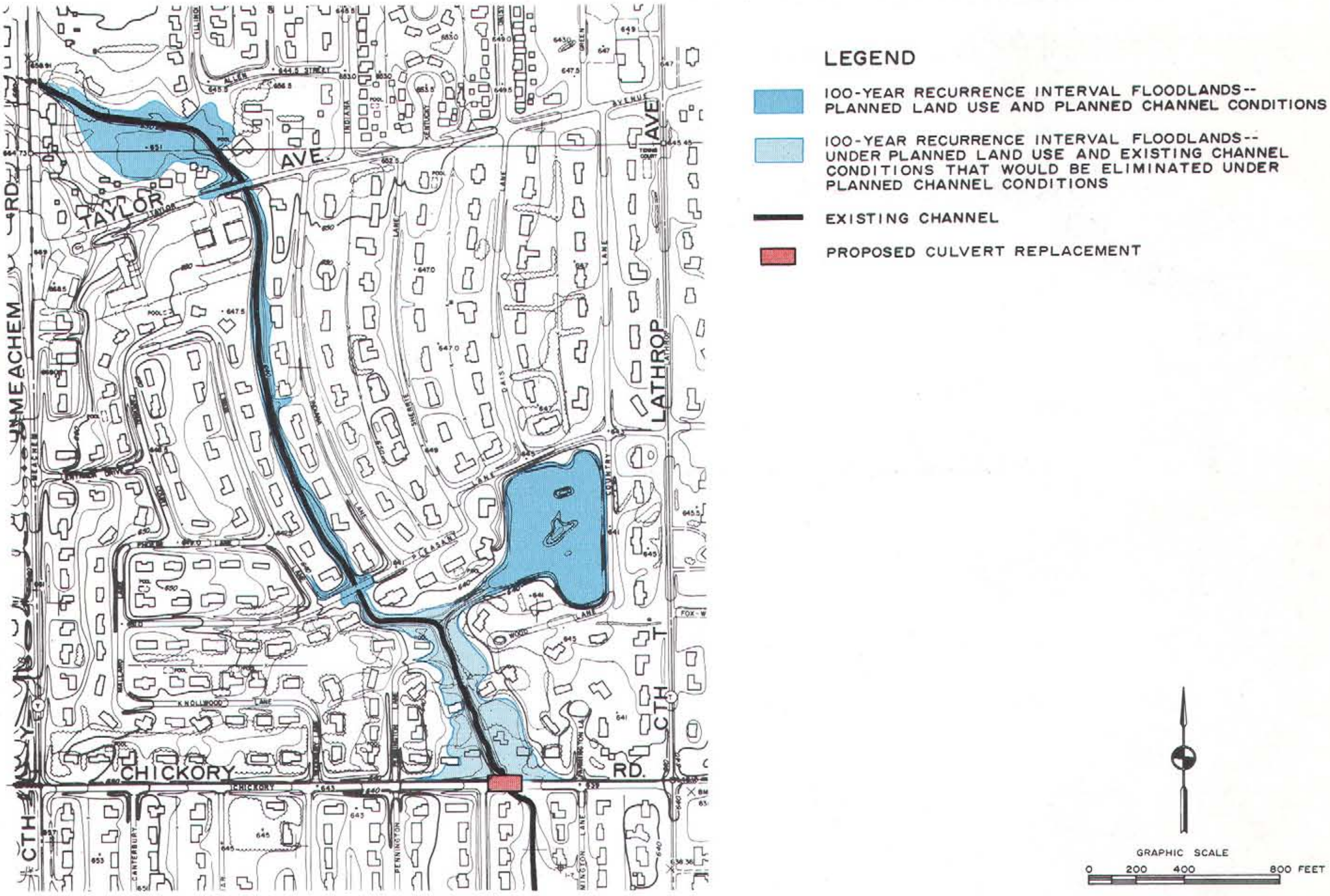


The recommended structural floodland management measures along the Lower Pike River include the construction of up to about 4.4 miles of low-level dikes to abate agricultural flooding problems. Under this flood control plan element, damages would be prevented from floods having a recurrence interval of up to 10 years.

Source: SEWRPC.

Map 89

RECOMMENDED STRUCTURAL FLOODLAND MANAGEMENT MEASURES ALONG SORENSON CREEK



The culvert replacement alternative was selected as the recommended flood control plan to alleviate the flood problem along Sorenson Creek. Under this flood control plan, the Chicory Road crossing of Sorenson Creek would be replaced with a clear span bridge. Damages would be prevented between Chicory Road and Pleasant Lane from floods up to and including the 100-year recurrence interval event.

Source: SEWRPC.

Impacts of Recommended Floodland Management Plan on Flood Flows and Stages: Implementation of the foregoing recommendations for flood control throughout the Pike River watershed, together with future urban land use development, may be expected to significantly impact flood flows and stages in the Pike River watershed. Such impact with respect to the regulatory 100-year recurrence interval flood are summarized for selected locations along the stream system of the Pike River watershed in Table 102. Along those stream reaches where channelization is recommended, peak flood stages may be expected to decrease. Along the Lower Pike River, where channelization is not recommended, the increased flood flows may be expected to result in slightly increased flood stages. More detailed data pertaining to peak flood flows and flood stages under planned land use and planned channel conditions are set forth in Appendix G.

Bridge Replacement: It is recommended that bridges and culverts on the major stream system of the Pike River watershed which have inadequate hydraulic capacity, as manifested by overtopping of the approach roadways or of the structure itself, be eventually modified or replaced so as to eliminate interference with the desirable operation of the highway and railroad transportation system. There are a total of 130 existing bridges and culverts on the major stream system. Of this total, 100, or 77 percent, as shown in Table 106, are hydraulically adequate and need not be modified or replaced except as may be necessary for transportation-related purposes. A total of seven of the crossings, or an additional 5 percent, represent stream crossings that, while not included in the flood control recommendations noted above, are hydraulically inadequate and should be modified or replaced in the normal course of events as the transportation system is renewed. The remaining

Table 106

BRIDGE REPLACEMENT/MODIFICATION RECOMMENDATIONS IN THE PIKE RIVER WATERSHED PLAN

Structure Identification			Hydraulically Adequate—Replace or Modify as Necessary for Transportation Purposes	Hydraulically Inadequate—Replace or Modify as Transportation System is Renewed	Replace or Modify in Accordance with Flood Control Recommendations
Stream	Name	River Mile[a]			
Pike Creek Subwatershed					
Pike Creek	STH 31/Green Bay Road. . . .	0.05		X	
	Private bridge	0.89	X		
	Private bridge	1.42	X		
	CTH E/12th Street	2.13			X
	Town of Somers transfer station.	3.17			X
	Chicago & North Western Transportation Company. . .	3.29	X		
	CTH L/Lichter Road	3.34	X		
	Private bridge	3.98			X
	Private bridge	4.12			X
	Private bridge	4.24			X
	STH 142/S. 43rd Street	4.86			X
	Footbridge.	4.90	X		
	STH 158/52nd Street.	5.90			X
	CTH K/60th Street	6.45			X
	Chicago, Milwaukee, St. Paul & Pacific railroad . .	6.85			X
Somers Branch	Private bridge	0.06	X		
	Private bridge	0.53	X		
	Chicago & North Western Transportation Company. . .	0.69	X		
	CTH EA/90th Street	1.11	X		
	Private bridge	1.43	X		
	Private bridge	1.77	X		
	Private bridge	1.94	X		
	Chicago, Milwaukee, St. Paul & Pacific railroad . .	1.95	X		
	Private bridge	2.31	X		
Airport Branch and Tributary to Airport Branch	Private bridge	0.18	X		
	Private bridge	0.39	X		
	Chicago, Milwaukee, St. Paul & Pacific railroad . .	0.41			X
Upper Pike River Subwatershed					
Upper Pike River	STH 31/Green Bay Road. . . .	10.38			X
	CTH KR/County Line Road. .	11.15			X
	Private bridge	11.56			X
	Braun Road	12.23			X
	Private bridge	12.99			X
	STH 11/Durand Road	13.29			X
	Chicago, Milwaukee, St. Paul & Pacific railroad . .	13.72			X
	Oakes Road	14.51			X
	STH 20/S. 20th Street	14.94			X
	Private bridge	15.00			X
	Footbridge.	15.15	X		
	Private bridge	15.29			X
	Private bridge	15.77	X		
	Spring Street.	16.24			X

Table 106 (continued)

Structure Identification: Stream	Structure Identification: Name	River Mile[a]	Hydraulically Adequate—Replace or Modify as Necessary for Transportation Purposes	Hydraulically Inadequate—Replace or Modify as Transportation System is Renewed	Replace or Modify in Accordance with Flood Control Recommendations
Bartlett Branch	Private bridge	0.12	X		
	Private bridge	0.32	X		
	Chicago & North Western Transportation Company. . .	0.34	X		
	Stuart Road	0.53	X		
	Footbridge.	0.67	X		
	Clinton Lane extended	0.79	X		
	Private bridge	1.07	X		
	Footbridge.	1.16	X		
	Spring Street.	1.21	X		
Waxdale Creek	Chicago & North Western Transportation Company. . .	0.27	X		
	Willow Road.	0.29	X		
	Chicago, Milwaukee, St. Paul & Pacific railroad . .	0.47	X		
	Buried conduit	0.51	X		
	Private bridge	1.11	X		
	90th Street.	1.24		X	
	CTH H/Wisconsin Street	1.89		X	
Chicory Creek	Private bridge	0.20	X		
	Chicago & North Western Transportation Company. . .	0.46	X		
	Private bridge	0.54	X		
	Private bridge	0.62	X		
	90th Street.	1.13	X		
Lamparek Ditch	Private bridge	0.54	X		
	Chicago & North Western Transportation Company. . .	0.77	X		
	90th Street.	1.56	X		
	Private bridge	2.12	X		
	Chicago, Milwaukee, St. Paul & Pacific railroad . .	2.26	X		
	Private bridge	2.61	X		
	Private bridge	2.73	X		
Lower Pike River Subwatershed					
Lower Pike River	STH 32/Alford Park Drive . . .	0.21	X		
	STH 32/Sheridan Road.	1.35	X		
	Footbridge.	1.52	X		
	Drive to Carthage College . . .	1.70	X		
	STH 32/S. 32nd Street.	1.79	X		
	Footbridge.	2.46	X		
	Footbridge.	2.69	X		
	Chicago & North Western Transportation Company. . .	3.04	X		
	CTH E/12th Street	3.27	X		
	CTH A/7th Street	4.61	X		
	Lathrop Avenue.	4.79		X	
	Chicago, North Shore & Milwaukee railroad (abandoned)	4.88	X		
	Private bridge	4.92	X		
	Private bridge	5.00	X		
	Private bridge	5.04	X		
	Private bridge	5.12	X		

Table 106 (continued)

Structure Identification: Stream	Structure Identification: Name	Structure Identification: River Mile[a]	Hydraulically Adequate—Replace or Modify as Necessary for Transportation Purposes	Hydraulically Inadequate—Replace or Modify as Transportation System is Renewed	Replace or Modify in Accordance with Flood Control Recommendations
Lower Pike River (continued)	Private bridge	5.31	X		
	Kenosha Country Club dam	5.31	X		
	Private bridge	5.37	X		
	Private bridge	5.40	X		
	Private bridge	5.44	X		
	Private bridge	5.52	X		
	Private bridge	5.59	X		
	CTH Y/22nd Avenue	5.63	X		
	CTH G/Wood Road	6.60	X		
	CTH A/7th Street	6.96	X		
	Petrifying Springs Park road	8.26	X		
	Footbridge	8.34	X		
	Footbridge	8.48	X		
	Footbridge	8.61	X		
	Footbridge	8.80	X		
	Footbridge	8.93	X		
	Park Drive, Footbridge and control structure	9.07	X		
	Petrifying Springs Park drive	9.39	X		
	CTH A/7th Street	9.55	X		
Nelson Creek	Private bridge	0.05	X		
	Chicago, North Shore & Milwaukee railroad (abandoned)	0.12	X		
	Private bridge	0.15	X		
	Lathrop Avenue	0.44	X		
	Lathrop Avenue	0.55	X		
	Lathrop Avenue	0.62		X	
	CTH KR/County Line Road	0.80	X		
	Private bridge	1.27	X		
	Private bridge	1.63	X		
	Private bridge	1.67	X		
Sorenson Creek	Private bridge	0.03	X		
	Private bridge	0.92	X		
	CTH KR/County Line Road	1.56	X		
	Private bridge	1.67	X		
	Chicago, North Shore & Milwaukee railroad (abandoned)	1.96	X		
	Private bridge	2.37	X		
	Lathrop Avenue	2.62	X		
	Chicory Road	2.93			X
	Private bridge	3.03	X		
	Pleasant Lane	3.15		X	
	Taylor Avenue	3.49	X		
Kenosha Branch	20th Avenue	0.76		X	
	Private bridge	0.82	X		
	Chicago, North Shore & Milwaukee railroad (abandoned)	0.87	X		
	CTH Y/22nd Avenue	0.90	X		
	25th Avenue	1.10	X		

[a] *Distance in miles along stream channel upstream from mouth or confluence.*

Source: SEWRPC.

23 crossings, or 18 percent, represent bridges and culverts specifically affected by the flood control recommendations set forth above and should be replaced in accordance with those recommendations. The design of all new bridges within the watershed should be based upon the applicable objectives and standards set forth in Chapter X.

Floodland Regulations: It is recommended that Kenosha and Racine Counties, the City of Kenosha, and the Village of Sturtevant review and, as necessary, revise their floodland zoning regulations to reflect the updated flood hazard data and the floodland management concepts and recommendations set forth in this report. Such regulations should be explicitly designed to complement the recommended watershed land use plan element, as well as the structural flood control measures recommended in the plan. In general, those 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 the installation of municipal improvements be zoned so as to prohibit incompatible future urban development. Those existing urban land uses in the floodlands scheduled to be floodproofed, elevated, or protected through future structural flood control measures should be appropriately zoned, including the imposition of an overlay floodplain regulatory zone that will ensure that proper attention is given to the flood hazards on these sites as future zoning and development decisions are made. Those lands which would be removed from the floodplain upon construction of the flood control improvements outlined in the plan should be zoned as floodplains until such time as the recommended flood control works are put in place, whereupon the lands should be rezoned for appropriate urban development.

Channel Maintenance: It is recommended that a regular stream channel maintenance program be undertaken throughout the major stream system of the Pike River watershed. This would include the periodic removal of sediment deposits, heavy vegetation, and debris from all watercourses in the watershed, including bridge openings and culverts. Such a program is necessary to ensure the future integrity of the existing and recommended stream bottom profile.

Flood Insurance: All of the civil divisions located wholly or partly within the watershed and designated by the Federal Emergency Management Agency (FEMA) as having flood hazard areas have taken the necessary steps to make their residents eligible to participate in the Federal Flood Insurance Program. Initial flood insurance studies have been completed by FEMA for unincorporated areas of Kenosha and Racine Counties, the Cities of Kenosha and Racine, and the Village of Sturtevant. It is recommended that FEMA review the flood hazard data set forth in the Pike River watershed plan and revise, as necessary, the local flood insurance studies to reflect the new flood hazard data developed under the watershed program. It is further recommended that owners of property in flood-prone areas purchase flood insurance to provide some financial relief for losses sustained in floods which may occur prior to the completion of any recommended flood control works. As any of the flood control works are implemented, it is further recommended that FEMA undertake necessary revisions to the flood insurance studies.

Lending Institution and Realtor Policies: It is recommended that lending institutions continue their practice of determining the floodprone status of properties prior to mortgage transactions and that the principal source of flood hazard information be that developed under the Pike River watershed study. It is further recommended that real estate brokers and salesmen and their agents continue to inform potential purchasers of property of any flood hazard which may exist at the site being traded in accordance with the rules of the Wisconsin Real Estate Examining Board.

Community Utility Policies and Emergency Programs: It is recommended that the policies of governmental units and agencies having responsibility for the design, construction, operation, and maintenance of public utilities and facilities—such as water supply, sewerage, drainageways, and streets and highways—within the watershed carry out those functions in a manner fully consistent with the land use and floodland regulation recommendations for the Pike River watershed. Although the hydrologically unpredictable "flashy" nature of flooding within the Pike River watershed renders a flood forecasting system impractical, it is recommended that, until recommended flood control works are completed, each watershed community develop procedures to provide floodland residents and other property owners with timely information about floods in progress.

Maintenance of Stream Gaging Networks: The stream gaging stations located throughout the Pike River watershed can provide critical data essential to the future rational management of the surface waters of the basin. It is recommended that the continuous recorder on the Pike River at the University of Wisconsin-Parkside Campus, the crest stage gage on Pike Creek at STH 142, and other low-flow or miscellaneous gages continue to be operated.

Recommended Water Quality Management Plan Element

The adopted regional water quality management plan, as refined and detailed under the watershed study, is recommended for adoption as the water quality management element of the Pike River watershed plan. The plan contains recommendations for the elimination of sanitary sewer flow relief devices; the abatement of pollution from industrial waste discharges; the abatement of pollution from municipal and private sewage treatment plants; the control of pollution from diffuse sources; and the development of a water quality monitoring program for the watershed.

Elimination of Sanitary Sewer Flow Relief Devices: The ultimate elimination of eight flow relief devices—crossovers and bypasses—is recommended in the Pike River watershed plan as in the adopted regional water quality management plan. The elimination is to be achieved by the responsible local units of government which are to determine the specific means to be applied, including the construction, as necessary, of trunk and relief sewers. It should be noted that there are no combined sewer overflows discharging within the Pike River watershed.

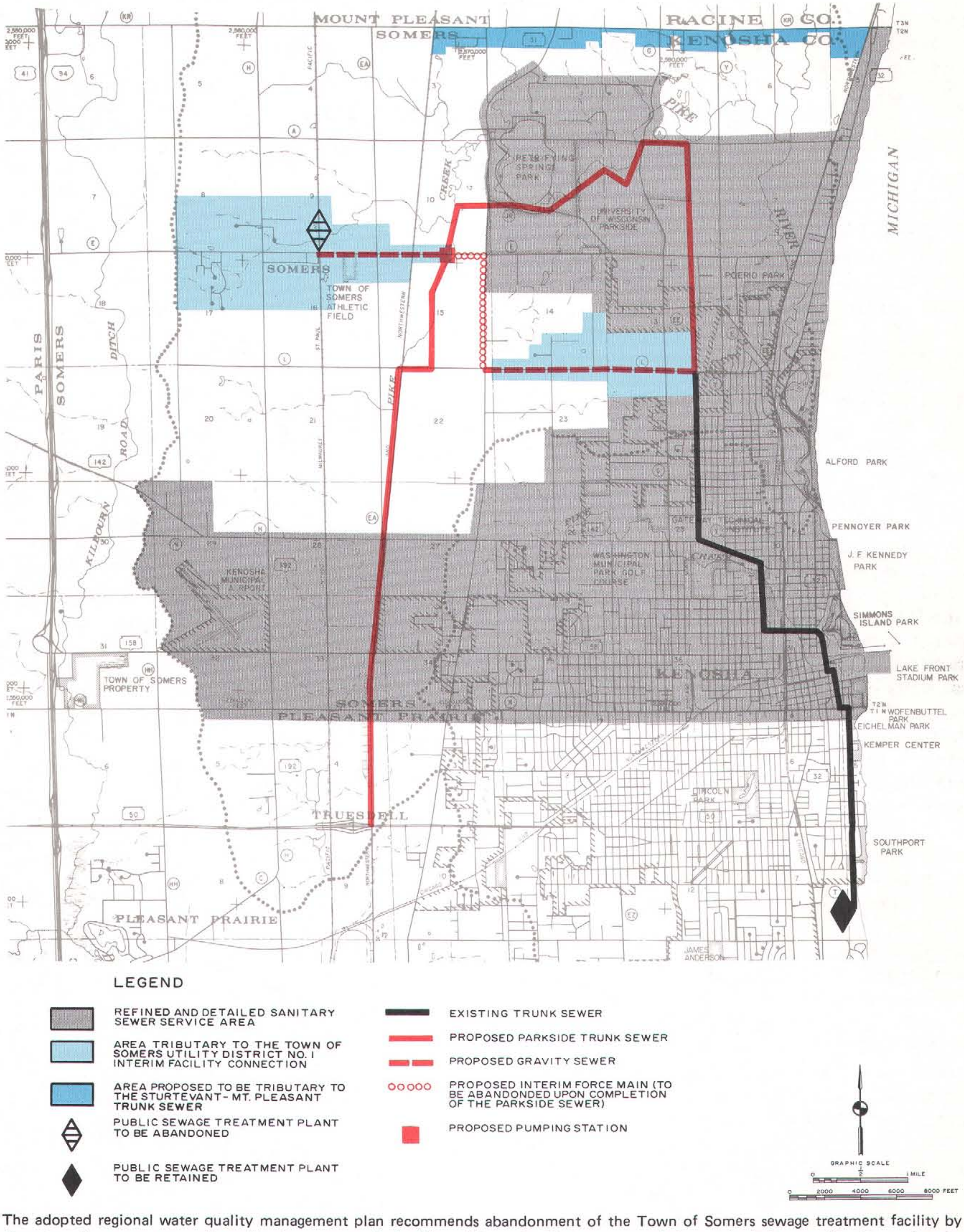
Local efforts have been initiated to eliminate these flow relief devices. Two of the eight flow relief devices—the bypass at the Sturtevant sewage treatment plant and the bypass in the Town of Mt. Pleasant—have been eliminated as of March 1980, following the construction of a major trunk sewer to convey wastewater from the Village of Sturtevant and portions of the Town of Mt. Pleasant to the City of Racine sewage treatment plant. The remaining six flow relief devices are located in the City of Kenosha. The City has completed facility planning and infiltration/inflow control studies which consider alternative means of eliminating these devices, and the attendant water pollution problems and public health hazards. Both conveyance system and sewage treatment plant improvements are planned in the City as a result of this facility planning process, and will serve to eliminate three of the six flow relief devices. Of the remaining three flow relief devices, two are proposed to be maintained but only utilized in extreme emergencies where the pumping station would be inoperable; and one has been connected to a storm sewer which discharges out of the Pike River watershed.

Abatement of Pollution From Industrial Waste Discharges: The recommended water quality management plan element of the Pike River watershed plan proposes that the direct or indirect discharge of industrial wastes into the Pike River and its tributaries be eliminated while allowing the continued discharge of clear water, such as spent cooling water, to the stream system. Such abatement can be achieved under the Wisconsin Pollutant Discharge Elimination System, which requires a permit and pollution abatement schedule for each industrial discharge device.

Abatement of Discharges of Domestic Wastewater From Municipal and Private Wastewater Treatment Plants: The adopted regional water quality management plan recommended abandonment of the municipal sewage treatment plants in the Village of Sturtevant and the Town of Somers, and the private sewage treatment plant serving the St. Bonaventure Seminary in the Village of Sturtevant. The Seminary plant was abandoned in December 1979 by diversion of wastewater to the collection system of the Village of Sturtevant. The Village plant was subsequently abandoned in March 1980 by diversion of wastewater to the City of Racine collection system. It is recommended that the sewage treatment facility located in the Town of Somers be abandoned by diversion of wastewater to the collection system of the City of Kenosha. To achieve this end, both long-term and short-term facilities have been proposed. A major trunk sewer is proposed to be constructed from the Kenosha system to the north and west to serve existing and planned development in the Town of Somers, including the area now connected to the Town of Somers treatment plant. In the regional water quality management plan, that trunk sewer was envisioned to be completed by about 1990. In addition, local plans have been initiated which would provide for the interim connection of portions of the Town of Somers and abandonment of the Somers sewage treatment plant by means of a combination gravity flow sewer and pumping station and force main system (see Map 90). This interim system would be installed prior to completion of the major trunk sewer connection to the Kenosha system. Portions of the interim system would be designed to be incorporated into the local collection and conveyance system once the major trunk sewer from Kenosha is completed.

Map 90

PROPOSED INTERIM CONNECTION OF THE TOWN OF SOMERS UTILITY DISTRICT NO. 1 SEWAGE TREATMENT PLANT



The adopted regional water quality management plan recommends abandonment of the Town of Somers sewage treatment facility by diversion of wastewater to the collection system of the City of Kenosha. The recommended watershed plan provides for an interim connection of portions of the Town of Somers to the Kenosha system and abandonment of the Somers sewage treatment plant by means of a combination gravity flow sewer, pumping station, and force main. This interim connection would be installed prior to completion of the major trunk sewer connection to the Kenosha system envisioned in the longer range plans.

Source: SEWRPC.

Control of Pollution From Diffuse Sources: It is recommended that urban communities in the Pike River watershed use a judicious blend of public education programs, litter and pet waste control, proper use of fertilizers and pesticides, construction erosion control, septic tank system management, critical area protection, improved timing and efficiency of street sweeping, leaf collection, catch basin cleaning, and industrial and commercial material storage facilities and runoff control to reduce pollution from diffuse sources. Effective management of remaining onsite wastewater disposal systems is recommended to avoid excessive instream concentrations of fecal coliform bacteria in the watershed.

It is recommended that diffuse source pollution from rural areas be reduced by utilization of public education programs, fertilizer and pesticide management, critical areas protection, crop residue management, conservation tillage, pasture management, contour plowing, livestock waste control, and construction erosion control. Particular emphasis should be given to livestock waste control measures to alleviate fecal coliform bacteria pollution of surface waters in the watershed; and to construction erosion control, in light of the extensive urban development possible during the planning period.

In addition to the foregoing measures for the control of nonpoint or diffuse source water pollution, it should be noted that onsite stormwater detention systems, such as those considered for application in the Town of Mt. Pleasant, do have a potential for abating pollution from nonpoint sources, particularly from urban sources, by reducing sediments and other pollutants in stormwater runoff. Pollutant removal is accomplished directly by settling within the basin. Additionally, the potential for erosion is reduced downstream of the basin as a result of the reduced peak rates of flow and attendant velocities. These potential water quality enhancement benefits should be taken into account on a case-by-case basis as onsite stormwater detention measures are considered throughout the watershed.

Development of Water Quality Monitoring Program: It is recommended that a water quality monitoring program be developed for the watershed to demonstrate and document changes in surface water quality attendant to plan implementation, and to help detect and locate future illegal sources of pollution. The basis for such a monitoring program should be the prospectus for water quality monitoring in the Region, which prospectus is currently being prepared by the Commission.

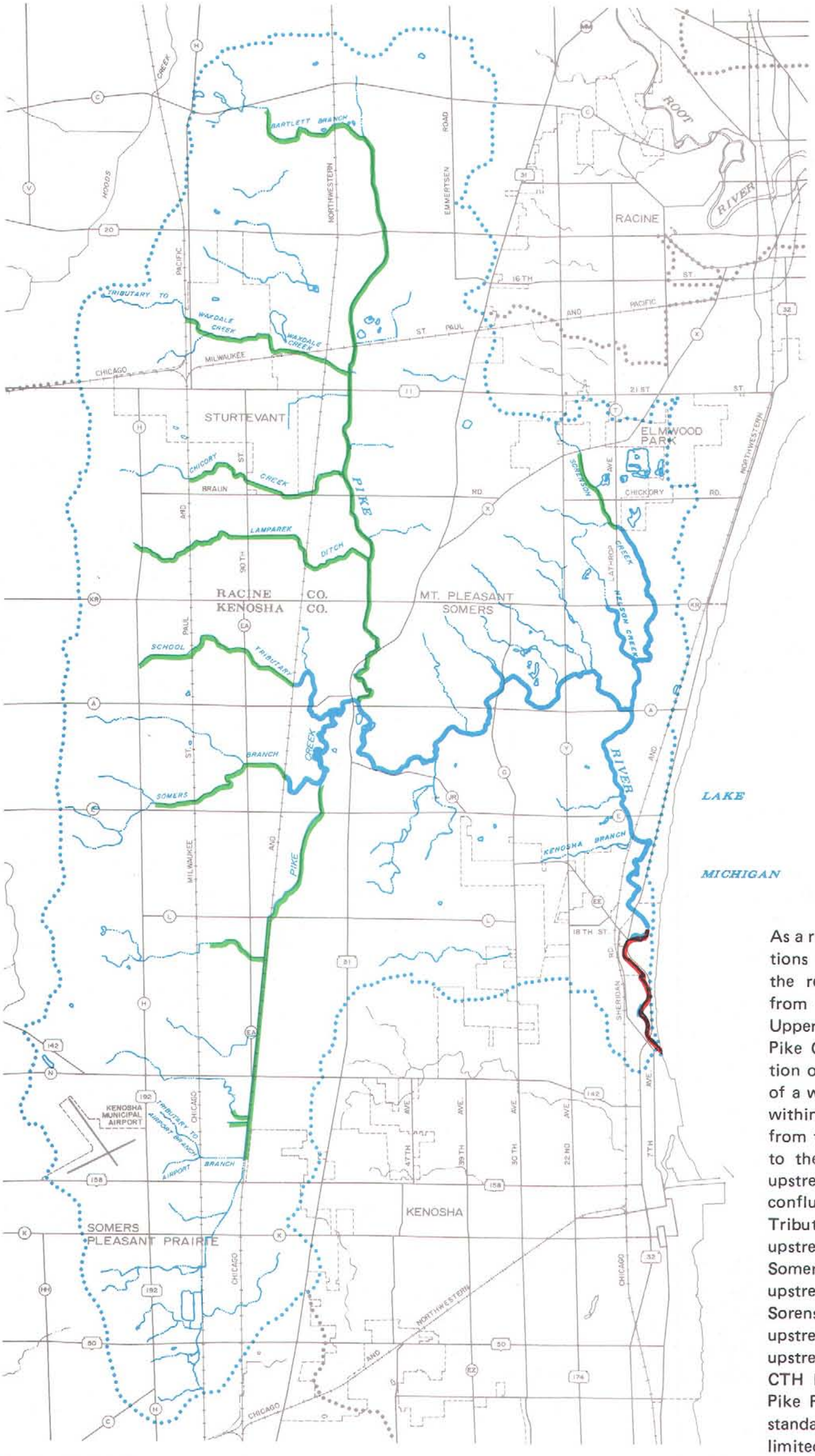
IMPACT OF RECOMMENDED COMPREHENSIVE WATERSHED PLAN ON WATER USE OBJECTIVES

The watershed development objectives, principles, and standards used in the preparation of the comprehensive Pike River watershed plan were set forth in Chapter X of this report. One of the water quality management planning objectives relates directly to the setting forth of recommended water use objectives and supporting water quality standards for the Pike River watershed stream system. The initially recommended water use objectives are shown on Map 43, page 312, of this report. The water quality standards attendant to those water use objectives as they were established on a preliminary basis prior to preparing the watershed plan are set forth in Table 80 on page 335.

The completion of the recommended comprehensive Pike River watershed plan, and in particular the floodland management element of that plan, made it necessary to reevaluate the viability of the initially recommended water use objectives in light of those plan elements. The results of that reevaluation review are summarized on Map 91 which sets forth the final recommended water use objectives for the perennial stream system in the Pike River watershed. As a result of the major channel improvement recommendations for flood control and drainage purposes set forth in the recommended plan for the Pike Creek downstream from the confluence with the Somers Branch and for the Upper Pike River upstream from the confluence with the Pike Creek, it is recommended that the water use objectives be confined within the Pike River watershed to the Lower Pike River from the lagoon at the Carthage College Campus upstream to the confluence with Pike Creek; along the Pike Creek downstream from the confluence with the Pike River to the confluence with the Somers Branch; along the School Tributary from the confluence with the Pike Creek upstream to the Chicago & North Western Railway; on the Somers Branch from the confluence with the Pike Creek upstream to the Chicago & North Western Railway; on Sorenson Creek from the confluence with the Pike River upstream to Lathrop Avenue; and on Nelson Creek upstream from the confluence with Sorenson Creek to CTH KR. The standards attendant to the recommended water use objectives are set forth in Table 107.

Map 91

PRE-PUBLIC HEARING-RECOMMENDED WATER USE OBJECTIVES FOR SURFACE WATERS IN THE PIKE RIVER WATERSHED: 2000



Source: SEWRPC.

As a result of the major channel improvement recommendations for flood control and drainage purposes set forth in the recommended plan for the Pike Creek downstream from the confluence with the Somers Branch and for the Upper Pike River upstream from the confluence with the Pike Creek, it was initially recommended that the application of water use objectives providing for the maintenance of a warm water fishery and full recreational use be limited within the Pike River watershed to the Lower Pike River from the lagoon at the Carthage College Campus upstream to the confluence with the Pike Creek; along Pike Creek upstream from the confluence with the Pike River to the confluence with the Somers Branch; along the School Tributary from the confluence with the Pike Creek upstream to the Chicago & North Western Railroad; on the Somers Branch from the confluence with the Pike Creek upstream to the Chicago & North Western Railroad; along Sorenson Creek from the confluence with the Pike River upstream to Lathrop Avenue; and along Nelson Creek upstream from the confluence with Sorenson Creek to CTH KR. All of the other perennial stream reaches in the Pike River watershed were initially recommended to meet standards for the maintenance of a limited fishery and for limited recreational use.

Table 107

FINAL RECOMMENDED WATER USE OBJECTIVES AND WATER QUALITY STANDARDS FOR STREAMS IN THE PIKE RIVER WATERSHED: 2000[a]

Water Quality Parameters	Combinations of Water Use Objectives Applicable to the Pike River Watershed Streams	
	Recreational Use, and Minimum Standards[b]	Limited Recreational Use, and Minimum Standards[b]
Maximum Temperature (^{o}F)	89[c]	89[c]
pH Range (standard units)	6.0-9.0[d]	6.0-9.0[d]
Minimum Dissolved Oxygen (mg/l)	5.0	3.0
Maximum Fecal Coliform (counts per 100 ml)	200-400[e]	200-400[e]
Maximum Total Residual Chlorine (mg/l)	0.01	0.5
Maximum Un-ionized Ammonia Nitrogen (mg/l)	0.02[f]	0.20[g]
Maximum Total Phosphorus (mg/l)	0.1	--
Other	--[h]	--[h]

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

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

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

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

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

[f]*This level of un-ionized ammonia is estimated to be present at the temperature range of 70-75^{o}F and a pH of 8.0 standard units, which approximates the critical conditions in the Pike River watershed, and at ammonia-nitrogen concentrations of about 0.4 mg/l or greater.*

[g]*This level of un-ionized ammonia is estimated to be present at the temperature range of 70-75^{o}F and a pH of 8.0 standard units, which approximate the critical conditions in the Pike River watershed, and at ammonia-nitrogen concentrations of about 4.0 mg/l or greater.*

[h]*Unauthorized concentrations of substances are not permitted that alone or in combination with other materials present are toxic. The determination of the toxicity of a substance shall be based upon the available scientific data base. References to be used in determining the toxicity of a substance shall include, but not be limited to, The Federal Register, Part V, Environmental Protection Agency, "Water Quality Criteria Documents; Availability," November 28, 1980; Quality Criteria for Water, EPA-440/9-76-003, U. S. Environmental Protection Agency, Washington, D. C., 1976; and Water Quality Criteria, 1972, EPA-R3-73-003, National Academy of Sciences, National Academy of Engineering, U. S. Government Printing Office, Washington, D. C., 1974. Questions concerning the permissible levels, or changes in the same, of a substance, or combination of substances, of undefined toxicity shall be resolved in accordance with the methods specified in Water Quality Criteria, 1972 and Standard Methods for the Examination of Water and Wastewater, 14th Edition, American Public Health Association, New York, 1975, or other methods approved by the Wisconsin Department of Natural Resources.*

Source: Wisconsin Department of Natural Resources and SEWRPC.

COST ANALYSIS

In order to assist public officials in evaluating the foregoing recommended comprehensive Pike 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 in the watershed for major flood control and drainage purposes in order to determine if sufficient monies were likely to be available to implement the floodland management portion of the recommended watershed plan. Similar analyses were not completed for the land use, park and open space, and water quality management recommendations set forth in the watershed plan, since those analyses were performed as part of the regional park and open space and regional water quality management plans and do not represent newly developed recommendations or new costs for the purposes of the Pike River watershed plan.

The schedule of capital and operation and maintenance costs for the recommended watershed plan is set forth in Table 108. This schedule assumes a 17-year plan implementation period beginning in 1984 and extending through the year 2000. The total capital cost of implementing the entire Pike River watershed plan is estimated at $20.2 million, representing an average annual capital expenditure over the 17-year period of nearly $1.2 million. Of this total, about $5.0 million, or about 25 percent and representing an annual average expenditure of $294,600, is required to implement the park and open space element of the plan, including the acquisition of primary environmental corridor lands; about $10.1 million, or about 50 percent of the total and representing an annual average expenditure of $593,900, is required for implementation of the water quality management element of the plan; and about $5.1 million, or 25 percent of the total and representing an annual average expenditure of about $298,400, is required for implementation of the floodland management element of the plan.

The total capital investment and operation and maintenance cost required for plan implemention may be expected to approximate $1.5 million on an average annual basis, or about $33.56 per capita per year over the 17-year plan implementation period. This per capita cost is based on a resident watershed population of 44,700 persons which is equal to the anticipated average resident population in the watershed between the 1980 population level of 33,400 persons and the planned year 2000 population level of 56,300 persons. The average annual costs of implementation of the land use and park and open space element, the water quality management element, and the floodland management element are estimated at, respectively, about $417,900, or $9.35 per capita per year; $744,800, or $16.66 per capita per year; and $329,800, or $7.38 per capita per year.

As noted above, the only significant newly proposed projects and accompanying expenditures in the Pike River watershed plan are those associated with the floodland management element. Accordingly, an analysis was conducted to determine the level of public expenditures for flood control and related improvements in the watershed in recent years in order to determine whether or not the recommended flood control improvements set forth in the plan could likely be accomplished by continuing the historic pattern of expenditures, or whether a change in that historic pattern would be required. A survey was made of the flood control expenditures by the local units of government in the Pike River watershed over the period 1972 through 1982. The results of this survey are set forth in Table 109. As indicated in this table, the local units of government in the watershed have collectively expended nearly $1.1 million over the last 11 years for major flood control and drainage improvements, representing an average annual expenditure of nearly $100,000. As noted above, the estimate of the capital expenditures required to implement the floodland element of the plan over the next 17 years would require an average annual expenditure of slightly over $300,000. Thus, it may be concluded that for full implementation of the plan to occur by the plan design year 2000, an increase in the average annual expenditure would be required from about $100,000 to about $300,000 annually. Alternatively, the period of implementation of the major flood control projects could be extended beyond the plan design year and thus reduce the average annual capital outlay required.

THE ABILITY OF THE RECOMMENDED COMPREHENSIVE PLAN FOR THE PIKE RIVER WATERSHED TO MEET ADOPTED OBJECTIVES AND STANDARDS

The watershed development objectives and supporting standards were formulated early in the Pike River watershed study as the second step in

Table 108

SCHEDULE OF CAPITAL AND OPERATION AND MAINTENANCE COSTS OF THE RECOMMENDED PLAN FOR THE PIKE RIVER WATERSHED BY PLAN ELEMENT AND YEAR: 1984-2000

		Land Use and Park and Open Space Element						
		Primary Environmental Corridor		Parks and Recreation Corridor		Subtotal		
Calendar Year	Project Year	Land Acquisition	Operation and Maintenance	Land Acquisition and Development	Operation and Maintenance	Capital	Operation and Maintenance	Total
1984	1	$ 205,600	$ 3,060	$ 196,100	$ 14,100	$ 401,700	$ 17,160	$ 418,860
1985	2	205,600	6,120	196,100	28,200	401,700	34,320	436,020
1986	3	205,600	9,180	196,100	42,300	401,700	51,480	453,180
1987	4	205,600	12,240	196,100	56,400	401,700	68,640	470,340
1988	5	205,600	15,300	149,200	65,500	354,800	80,800	435,600
1989	6	205,600	18,360	149,100	74,600	354,700	92,960	447,660
1990	7	205,600	21,420	149,100	83,700	354,700	105,120	459,820
1991	8	205,600	24,480	149,100	92,800	354,700	117,280	471,980
1992	9	205,600	27,540	149,100	101,800	354,700	129,340	484,040
1993	10	205,600	30,600	149,100	110,900	354,700	141,500	496,200
1994	11	- -	30,600	149,200	120,000	149,200	150,600	299,800
1995	12	- -	30,600	149,100	129,100	149,100	159,700	308,800
1996	13	- -	30,600	195,000	139,040	195,000	169,640	364,640
1997	14	- -	30,600	195,000	148,980	195,000	179,580	374,580
1998	15	- -	30,600	195,000	158,820	195,000	189,420	384,420
1999	16	- -	30,600	195,000	168,760	195,000	199,360	394,360
2000	17	- -	30,600	195,100	178,700	195,100	209,300	404,400
Watershed Total		$2,056,000	$382,500	$2,952,500	$1,713,700	$5,008,500	$2,096,200	$7,104,700
Annual Average		$ 120,900	$ 22,500	$ 173,700	$ 100,800	$ 294,600	$ 123,300	$ 417,900

		Water Quality Management Element								
		Point Source Pollution Abatement		Diffuse Source Pollution Abatement		Water Quality Monitoring		Subtotal		
Calendar Year	Project Year	Capital	Operation and Maintenance	Capital	Operation and Maintenance	Capital	Operation and Maintenance	Capital	Operation and Maintenance	Total
1984	1	$ 100,000	$ - -	$ 583,000	$ 30,000	$ - -	$ - -	$ 683,000	$ 30,000	$ 713,000
1985	2	744,000	- -	583,000	60,000	- -	- -	1,327,000	60,000	1,387,000
1986	3	743,000	16,000	583,000	90,000	- -	17,000	1,326,000	123,000	1,449,000
1987	4	- -	16,000	583,000	120,000	- -	- -	583,000	136,000	719,000
1988	5	- -	16,000	583,000	150,000	- -	- -	583,000	166,000	749,000
1989	6	- -	16,000	583,000	152,000	- -	- -	583,000	168,000	751,000
1990	7	- -	16,000	584,000	152,000	- -	- -	584,000	168,000	752,000
1991	8	- -	16,000	584,000	152,000	- -	17,000	584,000	185,000	769,000
1992	9	- -	16,000	427,000	152,000	- -	- -	427,000	168,000	595,000
1993	10	- -	16,000	427,000	152,000	- -	- -	427,000	168,000	595,000
1994	11	- -	16,000	427,000	152,000	- -	- -	427,000	168,000	595,000
1995	12	- -	16,000	427,000	152,000	- -	17,000	427,000	185,000	612,000
1996	13	- -	16,000	427,000	152,000	- -	- -	427,000	168,000	595,000
1997	14	- -	16,000	427,000	152,000	- -	- -	427,000	168,000	595,000
1998	15	- -	16,000	427,000	152,000	- -	- -	427,000	168,000	595,000
1999	16	- -	16,000	427,000	152,000	- -	- -	427,000	168,000	595,000
2000	17	- -	16,000	427,000	152,000	- -	- -	427,000	168,000	595,000
Watershed Total		$1,587,000	$240,000	$8,509,000	$2,274,000	$ - -	$51,000	$10,096,000	$2,565,000	$12,661,000
Annual Average		$ 93,400	$ 14,100	$ 500,500	$ 133,800	$ - -	$ 3,000	$ 593,900	$ 150,900	$ 744,800

Table 108 (continued)

		Floodland Management Element						
		Channel Improvements, Dikes, Bridge Replacement, Jetties		Structure Floodproofing and Elevation	Streamflow Gaging	Subtotal		
Calendar Year	Project Year	Capital	Operation and Maintenance	Capital	Operation and Maintenance	Capital	Operation and Maintenance	Total
1984	1	$ 37,900	$ 300	$	$ 7,000	$ 37,900	$ 7,300	$ 45,200
1985	2	137,800	300	46,900	7,000	184,700	7,300	192,000
1986	3	1,025,700	9,300	46,900	7,000	1,072,600	16,300	1,088,900
1987	4	978,200	17,300	46,900	7,000	1,025,100	24,300	1,049,400
1988	5	796,700	23,500	46,900	7,000	843,600	30,500	874,100
1989	6	502,400	26,600	46,900	7,000	549,300	33,600	582,900
1990	7	673,800	30,100	- -	7,000	673,800	37,100	710,900
1991	8	171,400	30,300	- -	7,000	171,400	37,300	208,700
1992	9	171,400	30,500	- -	7,000	171,400	37,500	208,900
1993	10	171,400	30,700	- -	7,000	171,400	37,700	209,100
1994	11	171,400	30,900	- -	7,000	171,400	37,900	209,300
1995	12	- -	30,900	- -	7,000	- -	37,900	37,900
1996	13	- -	30,900	- -	7,000	- -	37,900	37,900
1997	14	- -	30,900	- -	7,000	- -	37,900	37,900
1998	15	- -	30,900	- -	7,000	- -	37,900	37,900
1999	16	- -	30,900	- -	7,000	- -	37,900	37,900
2000	17	- -	30,900	- -	7,000	- -	37,900	37,900
Watershed Total		$4,838,100	$415,200	$234,500	$119,000	$5,072,600	$534,200	$5,606,800
Annual Average		$ 284,500	$ 24,400	$ 13,800	$ 7,000	$ 298,400	$ 31,400	$ 329,800

		Total		
Calendar Year	Project Year	Capital	Operation and Maintenance	Total
1984	1	$ 1,122,600	$ 54,460	$ 1,177,060
1985	2	1,913,400	101,620	2,015,020
1986	3	2,800,300	190,780	2,991,080
1987	4	2,009,800	228,940	2,238,740
1988	5	1,781,400	277,300	2,058,700
1989	6	1,487,000	294,560	1,781,560
1990	7	1,612,500	310,220	1,922,720
1991	8	1,110,100	339,580	1,449,680
1992	9	953,100	334,840	1,287,940
1993	10	953,100	347,200	1,300,300
1994	11	747,600	356,500	1,104,100
1995	12	576,100	382,600	958,700
1996	13	622,000	375,540	997,540
1997	14	622,000	385,480	1,007,480
1998	15	622,000	395,320	1,017,320
1999	16	622,000	405,260	1,027,260
2000	17	622,100	415,200	1,037,300
Watershed Total		$20,177,100	$5,195,400	$25,372,500
Annual Average		$ 1,186,900	$ 305,600	$ 1,492,500

Source: SEWRPC.

a seven-step planning process, and constitute the overall goals of the comprehensive plan. The objectives and standards established for the Pike River watershed planning program consist of objectives and standards adopted under related areawide land use, park and open space, and water pollution abatement planning programs, supplemented with objectives and standards developed under the Pike River watershed planning program. The adopted watershed development objectives and supporting standards provide the basis for plan preparation, test, and evaluation. It is appropriate to determine how well the recommended comprehensive plan for the watershed meets these 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 110.

The relatively small number of standards that could not be met or which would be only partially met under the recommended comprehensive plan for the Pike River watershed, as indicated in Table 110, support objectives that are inextricably related to the underlying natural base. The failure to meet those standards reflects the practically unavoidable effects on the natural resource base of the watershed of extensive agricultural development and increasing urbanization, effects not readily assimilated within the relatively small Pike River watershed. Adoption and implementation of the recommended watershed plan could, however, nevertheless result in substantial attainment of the adopted watershed development objectives, and

Table 109

FLOOD CONTROL EXPENDITURES BY LOCAL UNITS OF GOVERNMENT IN THE PIKE RIVER WATERSHED: 1972-1982

Year	Civil Division	Flood Control Measures	Cost
1972	Town of Mt. Pleasant	Lamparek Ditch channel improvement	$ 4,100
1973	Town of Mt. Pleasant	Bartlett Branch channel improvement	133,800
		Sorenson Creek channel improvement	14,400
1974	Town of Mt. Pleasant	Lamparek Ditch channel improvement	12,500
1975	Town of Mt. Pleasant	STH 31 detention pond	160,900
1976	Town of Mt. Pleasant	Pike River channel improvement	50,300
1977	Town of Mt. Pleasant	Heritage Heights outfall	83,400
1978	--	--	--
1979	--	--	--
1980	City of Kenosha	18th Street detention pond	258,500
1981	Town of Mt. Pleasant	Lamparek Ditch channel improvement	17,500
1982	Town of Mt. Pleasant	Lehner detention pond/ Madsen detention pond	320,300
Total			$1,055,700
11-Year Average			$ 95,973

Source: SEWRPC.

thus 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.

CONSEQUENCES OF NOT IMPLEMENTING THE RECOMMENDED COMPREHENSIVE PLAN FOR THE PIKE RIVER WATERSHED

Within the framework of the overriding goals of the Pike 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 in the Pike River watershed; and 2) preventing aggravation of the existing problems or the development of new environmental problems within the basin. This is believed to be so because preparation of the recommended comprehensive plan for the Pike River watershed involved the conduct of extensive inventories; application of state-of-the-art analytic tools; exhaustive examination of alternative subelements and careful evaluation of the technical, economic, and environmental impacts of each alternative; preparation of a plan implementation strategy and capital and operation and maintenance expenditure schedule; and several years of deliberation by the Pike River Watershed Committee, a committee comprised of knowledgeable and concerned citizens and public officials.

In the absence of a sound comprehensive watershed plan, a multitude of incorrect decisions are 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 to the development of new problems. Because the comprehensive plan for the Pike 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 consequence of not adopting and implementing the recommendations contained within the comprehensive plan for the Pike 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 watershed.

Table 110

ABILITY OF THE RECOMMENDED COMPREHENSIVE PLAN FOR THE PIKE RIVER WATERSHED TO MEET ADOPTED WATERSHED DEVELOPMENT OBJECTIVES AND STANDARDS

Objective Number	Objective Description	Standard		Degree to Which Standard is Met
		LAND USE OBJECTIVES		
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	High-density urban—eight net acres per 100 added dwelling units	Met[a]
			Medium-density urban—23 net acres per 100 added dwelling units	Met[a]
			Low-density urban—83 net acres per 100 added dwelling units	Met[a]
			Suburban—167 net acres per 100 added dwelling units	Met[a]
			Rural—500 net acres per 100 added dwelling units	Met[a]
		Park and recreation land allocation	Major—four net acres per 1,000 added persons	Met[a]
			Other—eight net acres per 1,000 added persons	Met[a]
		Industrial land allocation	Seven net acres per 100 added employees	Partially Met[a]
		Commercial land allocation	Major—one net acre per 100 added employees	Partially Met[a]
			Other—two net acres per 100 added employees	Partially Met[a]
		Governmental and institutional land allocation	Nine net acres per 1,000 added persons	Met[a]
2	A spatial distribution of the various land uses which will result in a compatible arrangement of land uses	Neighborhood units for urban high-, medium-, and low-density residential development		Could be Met[b]
		Suburban and rural residential land location		Met
		Industrial land location		Met
		Regional commercial land location		Met
3	A spatial distribution of various land uses which will result in the protection and wise use of the natural resources of the Region, including its soils, inland lakes and streams, wetlands, woodlands, and wildlife	Soils	Sewered urban development	Met[a]
			Unsewered suburban development	Met[a]
			Rural development	Met[a]
		Inland lakes and streams	25 percent of shoreline of perennial streams in natural state	Met
			50 percent of shoreline of perennial streams in nonurban use	Met
			Floodlands free from new incompatible urban development	Met
			Restrict encroachments in channels and floodways	Met
		Wetlands	Protect wetlands over 50 acres and those with high resource values	Met
		Woodlands	Protect 10 percent of watershed	Not Met
			Maintain five acres per 1,000 regional population	Met
		Wildlife	Maintain a wholesome habitat	Met

Table 110 (continued)

Objective Number	Objective Description	Standard	Degree to Which Standard is Met
4	A spatial distribution of the various land uses which is properly related to the supporting transportation, utility, and public facility systems in order to assure the economical provision of transportation, utility, and municipal services	Maximize use of existing transportation and utility facilities	Met[a]
		Transportation systems to provide access to urban areas	Could be Met
		Sewer service to residential areas	Met[a]
		Water supply to residential areas	Met[a]
		Residential land serviceable by mass transit facilities	Met
		Minimize penetration by major transportation routes of residential neighborhood units	Could be Met[b]
		Locate transportation terminal facilities near principal land uses served	Could be Met[b]
5	The development and conservation of residential areas within a physical environment that is healthy, safe, convenient, and attractive	Locate residential development in physically self-contained neighborhood units	Could be Met[b]
		Locate appropriate land uses within neighborhood units	Could be Met[b]
		Locate suburban and rural residential development properly to environment	Met
6	The preservation, development, and redevelopment of a variety of suitable industrial and commercial sites in terms of both physical characteristics and location	Regional industrial site requirements	Met[a]
		Regional commercial site requirements	Met[a]
		Local industrial site requirements	Could be Met[b]
		Local commercial site requirements	Could be Met[b]
7	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 spatial location	Could be Met[b]
		Regional park spatial location	Met[a]
		Areas of scientific, cultural scientific, and educational value	Met[a]
8	The preservation of land areas for agricultural uses in order to provide for certain special types of agriculture, to provide a reserve or holding zone for future needs, and to ensure the preservation of those unique rural areas which provide wildlife habitat and which are essential to shape and order urban development	Preserve all prime agricultural areas	Partially Met
		Preserve other appropriate agricultural areas	Partially Met
PARK AND OPEN SPACE OBJECTIVES			
1	The provision of an integrated system of public general-use outdoor recreation sites and related open space areas which will allow the resident population of the Region adequate opportunity to participate in a wide range of outdoor recreation activities	Sufficient recreation sites to meet the recreation demand of population: Regional	Met
		Multicommunity	Met
		Community	Met
		Neighborhood	Met
		Recreation sites located within corridors	Met
		Linear recreation corridor requirement	Met
		Recreation corridor dimensions	Met
		Travel distance to recreation corridors	Met
		Resource-oriented recreation corridors	Met

Table 110 (continued)

Objective Number	Objective Description	Standard	Degree to Which Standard is Met
2	The preservation of sufficient high-quality open space lands for protection of the underlying and sustaining natural resource base and enhancement of the social and economic well-being and environmental quality of the Region	Preserve all remaining nonurban lands within corridors	Met
		Preserve all prime agricultural lands	Partially Met
		Preserve agricultural lands adjoining recreation or educational sites	Partially Met
3	The efficient and economical satisfaction of outdoor recreation and related open space needs, meeting all other objectives at the lowest possible cost	Minimize the total of all expenditures required to meet park demands and open space needs	Met
	SANITARY SEWERAGE SYSTEM AND WATER QUALITY MANAGEMENT OBJECTIVES		
1	The development of land management and water quality control practices and facilities—inclusive of sanitary sewerage systems—which will effectively serve the existing regional urban development pattern and promote implementation of the regional land use plan, meeting the anticipated need for stormwater runoff control generated by the existing and proposed land uses	Sanitary sewer service to medium- and high-density urban development	Met[a]
		Sanitary sewer service to low-density development	Met
		Sanitary sewer service in poor soil areas	Met[a]
		Sanitary sewer service not provided to undeveloped primary environmental corridor lands	Met[a]
		Sanitary sewer service not provided to floodlands	Met
		Sanitary sewer service restricted in areas of soils with very severe limitations for urban development	Met[a]
		Orderly extension of sanitary sewerage facilities	Could be Met
		Sizing of sewerage facility components in accordance with land use plan	Met
		Treatment and disposal of industrial wastes	Met
		Provision of stormwater management facilities to existing proposed urban areas	Met[c]
		Priority to prime agricultural lands for land management practices	Could be Met[c]
2	The development of land management and water quality control practices and facilities—inclusive of sanitary sewerage systems—so as to meet the recommended water use objectives and supporting water quality standards as set forth on Map 43 and in Table 80	Level of treatment at sewage treatment plant	Not Applicable
		Sewage treatment plant discharge	Not Applicable
		Standards for sewage treatment plants	Not Applicable
		Existing sewage treatment plants scheduled to be abandoned	Not Applicable
		Prohibition of sewage bypasses to storm sewers and waterways	Met
		Elimination of combined and sanitary sewer overflows	Met
		Adequate design of sewage treatment plants	Not Applicable
		Best practicable treatment of sanitary sewage by 1983	Met[c]
		Best available treatment of industrial sewage by 1983	Met[c]
		No nonconforming pollutant discharge by 1985	Met[c]
		Stormwater treatment and land management practices	Met[c]
		Stream fencing and feedlot runoff control	Met[c]
		Orderly transition of rural lands to urban uses	Met[c]

Table 110 (continued)

Objective Number	Objective Description	Standard	Degree to Which Standard is Met
3	The development of land management and water quality control practices and facilities—inclusive of sanitary sewerage systems—that are properly related to and will enhance the overall quality of the natural and man-made environments	Location of new and replacement sewage treatment plants outside the 100-year recurrence interval floodplain	Not Applicable
		Floodproofing existing sewage treatment plants in the 100-year recurrence interval floodplain	Not Applicable
		Location of new and replacement sewage treatment and stormwater treatment and storage facilities for compatibility with existing and proposed development	Not Applicable
		Provision of aesthetically compatible new and replacement sewage treatment plants with buffer zones between existing and proposed development	Not Applicable
		Disposal of sewage treatent plant sludge	Not Applicable
		Proper location of pollutant storage facilities *in relation to the* 100-year recurrence interval floodplain	Not Applicable
		Elimination of discharges of heavy metals, pesticides, and other toxic and hazardous substances	Could be Met[c]
		Nondegradation of existing water quality	Could be Met[c]
4	The development of land management and water quality control practices and facilities—inclusive of sanitary sewerage systems—that are economical and efficient, meeting all other objectives at the lowest possible cost	Minimize investment and operating costs of sanitary sewerage systems and stormwater control facilities and related land management practices	Could be Met
		Minimize number of sanitary sewerage system and sewage treatment facilities	Met
		Maximize feasible use of sanitary sewerage facilities	Met
		Use of new and improved materials and management practices	Could be Met
		Staged or incremental construction of sanitary sewerage facilities	Met
		Minimize land acquisition costs for new sewer construction	Met
		Minimize excessive clear water inflows and infiltration into sanitary sewerage system	Met
		Integrated design of sanitary and storm sewer systems	Could be Met
5	The development of water quality management institutions—inclusive of the governmental units and their responsibilities, authorities, policies, procedures, resources, and supporting revenue-raising mechanisms which are effective and locally acceptable, and which will provide a sound basis for plan implementation, including the planning, design, construction, operation, maintenance, repair and replacement of water quality control practices and facilities, inclusive of sanitary sewerage systems, storm-water management systems, and land management practices	Develop and establish system of user charges and industrial cost recovery for program support	Could be Met
		Maximum utilization of existing institutional structures	Met
		Water pollution control by local entities	Met
		Provide management groups with necessary resources	Could be Met

Table 110 (continued)

Objective Number	Objective Description	Standard		Degree to Which Standard is Met
WATER CONTROL OBJECTIVES				
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 recurrence interval flood	Could be Met
			Arterial streets and highways—pass the 50-year recurrence interval flood	Could be Met
			Freeways and expressways—pass the 100-year recurrence interval flood	Could be Met
		New or replacement bridges and culverts shall pass the 100-year recurrence interval flood without raising the peak stage more than 0.1 feet		Could be Met
		Structure design shall maximize passage of ice flow and debris		Could be Met
		Certain new and replacement bridges and culverts shall pass the 100-year recurrence interval flood with two feet of freeboard		Could be Met
		Existing bridges and culverts to meet standards 1, 3, and 4 above		Not Met
		Channel improvements, dikes, and floodwalls should be restricted to the absolute minimum necessary		Met
		The height of dikes and floodwalls shall pass the 100-year recurrence interval flood with two 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 recurrence interval flood		Met
		Public land acquisition to eliminate water control facilities shall encompass the entire 100-year recurrence interval floodplain		Met
		Regulatory floodways shall accommodate existing committed and planned floodplain land uses		Could be Met
		Floodway stage increase limited to 0.1 foot based on equal degree of encroachment		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 support recreational use	Satisfy established water quality standards which are applicable except during 1) extreme low-flow periods and 2) extreme conditions recognized in the probabilistic approach to water quality standards achievement		Met

[a] *This standard has been met under the recommended land use plan and regional sanitary sewerage system plan because it served as an input to the plan design process.*

[b] *This standard could be met only by local community action.*

[c] *This standard has been met under the recommended water quality management plan because it served as an input to the plan design process.*

Source: SEWRPC.

The analysis of the likely consequences of not implementing the recommended comprehensive plan for the Pike River watershed is based primarily on two sources of information: 1) the data collected and the analyses conducted under the Pike 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. The likely consequences of not implementing the recommended comprehensive plan for the Pike River watershed are summarized in Table 111. Within the overall framework of the three basic plan elements—the land use and park and open space plan element, the floodland management plan element, and the water quality management

Table 111

PROBABLE CONSEQUENCES OF NOT IMPLEMENTING THE RECOMMENDED COMPREHENSIVE PLAN FOR THE PIKE RIVER WATERSHED

Plan Element	Plan Subelement	Probable Negative Consequences of Failure to Implement Plan Recommendations
Land Use	Overall land use	● Increased cost of public utilities and services such as sanitary sewerage, water supply, transportation, police, and fire protection ● Loss of much remaining prime agricultural land ● 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
	Park and open space plan	● Loss of recreational, aesthetic, environmental, and cultural values in park and open space lands
	Recreational trails	● Prevent full public use and enjoyment of primary environmental corridor lands
Floodland Management	Flood control measures for:	
	Bartlett Branch	● Continuation of average annual flood damage risk of $1,900 or more under existing conditions
	Somers Branch	● Continuation of average annual flood damage risk of $300 or more under existing conditions
	Airport Branch and Tributary to Airport Branch	● Probable future flood damage risk
	Sorenson Creek	● Continuation of average annual flood damage risk of $8,000 or more under existing conditions
	Pike Creek	● Continuation of average annual flood damage risk of $64,000 or more under existing conditions
	Upper Pike River	● Continuation of average annual flood damage risk of $11,100 or more under existing conditions
	Lower Pike River	● Continuation of average annual flood damage risk of $64,000 or more under existing conditions
	Pike River Estuary	● Continuation of average annual flood damage risk of $11,200 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 two-fold increase in average annual flood damages ● Loss of critical portions of primary environmental corridors
	Control of land use outside floodlands	● Increased runoff to the stream system resulting in up to a three-fold increase in average annual flood damages
	Flood insurance	● Large monetary losses absorbed by owners of flood-prone structures and property
	Lending institutions 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
Water Quality Management	Municipal sewage treatment plant abandonment	● Large nutrient load to Somers Branch, Pike Creek, and the Pike River
	Combined and sanitary sewer overflow abatement	● Continuation of overflows with resultant inorganic, organic, nutrient, pathogenic, and aesthetic pollution
	Industrial discharge abatement	● Localized pollution problems
	Sanitary sewer service to all new urban developments	● Localized and instream hazards and localized objectionable aesthetic conditions
	Elimination of malfunctioning onsite disposal systems	● Continued contamination of surface waters and groundwater with pathogenic pollution and continued nutrient loading and aesthetic pollution of streams
	Feedlot runoff control measures	● Localized instream health hazards and objectionable aesthetic conditions
	Rural and urban diffuse source pollution control measures	● Continued watershedwide surface water quality degradation during and immediately after runoff events, as well as during normal and low-flow periods

Source: SEWRPC.

plan element—Table 111 identifies each plan subelement and some likely negative consequences of failure to implement those subelements.

SUMMARY

The various plan elements recommended to be adopted as integral parts of the comprehensive plan for the Pike River watershed have all been described separately and in detail in the preceding chapters of this report. This chapter presents a concise description of the overall recommended comprehensive plan for the Pike River watershed as that plan was synthesized from the best alternatives considered. The comprehensive plan consists of a land use and park and open space element, a water quality management element, and a floodland management element.

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 orderly and economical land use pattern, and intensification of existing and creation of new developmental and environmental problems would thus be avoided. The primary environmental corridors of the watershed, together with the remaining undeveloped floodlands, would be protected from incompatible urban development, thereby assuring continuing enjoyment of the recreational, aesthetic, ecological, and cultural values associated with the riverine areas, while avoiding intensification of flood damage and water pollution problems. Primary environmental corridor preservation would be accomplished by public regulation and acquisition of corridor lands. The recommended plan would accommodate a planned year 2000 population in the watershed of about 56,300 persons and a planned employment level in the year 2000 of about 25,200 jobs. To accommodate the increase in population and employment, an additional 15 square miles of land would be converted from rural to urban use.

The overall land use plan element for the Pike River watershed is intended, in part, to minimize aggravation of existing flood problems and help prevent future flood problems. Structural flood control measures are also recommended, where necessary, to resolve existing flooding problems and enhance the overall drainage system of the watershed. In particular, the floodland management plan element includes recommendations for channel improvements and bridge replacement along the Pike Creek, the Airport Branch and the Tributary to Airport Branch, and the Upper Pike River; the construction of dikes along Bartlett Branch and the Lower Pike River; the construction of jetties at the mouth of the Pike River on Lake Michigan; and structure floodproofing and elevation along the Bartlett Branch and the Lower Pike River. No structural measures are recommended for Waxdale Creek and the Tributary to Waxdale Creek, Chicory Creek, Lamparek Ditch, Nelson Creek, and the Kenosha Branch.

In addition to the foregoing measures, the floodland management element of the plan includes recommended standards relative to bridge replacement to assure that major streets and highways remain operable during major flood events. Finally, the floodland management plan includes various supplemental measures intended to minimize the monetary losses associated with flooding, including participation in the Federal Flood Insurance Program and continuation of desirable lending institution and realtor policies concerning the sale of riverine area properties. Maintenance of a basic cooperative stream gaging program is also recommended.

The recommended Pike River watershed plan incorporates those water quality management measures set forth in the adopted regional water quality management plan which are directly applicable to the Pike River watershed. These include the abandonment of the single remaining municipal sewage treatment plant in the watershed—that serving the Town of Somers Utility District No. 1, the elimination or abatement of pollution from three sewage flow relief devices in the City of Kenosha, the institution of measures to control nonpoint source pollution from both rural and urban land surfaces, and the control of industrial waste discharges to the stream system.

A preliminary schedule of capital and operating and maintenance costs was prepared which, if followed, would result in total watershed plan implementation by the year 2000. The total capital cost of implementing the entire Pike River watershed plan is estimated at $20.2 million, representing an average annual capital expenditure over the 17-year period of nearly $1.2 million. Of this total, about $5.0 million, or about 25 percent and representing an annual average expenditure of $294,600, is required to implement the park and open space element of the plan, including the acquisition of primary environmental corridor lands; about $10.1 million, or about 50 percent of the total and representing an annual average expenditure of $593,900, is required for implementation of the water quality management element of the plan; and about $5.1 million, or 25 percent of the total and representing an annual average expenditure of about $298,400, is required for implementation of the floodland management element of the plan.

The total capital investment and operation and maintenance cost required for plan implemention may be expected to approximate $1.5 million on an average annual basis, or about $33.56 per capita per year over the 17-year plan implementation period. This per capita cost is based on a resident watershed population of 44,700 persons which is equal to the anticipated average resident population in the watershed between the 1980 population level of 33,400 persons and the planned year 2000 population level of 56,300 persons. The average annual cost of implementation of the land use and park and open space element, the water quality management element, and the floodland management element are estimated at, respectively, about $417,900, or $9.35 per capita per year; $744,800, or $16.66 per capita per year; and $329,800, or $7.38 per capita per year.

The only significant newly proposed projects and accompanying expenditures in the Pike River watershed plan are those associated with the floodland management element. The projects and accompanying expenditures associated with the park and open space and water quality management elements of the watershed plan were addressed in previous regional plans. An analysis was conducted to determine the level of public expenditures for flood control in the Pike River watershed in recent years in order to determine whether or not the flood control improvements set forth in the plan could be accomplished by simply continuing the recent historic pattern of expenditures. This analysis indicated that collectively local units of government are spending nearly $100,000 annually in the Pike River watershed for capital improvements relating to flood control. Implementation of the recommended floodland management element of the watershed plan over the next 17 years would require an average annual expenditure of slightly over $300,000. Accordingly, an increase in the average annual expenditure for flood control would be required to fully implement the plan by the design year 2000; alternatively, implementation of the major flood control projects could be extended beyond the plan design year.

An evaluation was made of the comprehensive plan relative to its ability to meet the adopted watershed development objectives and standards. The analysis indicates that 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 also conducted of the probable consequences of not implementing the recommended comprehensive plan for the Pike 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 watershed plan implementation, the Pike River watershed will be susceptible to aggravation of the costly existing water resource and water resource-related problems and to the development of new problems.

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Chapter XV

PLAN IMPLEMENTATION

INTRODUCTION

The recommended comprehensive plan for the Pike River watershed, as described in Chapter XIV of this report, provides a design for the attainment of the specific watershed development objectives formulated under the Pike River watershed study. The final watershed plan consists of three major elements: 1) a land use element, including open space preservation and outdoor recreation 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 Pike River watershed is designed to attain, to the extent practicable, the 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 provides that specification and is intended as a guide for use in the implementation of the Pike 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 Pike River watershed plan are identified; necessary or desirable formal plan adoption actions are 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.

PRINCIPLES OF PLAN IMPLEMENTATION

The plan implementation recommendations contained in this chapter are, to the maximum extent possible, based upon and related to existing 1980 governmental programs and are predicated upon existing enabling legislation. Because of the ever-present 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 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 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, be consistent with the adopted plans, but must 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 the protection of the underlying and sustaining natural resource base; flood control and flood damage abatement; and water quality control and pollution abatement.

[1] *The recommended land use plan element, the recommended floodland management plan element, and the recommended water quality management plan element, as well as the process used to arrive at these elements and the alternatives considered, are described in Chapters XI, XII, and XIII, respectively. The recommended comprehensive plan for the Pike River watershed is described in Chapter XIV of this report.*

Principal Means of Plan Implementation

There are three principal ways through which the necessary watershed plan implementation may be achieved—ways which 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, state, and federal agencies of government and by private investors. A wealth of definitive information about the natural and man-made features of the watershed, the hydrology and hydraulics of the watershed, and the water-related problems of the watershed—particularly flood damage and water pollution—was assembled under the Pike River watershed study. The use of this information base in arriving at development decisions on a day-to-day basis by the public and private interests involved contributes substantially toward implementation of the recommended watershed plan.

With respect to 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 plan 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 acquisition and development of proposed neighborhood parks and the development of urban outdoor recreation facilities. The preparation of such detailed plans will require the continuing development of close working relationships between the Commission, the Racine and Kenosha County Boards, the local units of government concerned, and certain other agencies—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. If properly utilized, this program should help 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 and Construction Phases of the Public Works Development Process

The planning process used to prepare the Pike 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. Because effective implementation of the Pike 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 Pike 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 for the development of public works for flood control, pollution abatement, water supply, sanitary sewerage, transportation, park and open space, or other public facilities and services.

Systems Planning: The systems planning phase concentrates on the precise definition of the problems to be addressed and on 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 to resolve the identified problems in accordance with agreed-upon objectives and supporting standards. In this first or systems planning phase, each alternative plan element is developed to sufficient detail to permit a sound consistent comparison of the technical practicality and economic feasibility of each alternative and a proper evaluation of its nontechnical and noneconomic characteristics.

Properly conducted, systems planning is comprehensive in three ways. First, it is comprehensive in 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 proper resolution of those problems. Water and water resource-related problems, for example, should be approached on a watershed basis because the watershed system is the most rational planning area for such problems. Man's use of the land and changes in such use in one portion of a watershed can markedly influence environmental problems in other areas of the watershed through, for example, the impact of urban development and channel modifications on downstream flood discharges and stages.

Second, properly conducted systems planning is comprehensive in that it considers not only the immediate problem but the relationship of the problem to broad land use, socioeconomic, 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 socioeconomic conditions within as well as outside the watershed. Therefore, the regional land use plan—as refined and detailed in the watershed planning process—is taken as a "given" in the preparation of the watershed plan so as to reflect regional land use, socioeconomic, and environmental conditions likely to influence the cause of, and solution to, water resource problems within the watershed.

Third, the systems planning phase of the three-phase public works development process is comprehensive in 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 are 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 examining each of the many possible alternative measures but rather examining alternatives that define the boundaries of the continuum and that are truly representative of the full range of available measures within the continuum.

Preliminary Engineering

Although systems planning requires considerable effort, it 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 great detail and depth as the first step toward implementation of the system plan. The 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 the implementing units and agencies of government concerned.

The preliminary engineering phase begins 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 its 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 of 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.

Final Design: Upon acceptance of the findings and recommendations of the preliminary engineering phase by the governmental units and agencies affected, the third or final design phase of the public works development process is initiated. This work should also be carried out by the implementing units and agencies of government concerned. 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 should move toward the development of the 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 should provide sufficient detail to permit potential contractors to submit bids for the project and to actually construct the recommended works. Engineers responsible for carrying out the final phase should 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 specifications.

Other Considerations: For many reasons, the three-phased public works development process does not always proceed in the simple three-step fashion as described above. In some situations, an iterative process is set in motion whereby a reexamination of an earlier step is required. For example during the preliminary engineering phase, a new alternative, based on additional information, may be developed that must be subjected to systems 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 to the systems planning phase to reconsider measures studied during that phase or to analyze additional measures as may be necessitated by 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, a solution to an environmental problem that was originally accepted as optimal, based on systems planning techniques and an agreed-upon set of objectives, could later, because of changing values and objectives, be rejected or encounter considerable opposition, necessitating an iteration to the systems planning phase.

The effective functioning of the three-phase public works development process is highly dependent on close cooperation among 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 them to undertake the necessary second or preliminary engineering phase and to make full use of the recommendations resulting from the first or systems planning phase of the public works development process.

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. In this instance, assuming adoption of the plan recommendations by the governmental units and agencies concerned, the preliminary engineering phase can be combined with the final design phase, the goal of which would be to provide a precise identification of structures requiring floodproofing and those requiring removal, and of the manner in which floodproofing and removal should be carried out.

In carrying out the three-phase process, there is a 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. Superimposition 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 certain state and federal regulations, applications by state and local units of government for federal grants in partial support of the planning, acquisition of land for and construction of public works facilities such 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 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 the Pike River watershed planning program in southeastern Wisconsin, 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 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 reviews can be of material assistance in achieving implementation of the recommended Pike River watershed plan.

In this respect, it should be noted that the Regional Planning Commission has formally adopted a policy statement on the review of applications submitted to the Commission for grants-in-aid. This policy requires that adopted plan elements, such as a comprehensive watershed plan, form the basis for review and comment of applications by the Commission. All projects that are the subject of applications are thus either certified as being in conformance with and serving to implement, not in conflict with, or in conflict with adopted regional plan elements. In considering the Regional Planning Commission's findings in this respect, it is 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, in particular the Pike River watershed, are located in that part of the State where the concentration of people is the largest, 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, the completely advisory role of the Commission makes actual implementation of the recommended Pike River watershed plan entirely dependent upon action by 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—counties, cities, villages, and towns—to special-purpose districts, such as metropolitan sewerage districts; 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 public agencies in existence, it becomes 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 are listed and discussed below.[2] 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. The creation of new agencies for watershed plan implementation should be considered only if the existing agencies fail to carry out the plan in a timely manner; and, if found necessary, new agencies should be created in such form as to effectively complement and supplement 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

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[2] *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, 2nd Edition, April 1977, and SEWRPC Technical Report No. 6, Planning Law in Southeastern Wisconsin, 2nd Edition, April 1977.*

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 Pike 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 Pike River watershed plan. The Pike 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 Pike 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, including police powers and acquisition, condemnation (eminent domain), and construction (tax appropriation) powers, important to comprehensive watershed plan implementation.

County Park and Planning Agencies: County government has considerable latitude 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. Instead of organizing such commissions, counties may elect to utilize committees of the county board to perform the park and outdoor recreation and zoning and planning functions. The powers are, however, 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.

In Racine County, responsibility for the acquisition, development, operation, and maintenance of parks and parkways is assigned to the Racine County Highway and Parks Committee of the County Board. Staff services with respect to park and parkway matters are provided by the County Parks Department which reports to the referenced County Board Committee. Planning, zoning, and subdivision plat review functions in Racine County are the responsibility of the Land Use, Agricultural, Environmental, and Extension Education Committee of the County Board. Staff activities in this area are provided by the County Planning and Zoning Department which reports to the referenced County Board Committee. The regulation of onsite sewage disposal systems is also the responsibility of the Land Use, Agricultural, Environmental, and Extension Education Committee of the County Board with staff services in this area provided by the County Department of Environmental Control.

In Kenosha County, responsibility for park and parkway acquisition, development, operation, and maintenance rests with the County Park Commission, which employs a staff. The planning, zoning, plat review, and onsite sewage disposal regulatory functions in Kenosha County are assigned to the Kenosha County Office of Planning, Zoning, and Sanitation under the supervision of the Kenosha County Planning and Zoning Committee.

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. This requirement is met in the Pike River watershed through the Racine County Highway and Parks Committee and the Kenosha County Highway Committee. Each county highway committee is responsible for laying out, constructing, and maintaining all county highways as authorized by the County Board of Supervisors. County highway committees work in close cooperation with the Wisconsin Department of Transportation. The Racine and Kenosha County Highway Committees have important responsibilities in implementation of the Pike River watershed plan with respect to the construction and reconstruction of certain highway bridges within the watershed.

County Land Conservation Committees: In 1982 the State Legislature abolished the former system of county soil and water conservation districts. These districts, while closely allied with county government operations, were in fact separate governmental units. In place of that system, the new legislation requires that the county boards of supervisors create within each county of the State a land conservation committee. In so doing, the State Legislature recognized that the county is the dominant local unit of government responsible for natural resource protection-related programs, and in particular for soil and water conservation programs. The new land conservation committees have a broad range of powers and duties, including the development and adoption of standards and specifications for management practices to control erosion, sedimentation, and nonpoint sources of water pollution; the distribution and allocation of available federal and state cost-sharing funds relating to soil and water conservation; the conduct of research and educational information programs relating to soil and water conservation; the conduct of programs designed to prevent flood damage, drainage, irrigation, groundwater, and surface water problems; the provision of financial, technical, and other assistance to landowners; the acquisition of land and other interests and property; the acquisition of machinery, equipment, and supplies required to carry out various land conservation programs; the construction, improvement, operation, and maintenance of structures needed for land conservation, flood prevention, and nonpoint source pollution control; and the preparation of a long-range natural resource conservation plan for the county, including an erosion control plan and program. As a committee of the county board, all of its activities are closely supervised by the county board and subject to the fiscal resources made available by the county board. Pursuant to the new law, both Racine and Kenosha Counties have created Land Conservation Committees to perform these various functions. Through these committees, both Racine and Kenosha Counties could have important implementation responsibilities not only for land conservation but for flood control measures in the Pike River watershed.

Municipal Planning Agencies: Municipal planning agencies include city, village, and town plan commissions created pursuant to Sections 62.23(1) and 61.35 of the Wisconsin Statutes. Such agencies are important to watershed plan implementation at the local level. All seven communities within the watershed have established plan commissions in accordance with Section 62.23(1) or 61.35 of the Wisconsin Statutes.

Municipal Utility and Sanitary Districts: Municipal utility districts may be created by cities, villages, and towns pursuant to Section 66.072 of the Wisconsin Statutes. Town sanitary districts may be created pursuant to Section 60.30 of the Wisconsin Statutes. Such special districts are authorized to plan, design, construct, operate, and maintain various public utility systems, including sanitary sewerage, water supply, and stormwater drainage systems. At the present time, there exist within the Pike River watershed five such districts: the Town of Mt. Pleasant Utility District No. 1, the Town of Mt. Pleasant Storm Water Drainage District, the Town of Pleasant Prairie Sewer Utility District D, the Town of Somers Utility District No. 1, and the Town of Somers Sanitary District No. 1. All but the Mt. Pleasant Storm Water Drainage District have been formed for the purpose of providing sanitary sewer service. The boundaries of these districts are shown on Map 8, page 34, of this report.

Areawide Agencies

Statutory provisions exist for the creation of the following areawide agencies having both general and specific planning and plan implementation powers potentially applicable to the implementation of the Pike River watershed plan.

Metropolitan Sewerage Districts: Sections 66.20 through 66.26 of the Wisconsin Statutes enables the creation of metropolitan sewerage districts outside of Milwaukee County. Such districts may be formed by the Wisconsin Department of Natural Resources (DNR) upon a request by resolution of the governing body of any municipality sought to be served by such a district. As noted in Chapter IX of this report, the DNR is required to hold a public hearing on the proposal to create a district and, in order for the DNR to order the creation of a district, must make certain findings. Cities and villages owning or operating sewage collection or disposal systems may object to being included in such a district in which case the DNR must honor such objection. No such metropolitan districts have been created to date to serve any portion of the Pike River watershed. In addition to being capable of properly carrying out projects relating to the conveyance and treatment of sanitary sewage, metropolitan sewerage districts may build stormwater drainage and flood control facilities.

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 within more than one municipality and in more than one county. The costs of any drainage improvements are assessed against the lands which are specifically benefited. The boundaries of the existing drainage districts are shown on Map 3, page 20, of this report.

Flood Control Boards: Chapter 87 of the Wisconsin Statutes provides that property owners living in a single, common drainage area may petition the Wisconsin Department of Natural Resources for the formation of a flood control board for the sole purpose of effecting flood control measures. The flood control boards are empowered to straighten, widen, deepen, and otherwise alter watercourses and build flood control works. All activities of such boards are subject to review by, and approval of, the Wisconsin Department of Natural Resources.

Comprehensive River Basin District: Areawide flood control, water quality, and land use plan implementation could be achieved through the establishment of a special comprehensive river basin district encompassing the entire watershed and capable of: raising revenues through taxation and bonding; land acquisition; construction and operation of 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 Pike 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[3] may contract with each other to form cooperative service commissions for the joint provision of any services or joint exercise of any powers that each municipality may be authorized to exercise separately. Such commissions have been given bonding powers for the purposes of acquiring, developing, and equipping land, buildings, and facilities for areawide projects. Economies can often be effected through the provision of 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.

Intergovernmental cooperation under such cooperative contract commissions may range from the sharing of expensive public works equipment to 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.

Regional Planning Commission: Although not a plan implementation agency as such, one other areawide agency warrants comment: the Regional Planning Commission. 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 grant-in-aid applications, 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 Pike River Watershed Committee, which 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 have either general or specific planning authority and hold certain plan implementation powers important to the adoption and implementation of the comprehensive Pike River watershed plan.

Wisconsin Department of Natural Resources (DNR): The DNR has broad authority and responsibility in the areas of park development, natural resources protection, water quality control, and water regulation. The DNR has the obligation to prepare a comprehensive statewide plan for outdoor recreation; and to develop long-range, statewide conservation and water resource plans. In addition, it has the authority to designate such

[3] *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.*

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; and to acquire conservation and scenic easements. The Secretary of the DNR has, pursuant to federal planning guidelines, the responsibility of certifying to the U. S. Environmental Protection Agency (EPA) areawide 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 for the construction of sewerage facilities.

As already noted in Chapter IX 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 DNR are set forth in Chapter 144 of the Wisconsin Statutes. Under this chapter, the DNR 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 Chapter 147 of the Wisconsin Statutes, the DNR 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 legislation establishes a waste discharge permit system and provides that no permit may be issued by the DNR for any discharge from a point source of pollution which is in conflict with any areawide waste water treatment and water quality management plan approved by the DNR. Also under this legislation, the DNR 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 DNR must include the conditions that waste discharges must meet, as applicable, and all effluent limitations, performance standards, effluent prohibitions, and pretreatment standards and any other limitations which must be met to comply with 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, and may include a timetable for appropriate action on the part of the owner or operator of any point waste discharge. This legislation and accompanying procedures is the primary enforcement tool of the Wisconsin Department of Natural Resources in achieving the established water use objectives and supporting water quality standards.

The DNR 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. In addition, the DNR has 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 Department of Health and Social Services. The DNR also has authority to regulate the following: water diversions, shoreland grading, dredging, encroachments, and deposits in navigable waters; the construction of neighboring ponds, lagoons, waterways, stream improvements, and pierhead and bulkhead lines; the construction, maintenance, and abandonment of dams; and water levels of navigable lakes and streams and lake and stream improvements, including the removal of certain lake bed materials. Finally, the DNR has 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 sewerage facilities; 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 DNR will be extremely important to the implementation of nearly all of the major elements of the comprehensive Pike River watershed plan.

Wisconsin Department of Transportation (WisDOT): This Department is broadly empowered to provide the State with an integrated transportation system. The WisDOT is responsible for administering all state and federal aid and highway and airport improvement; for planning, designing, constructing, and maintaining 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, the forest highway system, and the airport aid system, all subject to federal regulation and control. The WisDOT is also responsible for reviewing and approving changes in county trunk highway systems. As such, the WisDOT along with the respective county highway committees of the county boards of supervisors concerned, can contribute to full implementation of the Pike River watershed plan with respect to the construction and reconstruction of certain bridges and highway and airport facilities within the watershed.

Wisconsin Department of Agriculture, Trade, and Consumer Protection: Under the new Wisconsin Soil and Water Conservation Law, state-level soil and water conservation responsibilities have been placed in the Wisconsin Department of Agriculture, Trade, and Consumer Protection. Within that Department, the new law created a seven-member advisory Land Conservation Board. The Land Conservation Board reviews and comments on rules relating to soil and water conservation, administers the state's farmland preservation program, reviews all county erosion control plans and the annual county and long-range county land conservation plans, and generally advises the Secretary of the Wisconsin Department of Agriculture, Trade, and Consumer Protection and the University of Wisconsin on matters relating to soil and water conservation. As such, the Department and its Land Conservation Board will have plan implementation responsibilities relative to the Pike River watershed plan.

University of Wisconsin-Extension: A University of Wisconsin-Extension office is located within each county. Although the Extension has no statutory plan implementation powers, the Extension can aid communities in solving environmental problems by providing educational and informational programs to the general public, and by offering advice to local decision-makers and community leaders. The Extension carries out these responsibilities by conducting meetings, tours, and consultations, and by providing newsletters, bulletins, and research information.

Federal Level Agencies

There exist at the federal level the following agencies which administer federal aid and assistance programs that can have important implications for implementation of the recommended Pike River watershed plan because of their potential impact on the financing of both actual land acquisition and construction of specific facilities.

U. S. Environmental Protection Agency (EPA): The U. S. Environmental Protection Agency administers water quality management planning grants and sanitary sewerage facility construction grants. The latter can be particularly important to implementation of the water quality management element of the Pike River watershed plan. In addition, this agency is responsible for the ultimate achievement and enforcement of water quality standards for all interstate waters, should the states not adequately enforce such standards. In this respect, the EPA has delegated authority over the National Pollutant Discharge Elimination Systems (NPDES) permit issuance process whereby the Wisconsin Department of Natural Resources issues discharge permits under both state and federal authorities. Under guidelines promulgated by the EPA, areawide water quality management and sanitary sewerage facilities plans must be prepared as prerequisites to the receipt of federal capital grants in support of sewerage works construction. As a designated areawide water quality management planning agency under Section 208 of the Federal Water Pollution Control Act, the Regional Planning Commission is engaged in a continuing areawide water quality management planning program for southeastern Wisconsin.

U. S. Geological Survey: This agency conducts continuing programs on water resource appraisal and monitoring. The programs of the U. S. Geological Survey are important to the implementation of the continuous streamflow gaging program recommended in the Pike River watershed plan.

U. S. Department of Agriculture, Agricultural Stabilization and Conservation Service: This agency administers the Federal Agricultural and Conservation Program (ACP). This program provides grants to rural landowners in partial support of carrying out approved land and water conservation practices. Grants from this program could contribute to implementation of the land use and water quality elements of the Pike River watershed plan.

U. S. 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 land conservation committees 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 contribute to implementation of the land management and treatment measures recommended in the Pike River watershed plan.

Federal Emergency Management Agency: The Federal Emergency Management Agency serves as the primary federal agency responsible for emergency matters, including emergencies relating to flooding. Among its activities are the provision of technical assistance programs to state and local governments to reduce or eliminate flood risks and the administration of programs to assist individuals and businesses in obtaining insurance protection against floods. In order to ensure that its residents are eligible for the purchase of flood insurance, local communities must ensure that their floodland zoning regulations meet the minimum standards set forth in rules published by the Federal Emergency Management Agency.

U. S. Army Corps of Engineers: The U. S. Army Corps of Engineers can conduct planning studies and construct flood control facilities as authorized by the U. S. Congress. There are two programs which could be used by the Corps to undertake plan implementation activities in the Pike River watershed. Under Section 205 of the Federal Flood Control Act of 1948, as amended, the Corps is authorized under its small continuing authorities program to contribute to the design and construction phases of certain flood control projects, provided the maximum cost to the Corps is $4 million or less. Projects to be included under this program may be authorized by the Chief of Engineers. A second program, the general investigation program, requires explicit congressional authorization and appropriation. This type of project would be done in several phases, including a three-stage feasibility study followed by a construction phase. Both the feasibility study and the construction phase require explicit congressional approval, and implementation of projects under the program can require more than a decade to accomplish. There is no statutory limit to the funding which can be made available under this program. However, both of the programs require that the projects be demonstrated to be economically feasible and environmentally sound.

While the structural flood control elements comprising the recommended Pike River watershed floodland management plan can be implemented by existing local units and agencies of government, the Corps of Engineers could participate in the implementation of the plan provided that responsible local agencies or units of government are determined to pursue participation in implementation. This would require strong congressional, as well as local, support. Local implementation would be more certain and expeditious, but this certainty and expediency must be weighed by the governing bodies concerned against the potential financial support that may be available for plan implementation.

The Corps of Engineers also administers a regulatory program relating to the discharge of dredge and fill materials into the waters of the United States and adjacent wetlands. This program is administered pursuant to Section 404 of the Federal Water Pollution Control Act as amended in 1972. The administration of this program will have importance with respect to the land use, park and open space, floodland management, and water quality management elements of the Pike River watershed plan.

PLAN ADOPTION AND INTEGRATION

Upon adoption of the Pike 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 Pike River watershed and to all of the existing federal, state, areawide, and local units and agencies of government that have potential plan implementation functions. Adoption, endorsement, or formal acknowledgment of the comprehensive watershed plan by the local legislative bodies and the existing local, areawide, state, and federal level agencies concerned is highly desirable to assure a common understanding among the several governmental levels and to enable their staffs to program the necessary implementation work. This acceptance or acknowledgment is, in some cases, required by the Wisconsin Statutes before certain planning actions can proceed; such a requirement holding in the case of city and village 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 Pike River watershed is included in Appendix J. Adoption of the recommended Pike 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.

Upon adoption or endorsement of the Pike 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 Kenosha County Board of Supervisors formally adopt the Pike River watershed plan by resolution, pursuant to Section 66.945(12) of the Wisconsin Statutes, after a report and recommendation by the County Park Commission, the County Planning and Zoning Committee, the County Highway Committee, and the County Land Conservation Committee.

2. It is recommended that the Racine County Board of Supervisors formally adopt the Pike River watershed plan by resolution, pursuant to Section 66.945(12) of the Wisconsin Statutes, after a report and recommendation by the County Highway and Parks Committee; the County Land Use, Agricultural, Environmental, and Extension Education Committee; and the County Land Conservation Committee.

3. It is recommended that the Plan Commissions of the Cities of Kenosha and Racine, the Villages of Elmwood Park and Sturtevant, and the Towns of Mt. Pleasant, Pleasant Prairie, and Somers adopt the Pike 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 bodies, and that upon such certification the governing bodies also adopt the recommended plan.

4. It is recommended that the governing boards and commissions of the Town of Mt. Pleasant Utility District No. 1, the Town of Pleasant Prairie Sewer Utility District D, the Town of Somers Utility District No. 1, the Town of Somers Sanitary District No. 1, and the Town of Mt. Pleasant Stormwater Drainage District No. 1 adopt the Pike River watershed plan as it affects them by resolution, pursuant to Section 66.945(12) of the Wisconsin Statutes.

Areawide Agencies

1. It is recommended that the Kenosha and Racine County Drainage Boards formally acknowledge the Pike River watershed plan by resolution, pursuant to Section 66.945(12) of the Wisconsin Statutes.

State Level Agencies

1. It is recommended that the Wisconsin Natural Resources Board endorse the comprehensive Pike River watershed plan as an amendment to the previously endorsed regional water quality management plan, certify the plan as an amendment to the regional water quality management plan to the U. S. Environmental Protection Agency, and direct the staff of 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 Board, through its staff, coordinate the recommended Pike River watershed plan with those activities relating to water regulation and control; floodland, shoreland, and wetland zoning; and water quality management planning and water pollution abatement activities.

2. It is recommended that the Secretary of the Wisconsin Department of Transportation endorse the Pike River watershed plan and direct the department staff to give due consideration to the plan in the exercise of its various responsibilities governing the con-

struction and reconstruction of highway and attendant drainage facilities in the watershed.

3. It is recommended that the Secretary of the Wisconsin Department of Agriculture, Trade, and Consumer Protection, upon recommendation of the Land Conservation Board, endorse the Pike River watershed plan and direct the department staff to give due consideration to the plan in the exercise of its various responsibilities governing farmland preservation and soil and water conservation.

Federal Level Agencies

1. It is recommended that the U. S. Environmental Protection Agency formally accept and endorse the Pike River watershed plan as an amendment to the regional water quality management plan upon certification as such by the State of Wisconsin.

2. It is recommended that the U. S. Geological Survey endorse the Pike River watershed plan and continue its cooperative stream gaging program within the watershed.

3. It is recommended that the U. S. Department of Agriculture, Agricultural Stabilization and Conservation Service, formally acknowledge the Pike River watershed plan and utilize the plan recommendations in its administration of the federal agricultural and conservation program.

4. It is recommended that the U. S. Soil Conservation Service formally acknowledge the Pike River watershed plan and utilize the plan recommendations in the administration of its various technical assistance programs relating to soil and water conservation.

5. It is recommended that the Federal Emergency Management Agency formally acknowledge the Pike River watershed plan and use the floodland data contained in that plan as a basis for reviewing and updating its series of federal flood insurance studies.

6. It is recommended that the U. S. Army Corps of Engineers formally acknowledge the Pike 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 elements of the recommended Pike River watershed plan. It is also recommended that the Corps of Engineers use the land use and environmental corridor elements of the plan in carrying out its regulatory program relative to the placement of fill and the conduct of other activities in wetlands.

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 Pike 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, 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 foresaid 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 Pike River Watershed Committee in intergovernmental coordination.

LAND USE PLAN ELEMENT IMPLEMENTATION

The implementation of the land use plan element—including the overall land use, open space preservation, and outdoor recreation components—of the comprehensive Pike 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 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 elements are closely interrelated in nature and support and complement one another, but 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, a great deal will be achieved with respect to flood damage mitigation. Similarly, the maintenance and preservation of primary environmental corridors for natural resource protection and conservancy purposes will, in turn, assure the preservation 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 element, open space preservation plan element, and outdoor recreation plan element. A schedule of capital and operation and maintenance costs for this plan element is set forth in Table 112.

Overall Land Use Plan Element

The overall land use plan element of the Pike River watershed plan is a refinement of the year 2000 regional land use plan which in turn was included within the year 2000 regional water quality management plan. The overall land use plan element deals with land use both within and outside the riverine areas of the watershed.

Implementation of the overall land use plan element can best be accomplished through the adoption of the Pike River watershed plan and the implementation of that plan through local, state, and federal land use and land use-related regulations. The following methods are suggested for use in this respect.

Zoning Ordinances: Of all the land use plan implementation devices, the most readily available, most important, and most versatile are zoning ordinances, including zoning district regulations and zoning district delineations. Within incorporated municipalities in the Pike River watershed, zoning is the responsibility of the Cities of Kenosha and Racine and the Villages of Sturtevant and Elmwood Park. Within the unincorporated portions of the watershed, zoning responsibilities are jointly shared by the Town of Mt. Pleasant and Racine County, and the Towns of Pleasant Prairie and Somers and Kenosha County. In general, it is recommended that each of these local governments with zoning responsibility review and, as necessary, revise their existing zoning ordinances and zoning district maps so as to seek to implement the land use plan element of the Pike River watershed plan. The following suggestions are made to all zoning agencies within the watershed to assist them in this task.

Residential and Related Urban Areas: Not all of the areas shown as devoted to residential and other urban uses in the recommended watershed land use plan should be initially placed in urban land use districts. Only existing and platted but not yet fully developed residential areas and those areas that have immediate development potential which can be economically served by municipal utilities and facilities, and in particular sanitary sewerage and water supply facilities, 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

Table 112

SCHEDULE OF CAPITAL AND OPERATION AND MAINTENANCE COSTS OF THE PARK AND OPEN SPACE PLAN ELEMENT OF THE RECOMMENDED COMPREHENSIVE PLAN FOR THE PIKE RIVER WATERSHED BY YEAR: 1984-2000

		Primary Environmental Corridor (Kenosha County)		Sanders Park Expansion (Racine County)		Recreational Corridor Development (Kenosha County)		Additional Urban Parks (Local Units of Government)		Total	
Calendar Year	Project Year	Acquisition[a]	Operation and Maintenance[b]	Acquisition[c]	Operation and Maintenance[d]	Development[e]	Operation and Maintenance[f]	Acquisition and Development[g]	Operation and Maintenance[h]	Acquisition and Development	Operation and Maintenance
1984	1	$ 205,600	$ 3,060	$ 47,000	$ 5,000	$ --	$ --	$ 149,100	$ 9,100	$ 401,700	$ 17,160
1985	2	205,600	6,120	47,000	10,000	--	--	149,100	18,200	401,700	34,320
1986	3	205,600	9,180	47,000	15,000	--	--	149,100	27,300	401,700	51,480
1987	4	205,600	12,240	47,000	20,000	--	--	149,100	36,400	401,700	68,640
1988	5	205,600	15,300	--	20,000	--	--	149,200	45,500	354,800	80,800
1989	6	205,600	18,360	--	20,000	--	--	149,100	54,600	354,700	92,960
1990	7	205,600	21,420	--	20,000	--	--	149,100	63,700	354,700	105,120
1991	8	205,600	24,480	--	20,000	--	--	149,100	72,800	354,700	117,280
1992	9	205,600	27,540	--	20,000	--	--	149,100	81,800	354,700	129,340
1993	10	205,600	30,600	--	20,000	--	--	149,100	90,900	354,700	141,500
1994	11	--	30,600	--	20,000	--	--	149,200	100,000	149,200	150,600
1995	12	--	30,600	--	20,000	--	--	149,100	109,100	149,100	159,700
1996	13	--	30,600	--	20,000	45,900	840	149,100	118,200	195,000	169,640
1997	14	--	30,600	--	20,000	45,900	1,680	149,100	127,300	195,000	179,580
1998	15	--	30,600	--	20,000	45,900	2,520	149,100	136,300	195,000	189,420
1999	16	--	30,600	--	20,000	45,900	3,360	149,100	145,400	195,000	199,360
2000	17	--	30,600	--	20,000	45,900	4,200	149,200	154,500	195,100	209,300
Watershed Total		$2,056,000	$382,500	$188,000	$310,000	$229,500	$12,600	$2,535,000	$1,391,100	$5,008,500	$2,096,200
Annual Average		$ 120,900	$ 22,500	$ 11,100	$ 18,200	$ 13,500	$ 800	$ 149,100	$ 81,800	$ 294,600	$ 123,300

NOTE: All costs are estimated in constant 1980 dollars.

[a] *Assumes that 10 percent of the recommended 612 acres of primary environmental corridor land would be acquired in each of the first 10 years of plan implementation at an estimated average cost of about $3,400 per acre.*

[b] *Based on an annual operation and maintenance cost of $50 per acre for primary environmental corridor land.*

[c] *Assumes that 25 percent of the 40-acre Sanders Park addition would be acquired in each of the first four years of plan implementation at an estimated average cost of about $4,700 per acre.*

[d] *Based on an annual operation and maintenance cost of $500 per acre for major park land.*

[e] *Assumes that 20 percent of the recommended seven-mile recreation corridor along the main stem of the Pike River between Petrifying Springs County Park and the existing Kenosha County Bikeway would be developed in each of the final five years of plan implementation at an estimated average cost of about $32,800 per mile.*

[f] *Based on an annual operation and maintenance cost of $600 per mile for recreational trails.*

[g] *Assumes that the acquisition and development costs for the 12 proposed additional urban parks would be evenly distributed over the 17-year plan implementation period.*

[h] *Based on an annual operation and maintenance cost of $750 per acre for urban parks.*

Source: SEWRPC.

development. Such holding districts should be rezoned into the appropriate residential zoning district or supporting land use district, such as business or industrial districts, only when the community can economically and efficiently accommodate the proposed development. Certain residential areas may be initially zoned for very low density "country estate" and related rural and outdoor recreational uses. All residential zoning, however, should be properly related to the inherent suitabilities of the underlying soil resource base.

Agricultural Areas: Areas shown as prime agricultural land in the recommended watershed land use plan should be placed in an exclusive agricultural use district which essentially permits only agricultural uses and which prohibits land division into parcels of less than 35 acres in size. The enactment of such zoning will serve to qualify farmers whose lands are so zoned and who farm at least 35 acres for available state income tax credits. Significant wetlands, woodlands, and wildlife habitat areas that may lie outside the primary environmental corridors but within the general agricultural use areas on the land use plan map should be placed in appropriate conservancy zoning districts.

Primary Environmental Corridors: The primary environmental corridors shown on the recommended watershed land use plan should be placed 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 base conservation objectives of the watershed plan. Prime wildlife habitat areas, wetlands, woodlands, and undeveloped floodlands lying in corridors generally 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 private and public recreational facilities. The remaining area lying in the corridors may then be placed in agricultural or rural residential use districts, depending upon the limitations of the soils for the use of onsite sewage disposal systems.

Floodlands: Floodland regulations should be reviewed and updated as necessary in order to ensure the substantial maintenance in open uses of all undeveloped floodways and floodplains in the watershed. Either a basic floodland use district or an overlay floodland use district approach may be taken, depending upon local preference. In those cases where urban development already exists in the floodplain and where the watershed plan recommends structural measures for abatement of flood damages, including structure floodproofing and elevation, the construction of dikes, and the undertaking of channel improvements, it will be necessary to identify for selected stream reaches floodway districts so as to permit the placement of such existing urban development into floodplain fringe overlay districts, thereby avoiding rendering such uses nonconforming and at the same time ensuring that appropriate regulations are in place attendant to any future development.

Sanitary Sewer Extension Review: The Wisconsin Department of Natural Resources (DNR) must review and approve all locally proposed extensions of public sanitary sewer systems. It is recommended that the DNR review all such extensions against the basic land use recommendations contained in the Pike River watershed plan, ensuring that the development proposed to be served by extended sanitary sewers is compatible with the plan recommendations. Sanitary sewer extensions should not be approved in those instances where, for example, they are intended to serve urban development that might be located within primary environmental corridors or on prime agricultural lands.

Wetland Regulation: It is recommended that the DNR and the U. S. Army Corps of Engineers, in the administration of their various wetland regulatory programs, take into account the land use development, park and open space preservation and protection, and floodland management recommendations contained in the Pike River watershed plan. It should be noted that the plan recommendations include some that would seek to preserve and protect existing wetlands, and others that could result in the destruction of certain wetlands. It is accordingly recommended that the state and federal agencies concerned recognize the comprehensive nature of the Pike River watershed plan, making agency decisions on wetland regulation in a manner consistent with that plan. It is also recommended that counties, cities, and villages—all of which are now mandated by state law to enact protective wetland zoning attendant to all wetlands five acres or more in size within shoreland areas—take steps to adopt local zoning regulations to protect wetlands in a manner consistent with the recommended plan.

Open Space Preservation Plan Element

Implementation of the foregoing recommendations relating to the enactment of proper zoning attendant to primary environmental corridors, agricultural areas, woodlands, wetlands, and wildlife habitat areas will substantially contribute to implementation of the open space preservation plan element. In addition to the aforenoted regulatory actions, however, the plan recommends that those primary environmental corridor lands not already in public ownership—such as the corridor lands on the University of Wisconsin-Parkside campus—or in compatible private ownership—such as the corridor lands located through the Kenosha Country Club—be publicly acquired through whatever means possible, including purchase, dedication, and gift. Such lands total 612 acres in area and lie primarily along the Pike River from the mouth upstream to Petrifying Springs County Park, along the Sorenson Creek upstream from the confluence with the Pike River, and along Pike Creek upstream from the confluence with the Pike River. It is recommended that the Kenosha County Park Commission gradually acquire these undeveloped primary environmental corridor lands and preserve such lands in their natural state. This land acquisition recommendation was previously made in the regional park and open space plan and the more detailed park and open space plan prepared by the Commission jointly for the City of Kenosha and the Towns of Somers and Pleasant Prairie.

Secondary environmental corridors in the watershed are located along the Pike River through the Town of Mt. Pleasant, along the Pike Creek in the Towns of Somers and Pleasant Prairie, and along many of the more minor streams tributary to the Pike River and Pike Creek. Such secondary corridors are important, particularly since they serve as drainageways, and within developing urban areas can provide urban open spaces and locations for local parks. It is recommended that the local municipalities involved appropriately zone such secondary environmental corridor lands through the use of conservancy and floodland zoning and take such corridors into account in the land development process, perhaps incorporating such corridors into urban stormwater detention areas, associated drainageways, and neighborhood parks as may be required.

Outdoor Recreation Plan Element

In addition to continuing to maintain Petrifying Springs County Park as a large multipurpose outdoor recreation facility, it is recommended that the Kenosha County Park Commission assume responsibility for development of an approximately seven-mile recreational corridor along the main stem of the Pike River from Petrifying Springs County Park to Lake Michigan. It is recommended that Racine County, through its Highway and Parks Committee, continue to maintain Sanders Park in the Town of Mt. Pleasant and expand the site through the acquisition of about 40 acres. Finally with respect to the major parks in the watershed, it is recommended that the City of Kenosha complete the development of outdoor recreation facilities at Sam Poerio Park.

It is also recommended that the City of Kenosha, the Villages of Elmwood Park and Sturtevant, and the Towns of Mt. Pleasant and Somers continue to maintain the four existing community and neighborhood parks in the watershed, and over time, as the need for parks becomes evident, acquire and develop 12 new community and neighborhood parks.

FLOODLAND MANAGEMENT PLAN ELEMENT IMPLEMENTATION

The major floodland mangement recommendation contained in the Pike 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 primary environmental corridor lands along the Lower Pike River and Sorenson Creek. The application of floodland zoning was discussed in the previous section of this chapter. It is important to note, however, that the floodland zoning measures to be applied need to be coordinated with the implementation of the structural flood control measures described below. That is, the local zoning agencies, and in particular the Counties of Kenosha and Racine, need to apply appropriate floodland zoning to the existing floodlands in the watershed, particularly along the Pike Creek and the Upper Pike River, based upon future land use and existing channel conditions until such time as the recommended flood control measures in the form of channel improvements are undertaken. At that time, the floodland zoning regulations may be adjusted to reflect the improvements that have actually been put in place.

In addition to implementing sound floodland zoning, implementation of the floodland management plan element requires consideration of the structural measures for flood damage abatement, bridge replacement, maintenance of stream channels and hydraulic structure waterway openings, flood insurance, lending institution and realtor policies, and the maintenance of a stream gaging network. The implementation of each of these items is discussed below, while a schedule of the capital and operation and maintenance costs for this plan element is set forth in Table 113.

Pike Creek Channel Improvements

It is recommended that the Town of Somers create a sanitary district to undertake the necessary channel improvements, including bridge replacement, along Pike Creek. This includes the undertaking of channel cleaning and debrushing activities along Pike Creek from the confluence with the Pike River upstream to the confluence with Somers Branch, and the channel widening and deepening and bridge replacement activities required along the Pike Creek upstream from the confluence with the Somers Branch.

Airport Branch Channel Improvements

It is recommended that the City of Kenosha undertake any future channel improvements and related bridge replacement along the Airport Branch and the Tributary to Airport Branch. As noted in Chapter XIV, the undertaking of these channel improvements would be necessary only if it were to be ultimately determined to develop the lands generally lying east of the Kenosha Municipal Airport for industrial purposes, and then only if it were to be determined that it was desirable to fill the existing floodplains to permit additional industrial land use development. Those determinations can only be made at such time as the City of Kenosha makes a decision to extend its industrial park in a westerly direction from the Chicago & North Western Railroad tracks to the Kenosha Municipal Airport. The proposed channel improvements along the Airport Branch and the Tributary to Airport Branch should not, however, be undertaken without prior implementation of the

Table 113

SCHEDULE OF CAPITAL AND OPERATION AND MAINTENANCE COSTS OF THE FLOODLAND MANAGEMENT ELEMENT OF THE RECOMMENDED COMPREHENSIVE PLAN FOR THE PIKE RIVER WATERSHED BY YEAR: 1984-2000

Calendar Year	Project Year	Channel Improvements and Bridge Replacement Along Pike Creek (New Sanitary District)		Channel Improvements and Bridge Replacement Along the Airport Branch and Tributary to Airport Branch (City of Kenosha)		Channel Improvements and Bridge Replacement Along the Upper Pike River (Mt. Pleasant Stormwater Drainage District)		Dike Upstream of Spring Street on the Bartlett Branch (Mt. Pleasant Stormwater Drainage District)	
		Construction	Operation and Maintenance	Construction	Operation and Maintenance	Construction	Operation and Maintenance	Construction	Operation and Maintenance
1984	1	$ --	$ --	$ --	$ --	$ --	$ --	$37,900	$ 300
1985	2	--	--	--	--	--	--	--	300
1986	3	225,200	1,600	--	--	277,200	1,500	--	300
1987	4	225,200	3,200	--	--	277,200	3,000	--	300
1988	5	225,200	4,800	--	--	277,200	4,500	--	300
1989	6	225,200	6,400	--	--	277,200	6,000	--	300
1990	7	225,200	8,100	171,400	200	277,200	7,600	--	300
1991	8	--	8,100	171,400	400	--	7,600	--	300
1992	9	--	8,100	171,400	600	--	7,600	--	300
1993	10	--	8,100	171,400	800	--	7,600	--	300
1994	11	--	8,100	171,400	1,000	--	7,600	--	300
1995	12	--	8,100	--	1,000	--	7,600	--	300
1996	13	--	8,100	--	1,000	--	7,600	--	300
1997	14	--	8,100	--	1,000	--	7,600	--	300
1998	15	--	8,100	--	1,000	--	7,600	--	300
1999	16	--	8,100	--	1,000	--	7,600	--	300
2000	17	--	8,100	--	1,000	--	7,600	--	300
Watershed Total		$1,126,000	$105,100	$857,000	$9,000	$1,386,000	$98,600	$37,900	$5,100
Annual Average		$ 66,200	$ 6,200	$ 50,400	$ 500	$ 81,500	$ 5,800	$ 2,200	$ 300

Calendar Year	Project Year	Kenosha Country Club Dike System (Kenosha Country Club)		Dike System on Lower Pike River (New Drainage District)		Jetties and Dredging at Mouth of Pike River (City of Kenosha Park Commission)		Structure Floodproofing and Elevation on Somers Branch (Town of Somers)	Structure Floodproofing and Elevation on Bartlett Branch (Town of Mt. Pleasant)
		Construction	Operation and Maintenance	Construction	Operation and Maintenance	Construction	Operation and Maintenance		
1984	1	$ --	$ --	$ --	$ --	$ --	$ --	$ --	$ --
1985	2	--	--	--	--	47,500	--	10,700	19,300
1986	3	181,500	1,700	294,300	3,100	47,500	1,100	10,700	19,300
1987	4	181,500	3,500	294,300	6,200	--	1,100	10,700	19,300
1988	5	--	3,500	294,300	9,300	--	1,100	10,700	19,300
1989	6	--	3,500	--	9,300	--	1,100	10,700	19,300
1990	7	--	3,500	--	9,300	--	1,100	--	--
1991	8	--	3,500	--	9,300	--	1,100	--	--
1992	9	--	3,500	--	9,300	--	1,100	--	--
1993	10	--	3,500	--	9,300	--	1,100	--	--
1994	11	--	3,500	--	9,300	--	1,100	--	--
1995	12	--	3,500	--	9,300	--	1,100	--	--
1996	13	--	3,500	--	9,300	--	1,100	--	--
1997	14	--	3,500	--	9,300	--	1,100	--	--
1998	15	--	3,500	--	9,300	--	1,100	--	--
1999	16	--	3,500	--	9,300	--	1,100	--	--
2000	17	--	3,500	--	9,300	--	1,100	--	--
Watershed Total		$363,000	$50,700	$882,900	$130,200	$95,000	$16,500	$53,500	$96,500
Annual Average		$ 21,400	$ 3,000	$ 51,900	$ 7,700	$ 5,600	$ 1,000	$ 3,100	$ 5,700

Calendar Year	Project Year	Structure Floodproofing and Elevation on Lower Pike River (Town of Somers)	Chicory Road Bridge Replacement (Mt. Pleasant Stormwater Drainage District)	Streamflow Gaging (City of Kenosha Water Utility)	Total	
					Capital	Operation and Maintenance
1984	1	$ --	$ --	$ 7,000	$ 37,900	$ 7,300
1985	2	16,900	90,300	7,000	184,700	7,300
1986	3	16,900	--	7,000	1,072,600	16,300
1987	4	16,900	--	7,000	1,025,100	24,300
1988	5	16,900	--	7,000	843,600	30,500
1989	6	16,900	--	7,000	549,300	33,600
1990	7	--	--	7,000	673,800	37,100
1991	8	--	--	7,000	171,400	37,300
1992	9	--	--	7,000	171,400	37,500
1993	10	--	--	7,000	171,400	37,700
1994	11	--	--	7,000	171,400	37,900
1995	12	--	--	7,000	--	37,900
1996	13	--	--	7,000	--	37,900
1997	14	--	--	7,000	--	37,900
1998	15	--	--	7,000	--	37,900
1999	16	--	--	7,000	--	37,900
2000	17	--	--	7,000	--	37,900
Watershed Total		$84,500	$90,300	$119,000	$5,072,600	$534,200
Annual Average		$ 5,000	$ 5,300	$ 7,000	$ 298,400	$ 31,400

Source: SEWRPC.

recommended channel improvements along the Pike Creek.

Upper Pike River Channel Improvements

It is recommended that the Mt. Pleasant Stormwater Drainage District undertake the necessary channel improvements and related bridge replacement along the Upper Pike River. Such improvements would extend from CTH C downstream to the confluence with the Pike River in Petrifying Springs County Park. In this respect, the cooperation of the Kenosha County Park Commission will be required in order to ensure that the channel improvements at and immediately upstream from the confluence with the Pike Creek are carried out in a manner compatible with preservation to the maximum extent practicable of the natural environment in this area.

Bartlett Branch Dike

It is recommended that the Mt. Pleasant Stormwater Drainage District undertake the construction of a dike along the Bartlett Branch upstream of Spring Street. This would include acquisition of land for the dike, as well as any additional adjacent land necessary to permit local stormwater drainage behind the dike to percolate into the groundwater system.

Lower Pike River Dike System

As described in Chapter XIV, the watershed plan recommends the construction of a system of dikes on the Lower Pike River extending downstream from CTH G to about one-quarter mile downstream of the Chicago & North Western Railroad crossing. This reach includes the Pike River through the Kenosha Country Club grounds. Such a system of dikes would be advantageous to the operations of the Kenosha Country Club, eliminating inundation from floods having a recurrence interval of up to and including 10 years; reducing the damages to golf course tees, greens, and traps; reducing grounds maintenance costs after flood events; and increasing the average number of days during the year in which the course can be played. Upstream and downstream of the Kenosha Country Club the system of dikes would protect existing farms from agricultural flood damages caused by floods having a recurrence interval of up to 10 years. The benefits and costs of the system of dikes upstream and downstream of the Kenosha Country Club are described in Chapter XIV of this report, together with other considerations, such as the planned conversion of many of the farms currently experiencing flood damages along the Lower Pike River from rural to urban use over the next two decades.

It is recommended that the Town of Somers assume the leadership required to facilitate further consideration of the construction of the recommended dike system along the Lower Pike River, including through the Kenosha Country Club grounds. More specifically, it is recommended that the Town of Somers undertake the necessary preliminary engineering study to select a final level of protection and configuration for the dike system and prepare final cost estimates. Upon completion of the preliminary engineering studies, should it be determined to be desirable to proceed with construction of the dike system, it is recommended that a Lower Pike River Drainage District be created under the aegis of the Kenosha County Drainage Board to include all of the benefited properties. The potential boundaries of such a district are shown on Map 92. The dike construction would be carried out by the Drainage District with the necessary funds provided by assessment of the benefited properties.

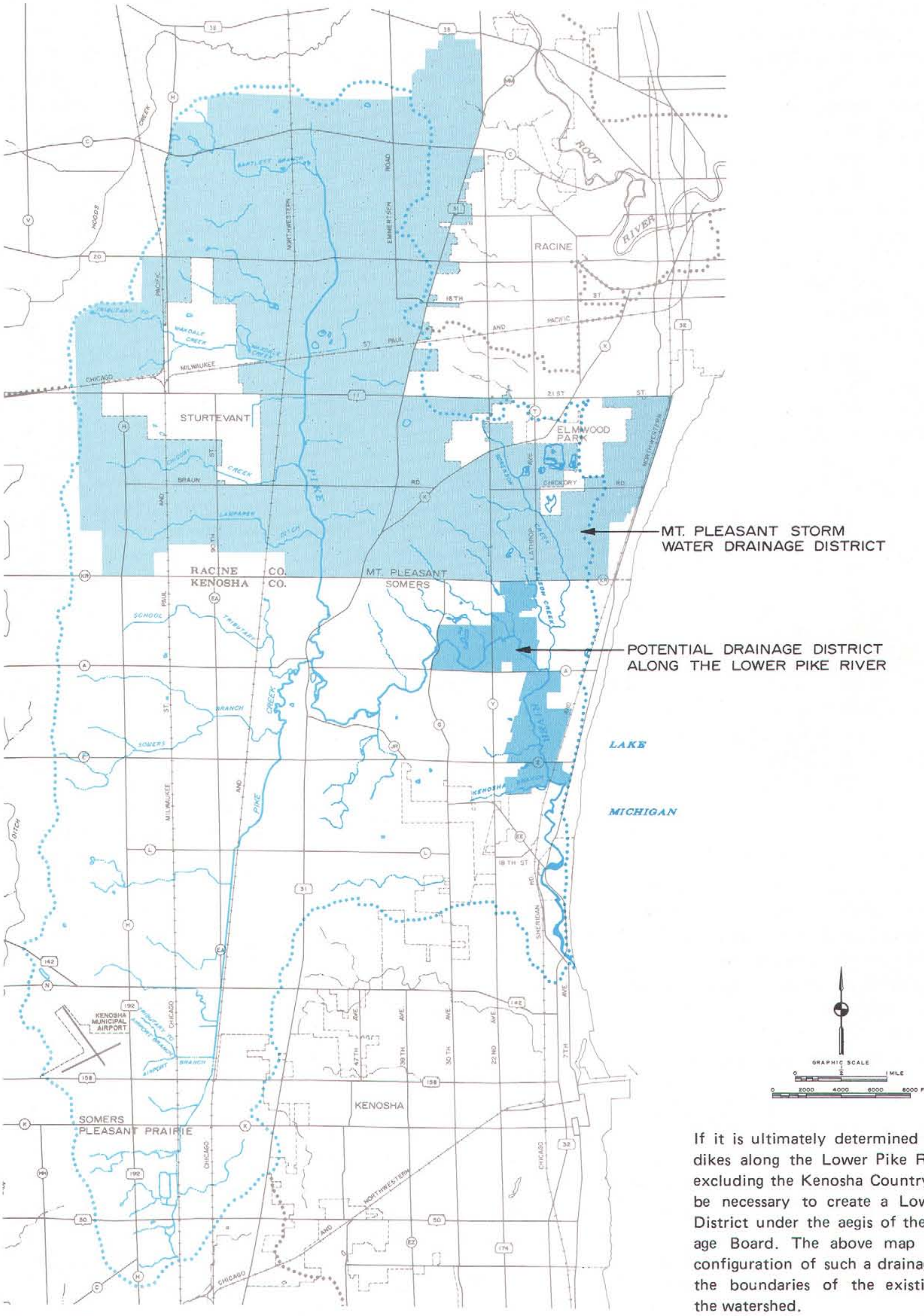
Should there be no consensus among the interests concerned on when to proceed with construction of the dike system following the preliminary engineering study, then each individual property owner would have to decide whether or not to individually undertake construction of portions of the dike system. Such an approach would be feasible for most property holdings, and particularly so for the Kenosha Country Club since the proposed dike system through the Country Club grounds could be constructed entirely by the Country Club without need for cooperative action by adjacent land owners.

Pike River Mouth Jetties and Dredging

It is recommended that the City of Kenosha Park Commission undertake the construction of the two parallel jetties and the dredging of the channel bottom between the jetties required to maintain channel flow capacity at the mouth of the Pike River at the shoreline of Lake Michigan. The City of Kenosha Park Commission has jurisdiction over the adjacent lands and is in the best position to carry out these particular flood control recommendations. It is further recommended that the City of Kenosha Park Commission seek a lakebed grant from the State Legislature for the lands that would be involved in the jetty construction and channel maintenance project. Securing such a lakebed grant would ensure that the City of Kenosha Park Commission would be free from any requirement to obtain a state permit to undertake the jetty construction and channel maintenance activities.

Map 92

BOUNDARIES OF THE MT. PLEASANT STORMWATER DRAINAGE DISTRICT AND THE POTENTIAL DRAINAGE DISTRICT ALONG THE LOWER PIKE RIVER



Source: SEWRPC.

If it is ultimately determined to construct a system of dikes along the Lower Pike River—either including or excluding the Kenosha Country Club—then it will likely be necessary to create a Lower Pike River Drainage District under the aegis of the Kenosha County Drainage Board. The above map identifies one potential configuration of such a drainage district, together with the boundaries of the existing drainage district in the watershed.

Chicory Road Bridge Replacement

It is recommended that the Mt. Pleasant Stormwater Drainage District undertake the proposed replacement of the Chicory Road bridge on Sorenson Creek. Replacement of this bridge would significantly abate the backwater effects that are currently caused by the inadequate structure.

Structure Floodproofing and Elevation

The recommended plan calls for structure floodproofing and elevation measures to be undertaken at several locations in the watershed, including along the Somers Branch and the Lower Pike River in the Town of Somers and City of Kenosha; and along the Bartlett Branch in the Town of Mt. Pleasant. Structure floodproofing and elevation would be undertaken by the property owners directly affected; as, for example, by Carthage College with respect to its field house located near the Lower Pike River, and the former Valley Supper Club with respect to its building also located near the Lower Pike River. It is recommended, however, that the two towns involved and the City of Kenosha make available at the request of, and at no cost to, the property owners concerned through their town engineers the professional services required to prepare plans for floodproofing and elevation of the individual buildings involved. In addition, it is recommended that the Towns of Somers and Mt. Pleasant and the City of Kenosha review their local building ordinances to ensure that appropriate regulations dealing with structure floodproofing are included. In addition, it is recommended that these local units of government explore on behalf of the property owners directly affected any available state and/or federal aids for such floodproofing measures.

Stream Flow Gaging

It is recommended that the City of Kenosha Water Utility, the U. S. Geological Survey, and the Regional Planning Commission continue the cooperative effort involved in maintaining the existing continuous recorder stream gaging station on the Pike River at the University of Wisconsin-Parkside campus. It is also recommended that the U. S. Geological Survey and the Wisconsin Department of Transportation continue to maintain the partial record peak-flow gage on Pike Creek at STH 142.

Bridge Replacement

It is recommended that the Wisconsin Department of Transportation, the Racine and Kenosha County Highway Committees, and any local units of government constructing or financing new bridges or replacing existing bridges over the stream channel system of the Pike River watershed design and construct such bridges in accordance with the water control facility objectives set forth in Chapter X of this report. It is further recommended that the highway agencies involved coordinate the replacement of any highway bridges with the agencies designated as being responsible for the construction of recommended channel improvements, particularly along Pike Creek and the Upper Pike River.

Flood Insurance

It is recommended that Kenosha and Racine Counties and the local units of government in the watershed continue to participate in the Federal Flood Insurance Program. It is further recommended that the Federal Emergency Management Agency take the data and information developed under the Pike River watershed study into account at such time as it may undertake revisions to the federal flood insurance studies that have been completed for the communities in the Pike River watershed. It is also recommended that owners of property in flood-prone areas purchase flood insurance for protection against losses sustained in future floods.

Lending Institutions and Realtor Policies

It is recommended that lending institutions continue to determine the flood-prone status of properties prior to granting of a mortgage. It is also recommended that real estate brokers and their agents continue to inform potential purchasers of property of any flood hazard which may exist at the site.

Maintenance of Stream Channels and Hydraulic Structure Waterway Openings

It is recommended that all governmental units and agencies in the watershed having jurisdiction over the highway and stream system, and in particular the Mt. Pleasant Stormwater Drainage District, 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 major water quality management recommendations contained in the Pike River watershed plan relate to the abandonment of the Somers sewage treatment facility, the elimination of the remaining six sanitary sewerage system flow relief devices in the watershed, the abatement of pollution from

Table 114

SCHEDULE OF CAPITAL AND OPERATION AND MAINTENANCE COSTS OF THE WATER QUALITY MANAGEMENT PLAN ELEMENT OF THE RECOMMENDED COMPREHENSIVE PLAN FOR THE PIKE RIVER WATERSHED BY YEAR: 1984-2000

Calendar Year	Project Year	Abandonment of Somers Sewage Treatment Plant (Town of Somers Utility District No. 1 and City of Kenosha)		Urban and Rural Diffuse Water Pollution Source Management Practices (designated management agencies)		Water Quality Monitoring Program (Wisconsin Department of Natural Resources)		Total	
		Capital	Operation and Maintenance	Capital	Operation and Maintenance	Capital	Operation and Maintenance	Capital	Operation and Maintenance
1984	1	$ 100,000	$ - -	$ 583,000	$ 30,000	$ - -	$ - -	$ 683,000	$ 30,000
1985	2	744,000	- -	583,000	60,000	- -	- -	1,327,000	60,000
1986	3	743,000	16,000	583,000	90,000	- -	17,000	1,326,000	106,000
1987	4	- -	16,000	583,000	120,000	- -	- -	583,000	136,000
1988	5	- -	16,000	583,000	150,000	- -	- -	583,000	166,000
1989	6	- -	16,000	583,000	152,000	- -	- -	583,000	168,000
1990	7	- -	16,000	584,000	152,000	- -	- -	584,000	168,000
1991	8	- -	16,000	584,000	152,000	- -	17,000	584,000	168,000
1992	9	- -	16,000	427,000	152,000	- -	- -	427,000	168,000
1993	10	- -	16,000	427,000	152,000	- -	- -	427,000	168,000
1994	11	- -	16,000	427,000	152,000	- -	- -	427,000	168,000
1995	12	- -	16,000	427,000	152,000	- -	- -	427,000	168,000
1996	13	- -	16,000	427,000	152,000	- -	17,000	427,000	168,000
1997	14	- -	16,000	427,000	152,000	- -	- -	427,000	168,000
1998	15	- -	16,000	427,000	152,000	- -	- -	427,000	168,000
1999	16	- -	16,000	427,000	152,000	- -	- -	427,000	168,000
2000	17	- -	16,000	427,000	152,000	- -	- -	427,000	168,000
Watershed Total		$1,587,000	$240,000	$8,509,000	$2,274,000	$ - -	$51,000	$10,096,000	$2,565,000
Annual Average		$ 93,400	$ 14,100	$ 500,500	$ 133,800	$ - -	$ 3,000	$ 593,900	$ 150,900

Source: SEWRPC.

industrial waste discharges, the abatement of pollution from diffuse sources, and the conduct of a water quality monitoring program. The following addresses each of these subelements of the plan by responsible unit or agency of government, while a schedule of the capital and operation and maintenance costs for this plan element is set forth in Table 114.

Abandonment of Somers Sewage Treatment Facility

It is recommended that the Town of Somers Utility District No. 1 and the City of Kenosha cooperatively work toward abandonment of the Somers sewage treatment facility as soon as possible. Owing to funding constraints, it is recognized that the construction of the long-planned extension of the Parkside trunk sewer, as envisioned in the areawide water quality management plan, may have to be deferred perhaps beyond the planning period for the watershed plan. Accordingly, it is recommended that consideration be given by the Town of Somers and the City of Kenosha to immediate construction of an interim connection that would provide for abandonment of the Somers sewage treatment facility by means of a combination gravity flow sewer and pumping station and force main system. The implementation of this measure would remove the last sewage treatment plant discharge from the Pike River system.

Elimination of Sewage Flow Relief Devices

The only remaining devices providing sanitary sewerage system flow relief by discharging new sewage to the stream system of the Pike River watershed are five crossovers from the sanitary sewer system to the storm sewer system in the City of Kenosha, two of which are proposed to be maintained to serve pumping stations in emergency purposes. It is recommended that the City of Kenosha take timely action to eliminate the remaining three crossovers, including the construction of relief sewers as may be necessary.

Abatement of Pollution from Industrial Waste Discharges

It is recommended that the five existing, and any future, industrial point sources of pollution discharging directly or indirectly to the Pike River watershed stream system be controlled. The method of control is the setting of discharge limitations for each outfall by the Wisconsin Department of Natural Resources under the Wisconsin Pollutant Discharge Elimination System (WPDES).

Abatement of Pollution From Diffuse Sources

It is recommended that the communities within the watershed use a judicious blend of education and regulation to encourage citizens to apply low-cost measures such as, for urban areas, control of litter and pet waste; proper application of chemical and organic fertilizers and pesticides to lawns and shrubbery; and, for rural areas, minimum soil conservation practices. All critical areas of upland, shoreland, and stream bank erosion should be identified and protected in both urban and rural areas. It is also recommended that, through local building codes, builders be required to control soil erosion during demolition and construction activities, and that proper storage and runoff control be provided for all facilities handling materials which may be hazardous to the environment. The University of Wisconsin-Extension should provide assistance in the public education process required to control litter and pet wastes and in the application of fertilizers and pesticides. The U. S. Soil Conservation Service should provide technical assistance in the development of specific diffuse source pollution control measures by local communities. In addition, it is recommended that Kenosha and Racine Counties continue to regulate the installation and maintenance of septic tank systems through their respective sanitary codes. It is further recommended that local public works departments examine the manner in which municipal services, such as street and storm sewer system cleaning and maintenance and garbage collection, are performed to determine if the amount of dust, dirt, and litter that accumulates on the road surfaces and adjacent areas and that is, therefore, subject to washoff to the stream system can be significantly reduced, particularly in advance of major runoff events, with marginal increases in cost. Finally, it is recommended that proper application and control of street deicing material be practiced by the necessary agencies within the watershed to minimize the chloride loadings to the surface waters of the Pike River watershed.

Continuing Water Quality Monitoring Program

It is recommended that the Regional Planning Commission in cooperation with the Wisconsin Department of Natural Resources and the major units of government in the Pike River watershed develop and implement a continuing water quality monitoring program. Such a program would demonstrate and document the changes in surface water quality attendant to implementation of the Pike River watershed plan and would help detect, locate, and control future sources of pollution.

FINANCIAL AND TECHNICAL ASSISTANCE

Upon adoption of the various land use, park and open space, floodland management, and water quality management plan elements and any necessary schedules of capital costs and operation and maintenance expenditures, it becomes important for 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. In addition to using current tax revenue sources, such as property taxes, fees, fines, public utility earnings, highway aids, and state-shared taxes, the local units of government can make use of such revenue sources 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 available ranges 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 Service and the Regional Planning Commission itself.

Borrowing

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 their taxable property, with certain exceptions, including school bonds and revenue bonds. Such borrowing powers, which are related directly to implementation of the comprehensive Pike River watershed plan, include the following:

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. 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.

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.

Community Development Block Grant 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, provides grants to local units of government for a variety of purposes, including the construction or improvement of public utilities and facilities, economic development activities, and housing rehabilitation. These grants are available as entitlement grants to cities with populations in excess of 50,000 and are available as "small city grants" to communities of less than 50,000 persons. The latter are made in Wisconsin through the Wisconsin Department of Development.

State Water Pollution Prevention and Abatement Program

A state water pollution prevention and abatement program was established in 1978. This program is referred to as the "Wisconsin Fund" and is administered by the Wisconsin Department of Natural Resources pursuant to rules set forth in Chapter NR 128 of the Wisconsin Administrative Code. The program 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 where new sewage treatment plants are being built in unsewered communities; and other appurtenances. Only that portion of the project required to accommodate 10 years of development in the tributary area is eligible for assistance. For nonfederally aided projects, the state grant may cover as much as 75 percent of the total cost of facilities planning activities, and up to 60 percent of the eligible costs of construction. For projects receiving federal aid, the state grant may be combined with federal assistance to provide a maximum of 75 percent of the eligible cost of the project.

State Water Quality Nonpoint Control Grants Program

As an element of the Wisconsin Fund, this program is administered by the Wisconsin Department of Natural Resources to provide grants for urban and rural nonpoint source controls. The grant share is not to exceed 50 percent of the cost of implementing the eligible land management practices. However, when combined with federal grant assistance, up to 70 percent grant shares may be provided.

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 Water Resources Investigation Program

The U. S. 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 approval of a particular project by the U. S. Congress. After feasibility studies and public hearings, the U. S. Army Corps of Engineers will undertake the construction of such flood control works as channel improvements, dikes and floodwalls, and reservoirs. Costs for all lands, easements, and necessary rights-of-way and all other such costs, however, must be provided by the local unit of government in accordance with established cost-sharing policies. In addition, the local unit of government must agree to maintain and operate all facilities constructed under the program in accordance with regulations prescribed by the Secretary of the Army.

The U. S. Army Corps of Engineers can undertake flood control projects under two separate authorities. Under Section 205 of the Federal Flood Control Act of 1948 as amended, the Corps is authorized to contribute to the design and construction phases of relatively small-scale flood control projects, provided that the maximum cost to the Corps is $4 million or less. Projects eligible under this program can be authorized directly by the Chief of Engineers and, therefore, project implementation times are shorter than under the other Corps' program, typically approximately five to 10 years. A second program, the general investigation program, requires explicit congressional authorization and appropriation. This type of project requires implementation in several phases over many years, including completion of a three-stage feasibility study followed by a construction phase. Both the feasibility study and the construction phase require explicit congressional approval, and implementation of projects under this program typically require from 20 to 30 years to accomplish. Under both Corps' programs, the projects must be demonstrated to be economically feasible and environmentally sound. Flood control projects within the Pike River watershed are relatively small and could possibly be undertaken under the small-scale program of the Corps noted above.

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. 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 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 Service, 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. 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. The Wisconsin Department of Natural Resources also 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.

Areawide Agencies: The Southeastern Wisconsin Regional Planning Commission provides 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; preparation of special base and soil mapping; preparation of suggested zoning, official mapping, and land division ordinances; provision of information regarding federal and state aid programs; and 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 land conservation committees 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.

SUMMARY

This chapter has described the various means available and recommended specific procedures for implementation of the recommended comprehensive Pike River watershed plan. The most important recommended plan implementation actions are summarized in the following paragraphs by level of government and responsible agency or unit of government.

Local Level

The local level agencies involved in implementation of the Pike River watershed plan consist of Kenosha and Racine Counties; the Cities of Kenosha and Racine; the Villages of Elmwood Park and Sturtevant; the Towns of Mt. Pleasant, Pleasant Prairie, and Somers; and the special sanitary, utility, and drainage districts formed in the three towns. The specific recommended actions for each of these units and agencies of government are as follows:

Kenosha County: It is recommended that Kenosha County, through its various committees, commissions, boards, and the County Board of Supervisors, act to implement the recommended watershed plan in the following manner:

1. That the County Board of Supervisors adopt the recommended Pike River watershed plan after a report and recommendation by the County Park Commission, the County Planning and Zoning Committee, the County Highway Committee, the County Land Conservation Committee, and the County Drainage Board, as a guide to land use, park and open space, floodland management, and water quality management in the Pike River watershed;

2. That the County Drainage Board acknowledge the comprehensive Pike River watershed plan and use the plan as a frame of reference in any future activities regarding drainage;

3. That the County Planning and Zoning Committee and County Board review and revise as necessary the Kenosha County Zoning Ordinance to implement the recommendations set forth in the land use, floodland management, and water quality management elements of the Pike River watershed plan;

4. That the County Park Commission acquire over time through purchase, dedication, and gift as may be timely and appropriate, the remaining undeveloped primary environmental corridor lands along the Pike River and Sorenson Creek and preserve such lands in their natural state;

5. That the County Park Commission design, construct, and maintain the recommended seven-mile recreation trail along the main stem of the Pike River from Petrifying Springs County Park to Lake Michigan;

6. That the County Park Commission cooperate with the Town of Mt. Pleasant Stormwater Drainage District in designing, constructing, and maintaining the recommended stream channel improvements along the Upper Pike River from CTH KR downstream to the confluence with the Pike Creek in Petrifying Springs County Park;

7. That the County Highway Committee, as the highway system under its jurisdiction is maintained and reconstructed over time, construct new and replace existing bridges over the Pike River stream channel system in accordance with the recommended water control facility objectives and standards; and

8. That the County Land Conservation Committee assume the lead responsibility for nonpoint source water pollution control throughout the Kenosha County portion of the watershed.

Racine County: It is recommended that Racine County, through its various committees, commissions, boards, and the County Board of Supervisors, act to implement the recommended watershed plan in the following manner:

1. That the County Board of Supervisors adopt the recommended Pike River watershed plan after a report and recommendation by the County Highway and Parks Committee; the County Land Use, Agricultural, Environmental, and Extension Education Committee; the County Land Conservation Committee; and the County Drainage Board, as a guide to land use, park and open space,

floodland management, and water quality management in the Pike River watershed;

2. That the County Drainage Board acknowledge the comprehensive Pike River watershed plan and use the plan as a frame of reference in any future activities regarding drainage;

3. That the County Land Use, Agricultural, Environmental, and Extension Education Committee and the County Board review and revise as necessary the Racine County Zoning Ordinance to implement the recommendations set forth in the land use, floodland management, and water quality management elements of the Pike River watershed plan, and cooperate with the Town of Mt. Pleasant in similarly reviewing and revising as necessary the Town Zoning Ordinance;

4. That the County Highway and Parks Committee acquire land for and develop the recommended expansion of Sanders Park;

5. That the County Highway and Parks Committee, as the highway system under its jurisdiction is maintained and reconstructed over time, construct new and replace existing bridges over the Pike River stream channel system in accordance with the recommended water control facility objectives and standards; and

6. That the County Land Conservation Committee assume the lead responsibility for diffuse source pollution control throughout the Racine County portion of the watershed.

City of Kenosha: It is recommended that the City of Kenosha, through its various committees, commissions, boards, and the Common Council, act to implement the recommended watershed plan in the following manner:

1. That the Common Council adopt the recommended Pike River watershed plan after a report and recommendation by the Board of Public Works, City Plan Commission, and City Park Commission, as a guide to land use, park and open space, floodland management, and water quality management in the Pike River watershed;

2. That the City Plan Commission and the Common Council review and revise as necessary the City of Kenosha Zoning Ordinance to implement the recommendations set forth in the land use, floodland management, and water quality management elements of the Pike River watershed plan;

3. That the City Plan Commission and the Common Council review the City building code to ensure that appropriate regulations are included dealing with structure floodproofing, and provide professional engineering assistance to landowners affected by the structure floodproofing recommendations of the plan;

4. That the City Park Commission complete development of the Sam Poerio Park;

5. That the City Park Commission acquire and develop as necessary over time the recommended system of neighborhood parks in the watershed;

6. That the City Park Commission design, construct, and maintain the recommended jetties at the mouth of the Pike River on Lake Michigan and periodically maintain the Pike River channel between the jetties;

7. That the Board of Public Works determine the desirability of undertaking the channel improvements on the Airport Branch and the Tributary to Airport Branch as the Kenosha industrial park is expanded over time and, if found to be desirable, undertake such improvements. In the alternative, the Board may require preservation of the natural floodlands and attendant floodwater storage capacity along these stream channels as an integral part of the design of industrial parks or other urban development in the area;

8. That the Board of Public Works cooperate with the Town of Somers Utility District No. 1 in facilitating the abandonment of the Somers sewage treatment facility;

9. That the Board of Public Works eliminate three crossovers that divert sanitary sewage into the Pike River stream system;

10. That the Board of Public Works carry out responsibilities as the designated management agency for diffuse source pollution control; and

11. That the Kenosha Water Utility continue the cooperative stream gaging program involving the continuous stage recorder stream gage on the Pike River.

City of Racine: It is recommended that the City of Racine through its various committees, commissions, boards, and the Common Council, act to implement the recommended watershed plan in the following manner:

1. That the Common Council adopt the recommended Pike River watershed plan after a report and recommendation by the Board of Public Works and the City Plan Commission;

2. That the City Plan Commission and the Common Council review and revise as necessary the City of Racine Zoning Ordinance to implement the recommendations set forth in the land use, floodland management, and water quality management elements of the Pike River watershed plan; and

3. That the Board of Public Works carry out the responsibilities as the designated management agency for diffuse source pollution control.

Village of Elmwood Park: It is recommended that the Village of Elmwood Park through its various committees, commissions, boards, and the Village Board, act to implement the recommended watershed plan in the following manner:

1. That the Village Board adopt the recommended Pike River watershed plan after a report and recommendation by the Village Plan Commission, as a guide to land use, park and open space, floodland management, and water quality management in the Pike River watershed;

2. That the Village Board carry out responsibilities as the designated management agency for diffuse source pollution control;

3. That the Village Plan Commission and Village Board review and revise as necessary the Village of Elmwood Park Zoning Ordinance to implement the recommendations set forth in the land use, floodland management, and water quality management elements of the Pike River watershed plan; and

4. That the Village Park Commission provide a neighborhood park as recommended in the plan.

Village of Sturtevant: It is recommended that the Village of Sturtevant, through its various committees, commissions, boards, and the Village Board, act to implement the recommended watershed plan in the following manner:

1. That the Village Board act to adopt the recommended Pike River watershed plan after a report and recommendation by the Village Plan Commission as a guide to land use, park and open space, floodland management, and water quality management in the Pike River watershed;

2. That the Village Board carry out responsibilities as the designated management agency for diffuse source pollution control;

3. That the Village Plan Commission and Village Board review and revise as necessary the Village of Sturtevant Zoning Ordinance to implement the recommendations set forth in the land use, floodland management, and water quality management elements of the Pike River watershed plan; and

4. That the Village Park and Recreation Committee and Village Board acquire and develop as necessary over time the recommended system of local or neighborhood parks in the watershed.

Town of Mt. Pleasant: It is recommended that the Town of Mt. Pleasant, through its various committees, commissions, boards, and the Town Board, act to implement the recommended watershed plan in the following manner:

1. That the Town Board adopt the recommended Pike River watershed plan after a report and recommendation by the Town Plan Commission, Town Park Commission, Town Utility District No. 1, and Town Stormwater Drainage District No. 1 as a guide to land use, park and open space, floodland management, and water quality management in the Pike River watershed.

2. That the Town Plan Commission and Town Board review and revise as necessary the Town Zoning Ordinance to implement the recommendations set forth in the land use, floodland management, and water quality management elements of the Pike River watershed plan.

3. That the Town Plan Commission and Town Board review the town building code to ensure that appropriate regulations are included dealing with structure floodproofing, and provide professional engineering assistance to landowners affected by the structure floodproofing recommendations of the plan;

4. That the Town Board carry out responsibilities as the designated management agency for diffuse source pollution control;

5. That the Town Park Commission acquire and develop as necessary over time the recommended system of local or neighborhood parks in the watershed;

6. That the Commission of the Town of Mt. Pleasant Utility District No. 1 adopt the recommended Pike River watershed plan as a guide to land use and sewerage facility development in the district;

7. That the Commission of the Town of Mt. Pleasant Stormwater Drainage District No. 1 adopt the recommended Pike River watershed plan as a guide to land use and stormwater management in the district;

8. That the Commission of the Town of Mt. Pleasant Stormwater Drainage District No. 1 design, construct, and maintain the recommended channel improvements, including bridge replacement, along the Upper Pike River;

9. That the Commission of the Town of Mt. Pleasant Stormwater Drainage District No. 1 design, construct, and maintain the recommended dike along the Bartlett Branch; and

10. That the Commission of the Town of Mt. Pleasant Stormwater Drainage District No. 1 design and construct the replacement bridge at Chicory Road over the Sorenson Creek.

Town of Pleasant Prairie: It is recommended that the Town of Pleasant Prairie, through its various committees, commissions, boards, and the Town Board, act to implement the recommended watershed plan in the following manner:

1. That the Town Board adopt the recommended Pike River watershed plan after a report and recommendation by the Town Plan Commission, Town Park Commission, and Town Sewer Utility District D as a guide to land use, park and open space, floodland management, and water quality management in the Pike River watershed;

2. That the Town Plan Commission and Town Board assist Kenosha County in the review and revision of the Kenosha County Zoning Ordinance to reflect the recommendations set forth in the land use, floodland management, and water quality management elements of the Pike River watershed plan; and

3. That the Town Board carry out the responsibilities as the designated management agency for diffuse source pollution control.

Town of Somers: It is recommended that the Town of Somers, through its various committees, commissions, boards, and the Town Board, act to implement the recommended watershed plan in the following manner:

1. That the Town Board adopt the recommended Pike River watershed plan after a report and recommendation by the Town Plan Commission, Town Utility District No. 1, and Town Sanitary District No. 1 as a guide to the land use, park and open space, floodland management, and water quality management in the Pike River watershed;

2. That the Town Plan Commission and Town Board assist Kenosha County in the review and revision of the Kenosha County Zoning Ordinance to reflect the recommendations set forth in the land use, floodland management, and water quality management elements of the Pike River watershed plan;

3. That the Town Plan Commission and Town Board review the town building code to ensure that appropriate regulations are included dealing with structure floodproofing, and provide professional engineering assistance to landowners affected by the

structure floodproofing recommendations of the plan;

4. That the Town Board abandon the Somers sewage treatment plant, connecting the existing sanitary sewerage system to the City of Kenosha system;

5. That the Town Board carry out responsibilities as the designated management agency for nonpoint source water pollution control;

6. That the Town Board take the lead in sponsoring the necessary preliminary engineering studies of the system of dikes proposed to protect floodprone lands along the Lower Pike River, cooperating with the agricultural landowners and the Kenosha Country Club in conducting the studies and in forming a new drainage district;

7. That the Town Park Commission acquire and develop as necessary over time the recommended system of local or neighborhood parks in the watershed;

8. That the Commission of the Town of Somers Utility District No. 1 adopt the recommended Pike River watershed plan as a guide to land use and sewerage facility development in the watershed;

9. That the Commission of the Town of Somers Sanitary District No. 1 adopt the recommended Pike River watershed plan as a guide to land use and sewerage facility development; and

10. That the Town Board create a new sanitary district to design, construct, and maintain the recommended channel improvements, including bridge replacement, along the Pike Creek.

<u>State Level</u>
The state level agencies involved in implementation of the Pike River watershed plan consist of the Wisconsin Departments of Natural Resources, Transportation, and Agriculture, Trade, and Consumer Protection. The specific recommended actions for each of these state agencies are as follows:

<u>Wisconsin Department of Natural Resources</u>: It is recommended that the Wisconsin Department of Natural Resources:

1. Endorse the comprehensive Pike River watershed plan as an amendment to the previously endorsed areawide water quality management plan for the Southeastern Wisconsin Region and certify the plan as such through the Governor to the U. S. Environmental Protection Agency.

2. Direct the staff of the Wisconsin Department of Natural Resources to integrate the watershed plan recommendations into its broad range of agency responsibilities and to assist in coordinating plan implementation over the next two decades. In particular, those department decisions to be made with respect to the extension of locally proposed sanitary sewers, wetland regulation, and the regulation of industrial waste discharges should be made in a manner fully consistent with the recommended plan.

3. Cooperate with the Southeastern Wisconsin Regional Planning Commission and the local units of government in the watershed in designing and carrying out a continuing water quality monitoring program.

<u>Wisconsin Department of Transportation</u>: It is recommended that the Wisconsin Department of Transportation:

1. Endorse the recommended Pike River watershed plan.

2. Continue to cooperate in the stream gaging program by financially supporting a partial record peak-flow gage on the Pike Creek at STH 142.

3. Construct new and replace existing bridges over the Pike River stream channel system in accordance with the recommended water control facility objectives and standards as the highway system under its jurisdiction is maintained and reconstructed over time.

<u>Wisconsin Department of Agriculture, Trade, and Consumer Protection</u>: It is recommended that the Wisconsin Department of Agriculture, Trade, and Consumer Protection:

1. Endorse the Pike River watershed plan.

2. Refer the plan to the Land Conservation Board and direct that Board to utilize the

plan recommendations, as appropriate, in its various responsibilities governing farmland preservation and soil and water conservation.

Federal Level

The federal agencies involved or potentially involved in implementation of the Pike River watershed plan consist of the U. S. Environmental Protection Agency; the U. S. Geological Survey; the U. S. Department of Agriculture, Agricultural Stabilization and Conservation Service; the U. S. Soil Conservation Service; the Federal Emergency Management Agency; and the U. S. Army Corps of Engineers. The specific recommended actions for each of these federal agencies are as follows:

U. S. Environmental Protection Agency: It is recommended that the U. S. Environmental Protection Agency formally accept and endorse the Pike River watershed plan as an amendment to the regional water quality management plan upon certification as such by the Governor of the State of Wisconsin.

U. S. Geological Survey: It is recommended that the U. S. Geological Survey endorse the Pike River watershed plan and continue to work with the Regional Planning Commission and state and local units of government in conducting the cooperative stream gaging program in the watershed.

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 formally acknowledge the Pike River watershed plan and utilize the plan recommendations in the administration of the federal agricultural and conservation program.

U. S. Soil Conservation Service: It is recommended that the U. S. Soil Conservation Service formally acknowledge the Pike River watershed plan and utilize the plan recommendations in the administration of its various technical assistance programs relating to soil and water conservation.

Federal Emergency Management Agency: It is recommended that the Federal Emergency Management Agency formally acknowledge the Pike River watershed plan and use the floodland data contained in the plan as a basis for reviewing and updating federal flood insurance studies.

U. S. Army Corps of Engineers: It is recommended that the U. S. Army Corps of Engineers formally acknowledge the Pike River watershed plan; cooperate upon request with any local or state units and agencies of government for assistance in the review, design, and construction phases of the floodland management element of the recommended plan; and use the land use and environmental corridor elements of the plan in carrying out its regulatory program relative to the placement of fill in wetlands.

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Chapter XVI

SUMMARY AND CONCLUSIONS

This report presents the major findings and recommendations of the Southeastern Wisconsin Regional Planning Commission Pike River watershed planning program. The report sets forth the basic concepts underlying the study and the factual findings of the extensive inventories conducted under the study. It identifies and, to the extent possible, quantifies the existing water-related developmental and environmental problems of the watershed, and sets forth forecasts of future economic activity, population growth, and land use and concomitant probable future water-related developmental and environmental problems. The report presents alternative plan elements relating to floodland management, water pollution abatement, and land use, and sets forth a recommended plan for the development of the watershed and the resolution of its existing flood damage and water pollution problems based upon regional and watershed development objectives adopted by the watershed committee, and for avoiding the creation of future flood damage and water pollution problems. In addition, it contains financial analyses related to, and specific recommendations for, plan implementation.

STUDY ORGANIZATION AND PURPOSE

The Pike River watershed study, which resulted in the preparation of this report, is the sixth comprehensive watershed planning program to be undertaken by the Southeastern Wisconsin Regional Planning Commission. This watershed study was undertaken within the statutory authority of the Commission and upon the specific request of the Counties of Kenosha and Racine. Funding for the study was provided by Kenosha and Racine Counties. The study was guided from its inception by the Pike River Watershed Committee, an advisory committee to the Commission composed of 24 local, state, and federal public officials, technicians, and concerned citizen leaders from throughout the watershed. The technical work was carried out by the Commission staff with the assistance of cooperating governmental agencies, including the U. S. Geological Survey; the U. S. Department of Agriculture, Soil Conservation Service; the Wisconsin Department of Natural Resources; and private consultants engaged by the Commission, including Hydrocomp, Inc., specialists in hydrologic simulation modeling, and Alster-Ayres & Associates, Inc., photogrammetric and control survey engineers. The disciplines provided by the cooperating governmental agencies and private consultants included groundwater and surface water hydrology and hydraulics, environmental protection and natural resource conservation, mathematical simulation modeling, and control survey and photogrammetric engineering.

The study was founded upon the recognition by concerned public officials that such water-related resource problems as flooding and water pollution are directly and inextricably interrelated, not only with each other, but also with problems of areawide urbanization which transcend local governmental boundaries and that solutions to such areawide problems must be sought on a watershed basis. Therefore, the primary purpose of the Pike River watershed planning program is to help abate the serious water resource and water resource-related problems of the Pike River basin by developing a workable plan to guide the staged development of multipurpose water resource facilities and related resource conservation and management programs for the watershed. More specifically, the objectives of the planning program are to:

- Prepare a plan for the management of the floodlands along the major waterways of the Pike River watershed, including measures for the mitigation of existing flood problems and measures for the minimization of future flood problems.

- Prepare a plan for surface water quality management within the Pike River watershed, incorporating measures to abate existing pollution problems and measures intended to prevent future pollution problems.

- Refine and adjust the regional land use and park and open space plans within the watershed to help promote a more rational adjustment of land uses to the surface water resources of the watershed.

The problems to be addressed in the watershed study were articulated by the Watershed Committee in the prospectus for the study published on April 1, 1979.[1] An initial public hearing on the need for, and proposed scope and content of, the study held on February 7, 1980, reinforced the findings of the Watershed Committee that flooding and pollution were the two problems of greatest concern to residents of the watershed. To be effective in abating problems of flooding, water pollution, and improper and changing land use within the watershed, the watershed plan was developed to be amenable to cooperative adoption and joint implementation by all levels and agencies of government concerned.

This report can only summarize briefly the large volume of information assembled in the extensive data collection, analysis, and forecasting phases of the Pike River watershed study. However, all of the basic data are on file in the Commission offices and are available to member units and agencies of government and to the general public upon specific request. This report, therefore, serves the additional purpose of indicating the types of data which are available from the Commission and which may be of value in assisting federal, state, and local units of government and private investors in making better decisions about community development within the Region.

INVENTORY, ANALYSIS, AND FORECAST FINDINGS

Geography

The Pike River watershed is a surface water drainage unit approximately 52 square miles in areal extent, lying in both Kenosha and Racine Counties. The Pike River from its source in Section 10, Township 3 North, Range 22 East, in the Town of Mt. Pleasant flows southerly to Petrifying Springs County Park in the Town of Somers, Kenosha County, while being joined by several perennial and intermittent tributaries. In Petrifying Springs County Park, the river is joined by a major tributary, Pike Creek. The river then flows generally easterly to within approximately one mile of the Lake Michigan shoreline where it is joined from the north by Sorenson Creek. The river then flows southerly about four miles until it discharges to Lake Michigan approximately one mile north of the City of Kenosha harbor.

The boundaries of the watershed and its salient hydrographic and cultural features are shown on Map 3, page 20, of this report. The watershed lies in two counties—Kenosha and Racine—three towns—Mt. Pleasant, Somers, and Pleasant Prairie—two cities—Kenosha and Racine—and two villages—Elmwood Park and Sturtevant. The area of each civil division within the watershed, the percent of the watershed area within each civil division, and the percent of each civil division area within the watershed is shown in Table 1, page 21, of this report. The population in the watershed by civil division is shown in Table 3, page 25. These local units of government have the basic responsibility for land use control and land cover management within the watershed and for the provision of basic community services. The seven communities located wholly or partly in the watershed are responsible for the provision of sanitary trunk sewer service, sewage treatment, and water pollution control within the entire Pike River watershed. These communities are joined by three drainage districts located wholly or partly in the watershed with responsibility for drainage and flood control, as well as by three sanitary or utility districts having reponsibility for sewerage facilities. The Kenosha County Park Commission and the Racine County Highway and Parks Committee are responsible for providing park and related open space lands within the watershed. Certain state and federal government agencies, including, importantly, the Wisconsin Department of Natural Resources and the U. S. Environmental Protection Agency, also have important responsibilities for water resource conservation and management within the watershed.

Population and Economic Activity

The 1975 population of the watershed was estimated at about 29,000 persons, or about 2 percent of the population of the Region. The resident population of the watershed is expected to increase to about 56,000 persons by the year 2000, an increase of about 27,000 persons, or 93 percent.[2]

Employment in the watershed is expected to increase during the next two decades at a rate greater than that of the Region as a whole, reflecting a continued decentralization of economic activity from the established urban areas of the Region to suburban and rural locations. Employment within the watershed in 1970 totaled about 8,300 jobs and is expected to increase to about

[1] *See Pike River Watershed Planning Program Prospectus, SEWRPC, April 1979.*

[2] *The 1980 population of the watershed is estimated at 33,400.*

25,200 jobs by the year 2000, an increase of about 16,900 jobs, or about 204 percent, over the 30-year period. This large anticipated job increase is primarily related to the location in the Pike River watershed of the two major regional industrial land use centers called for in the adopted regional land use plan to serve the metropolitan Racine and Kenosha areas.

Land Use

As shown on Map 7, page 32, of this report, the Pike River watershed is still predominantly rural with over 37 square miles, or 72 percent, of the total watershed area being in rural land use. Agriculture is the predominant land use in the watershed, occupying over 32 square miles, or about 63 percent, of the total watershed area. In 1975 urban land uses within the watershed occupied about 14 square miles, or 28 percent of the total area of the watershed. The dominant urban land use categories in the basin are residential and transportation-communication-utility facilities which encompass, respectively, 12 and 9 percent of the total watershed area; and 44 and 34 percent, respectively, of the urban area of the watershed.

Public Utility Service and Transportation Facilities

The public utility base of the watershed is well developed. Electric power is supplied throughout the watershed by the Wisconsin Electric Power Company and natural gas service is supplied by the Wisconsin Natural Gas Company. Sanitary sewerage service is supplied by eight sanitary sewerage entities which serve about 84 percent of the total resident population of the watershed. Public water supply, utilizing Lake Michigan as a source, is also available throughout the watershed through four public water supply entities.

The Pike River watershed is served by a well-developed surface transportation system consisting of a particularly good network of all-weather streets and highways, and urban mass transit service. The watershed is traversed by a network of railway lines which provide freight service; one line also provides scheduled Amtrak passenger service between Milwaukee and Chicago. The Kenosha Municipal Airport, lying almost entirely within the Pike River watershed, is the only airport located in the basin.

Climate

The Pike River watershed has a climate characterized by a progression of markedly different seasons because of its midcontinental location, far removed from the moderating effect of the oceans. An essentially continuous pattern of distinct weather changes occurring at about three-day intervals is superimposed on the seasonal pattern. Air temperatures in the watershed range from a daily average of about 22°F in January to 72°F in July, while the extremes range from a low of about -25°F to a high of approximately 105°F.

The average annual precipitation within the watershed is 32.4 inches, and the average total monthly precipitation ranges from a low of 1.27 inches in February to a high of 3.89 inches in June. The watershed receives, on the average, 46.3 inches of snow and sleet per year, which, when converted to its water equivalent, constitutes 14 percent of the total annual precipitation. The average annual snowfall ranges from a low of five inches to a high of approximately 109 inches. As a result of its proximity to Lake Michigan, the eastern part of the watershed experiences an average of about five inches more seasonal snow and sleet accumulation than does the western part of the watershed.

Prevailing winds follow a clockwise pattern over the seasons of the year, being generally northwesterly in the late fall and in winter, northeasterly in the spring, and southwesterly in the summer and early fall. Daylight hours in the basin range from a minimum of about nine hours on or about December 22, to a maximum of about 15 hours on or about June 21. During the summer months, about one-third of the days may be expected to be categorized as clear, one-third as partly cloudy, and one-third as cloudy. Greater sky cover occurs in the winter, when more than one-half of the days are classified as cloudy, with the remainder being approximately equally divided between partly cloudy and clear.

Physiography and Geology

The Pike River watershed is an irregularly shaped drainage basin with its major axis lying in an approximately north-south direction. The watershed has a total area of approximately 52 square miles, with a length—measured from the northern to the southern extremities of the basin—of approximately 13.3 miles and a maximum width of about 5.6 miles. The Pike River watershed is bounded on the north by the Root River watershed, on the west by the Des Plaines River watershed, and on the south by lands that drain directly to Lake Michigan.

The Pike River begins its 18.39-mile route to Lake Michigan from its origin near the intersection of Airline Road and CTH C in the northwest one-quarter of Section 10, Township 3 North, Range

22 East, in the Town of Mt. Pleasant. From its source, the river flows in a generally easterly direction for about one mile before turning south and flowing to Petrifying Springs Park in the Town of Somers in Kenosha County. From there, the river flows in a generally easterly direction to approximately one mile from the Lake Michigan shoreline, where it turns south and flows to its confluence with Lake Michigan. The Pike River acts as an estuary of Lake Michigan from its mouth to the lagoon located on the Carthage College Campus, a distance of about 1.4 miles. Pike Creek, the largest tributary to the Pike River, begins its 5.28-mile route to the Pike River from its point of origin near the intersection of the Chicago & North Western Railway and STH 158 in the northwest one-quarter of Section 33, Township 2 North, Range 22 East, in the Town of Somers. From there it flows in a north-northeasterly direction to its confluence with the Pike River in Petrifying Springs Park. Several other streams are tributary to the Pike River or Pike Creek, including Bartlett Branch, Waxdale Creek, Chicory Creek, Lamparek Ditch, Sorenson Creek, Nelson Creek, Somers Branch, and Airport Branch. The stream system selected for detailed analysis and study totals 42.09 miles and is shown on Map 26, page 124.

Watershed topography and physiographic features have been largely determined by the underlying bedrock and overlying glacial deposits. The Niagara Cuesta, on which the watershed lies, is a gently eastward sloping bedrock surface. Glacial deposits overlying the bedrock formations from the surface topography of the watershed consist primarily of gently sloping ground moraine—heterogeneous material deposited by the glacial ice. Surface elevations within the watershed range from a high of approximately 780 feet above National Geodetic Vertical Datum (Mean Sea Level Datum) at the border of the watershed west of the Village of Sturtevant to approximately 590 feet above National Geodetic Vertical Datum at the mouth, a maximum relief of 190 feet.

Wildlife and Wildlife Habitat

As a result of urban and agricultural activity and the associated decrease in woodlands, wetlands, and other natural areas, wildlife habitat has sharply decreased in the Pike River watershed. About 1,360 acres of significant wildlife habitat remain within the watershed, of which about 73 percent is rated as having a relatively low-value category. The remaining wildlife resources are particularly important to the Pike River watershed because of their recreational, educational, and aesthetic values, and because of the element of naturalness and diversity that they impart to both the urban and rural environments of the watershed.

Existing and Potential Park, Outdoor Recreation, and Related Open Space Sites

A total of 35 existing park, outdoor recreation, and related open space sites lie within the watershed, encompassing a combined area of 1,918 acres, or about 6 percent of the total area of the watershed. A watershedwide inventory indicated that eight potential recreation and related open space sites exist in the Pike River watershed. Four of these sites, covering about 243 acres, are located in the Town of Mt. Pleasant in Racine County. The remaining four sites, covering about 610 acres, are located in the Town of Somers in Kenosha County.

Environmental Corridors

The delineation of natural resource and natural resource-related elements produces an essentially lineal pattern of narrow, elongated areas which have been termed "environmental corridors" by the Commission. As of 1975, primary environmental corridors in the watershed occupied 1,189 acres, or 3 percent of the watershed area. By way of contrast, primary environmental corridors total about 20 percent of the entire seven-county Southeastern Wisconsin Region. Secondary environmental corridors occupied 596 acres, or about 2 percent of the watershed. Isolated natural features, other smaller pockets of concentrations of natural resource base elements, occupy about 654 acres, or 2 percent of the watershed area. The continued preservation of these corridors in park and related open space uses is essential to maintaining the overall quality of the environment in the watershed.

Water Law

With the passage of the Federal Water Pollution Control Act Amendments of 1972, the U. S. Congress set in motion a series of actions which will have many ramifications for water quality management within the Pike River watershed. Water use objectives and supporting water quality standards now are required for all navigable waters in the United States, and it is a national goal to eliminate the discharge of pollutants into the navigable waters by 1985. To meet this goal, the Act requires the enactment of specific effluent limitations for all point sources of water pollution to be enforced through a pollutant discharge permit system.

Responsibility for water quality management in Wisconsin is centered in the Wisconsin Department of Natural Resources. The Department is given authority to prepare long-range water resources plans, to establish water use objectives and supporting water quality standards applicable to all waters of the State, to establish a pollutant discharge permit system, and to issue pollution abatement orders.

Surface Water Hydrology and Hydraulics

Quantitative knowledge of the complex hydrologic cycle as it affects the watershed is necessary to assess the availability of surface water and groundwater for various uses and to improve the water resources management potential. The quantitative relationships between inflow and outflow, termed the hydrologic budget, were determined for the watershed. Precipitation is the primary source of water to the watershed and averages about 32 inches annually. Surface water runoff and evapotranspiration losses constitute the primary outflow from the basin. The average annual runoff approximates 13 inches, and the annual evapotranspiration loss totals about 12 inches.

The streamflow and flood stage records available for the Pike River system reveal that two flooding seasons exist. The period February through April is a high runoff period because of the effects of snow accumulation and frozen ground in February and March, and the effects of snowmelt or rainfall on near-saturated soils in March and April when the drying effects of transpiration are still minimal and when air and surface temperatures still inhibit evaporation. The other period in June experiences frequent severe thunderstorms occurring before the peak period of summer evapotranspiration and heavy foliation.

The Pike River watershed is comprised of three subwatersheds, as shown on Map 30, page 139. These subwatersheds are: 1) the Lower Pike River subwatershed which encompasses 15.00 square miles, or 29.1 percent of the total watershed area; 2) the Upper Pike River subwatershed which encompasses 17.34 square miles, or 33.6 percent of the total watershed area; and 3) the Pike Creek subwatershed which encompasses 19.20 square miles, or 37.3 percent of the total watershed area. The streams studied in the Lower Pike River subwatershed included the Pike River, Sorenson Creek, Nelson Creek, and Kenosha Branch; in the Upper Pike River subwatershed, the Pike River, Bartlett Branch, Waxdale Creek, Tributary to Waxdale Creek, Chicory Creek, and Lamparek Ditch; and in the Pike Creek subwatershed, the Pike Creek, Somers Branch, Airport Branch, and Tributary to Airport Branch.

Hydrologic-hydraulic information, including land use, channel slope, hydraulic structure, and channel modification data, was inventoried and analyzed for each of the subwatersheds of the basin. Approximately 42 lineal miles of streams within the watershed were selected for development of detailed flood hazard information, including discharge-frequency relationships, flood stage profiles, and mapped areas of inundation for selected flood recurrence intervals. Detailed data were obtained for 71 hydraulically significant bridges, culverts, and sills—out of a total of 115 such structures on the stream system studied—and 700 floodland cross-sections were prepared for that portion of the stream system modeled under the Pike River watershed study.

Of the approximately 42 lineal mile stream system studied, about 17 miles, or 41 percent, have been significantly modified through man-made channel improvements, as shown on Map 28, page 132, of this report. The modified stream reaches lie largely along the Pike Creek, the Upper Pike River, Bartlett Branch, Chicory Creek, Lamparek Ditch, and Sorenson Creek.

Water Resources Simulation Model

A quantitative analysis of watershed surface water hydrology, hydraulics, and water quality under existing and alternative future conditions is a fundamental requirement of any comprehensive watershed planning effort. Hydrologic-hydraulic-water quality-flood economics simulation, accomplished with a set of interrelated digital computer programs, is an effective way to conduct this quantitative analysis. The Water Resource Simulation Model developed primarily from existing computer programs for use in the Pike River watershed planning program consists of the following five submodels: the hydrologic submodel, hydraulic submodel No. 1, hydraulic submodel No. 2, the water quality submodel, and the flood economics submodel.

The principal function of the hydrologic submodel is to determine the volume and temporal distribution of runoff from the land to the stream system using meteorological data and land data. Hydraulic submodel No. 1 accepts as input the runoff from the land surface for each hydrologic land segment type in the watershed, as produced by the hydrologic submodel, aggregates these data with point source discharges and performs routing through the stream system, thereby producing a continuous series of discharge values at predetermined locations along the surface water system of the watershed. Hydraulic submodel No. 2 computes flood stages attendant to flood flows of specified recurrence intervals as determined using hydraulic submodel No. 1. This permits the ready preparation of flood stage profiles to be used in the delineation of flood hazard areas and as input to the flood economics submodel. The flood economics submodel performs two principal functions: the calculation of average annual flood damages; and the calculation of the cost of certain flood control measures, such as floodproofing, elevation and removal of structures, construction of earthen dikes and concrete floodwalls, and major channelization works. The water quality submodel simulates, at selected locations on the surface water system, the time-varying concentrations, or levels, of water quality indicators, including temperature, dissolved oxygen, fecal coliform bacteria, phosphate-phosphorus, total dissolved solids, carbonaceous biochemical oxygen demand, ammonia-nitrogen, nitrate-nitrogen, nitrite-nitrogen, and chloride.

Many of the algorithms incorporated into the Water Resources Simulation Model are approximations of complex natural phenomena; therefore, it is necessary to calibrate the model. Calibration consists of comparing simulated values, such as flood discharges or flood stages, with observed values of the same phenomena and, if a significant difference exists, making adjustments in the model so that it better simulates the actual conditions. The hydrologic submodel and hydraulic submodels Nos. 1 and 2 were calibrated by comparing the simulated discharges and stages to measured discharges and stages at the stream flood and crest stage gaging stations located on Pike Creek and the Pike River, and by comparing simulation stages to historic flood data available at several other locations in the watershed. The water quality submodel was calibrated using data obtained from the Commission extensive 1976 stream water quality monitoring program.

Flood Characteristics, Damage and Risk

Flood damage in the Pike River watershed has been largely a consequence of the failure to recognize and account for the relationships which exist between the use of land, both within and outside the natural floodlands of the watershed, and the flood flow behavior of the stream system of the watershed. A distinction must be drawn in this report between flood inundation problems—which are among the most critical water resource problems addressed in the watershed planning effort—and storm water drainage problems—which are beyond the scope of the Pike River watershed planning program. Flood inundation problems are defined as damaging inundation which occurs along streams and watercourses as the direct result of water moving out of, and away from, those streams and watercourses and include both primary and secondary flooding. The former is caused by the flood waters directly entering structures resulting in damage and hazards to public health and safety; the latter consists of floodwaters entering and surcharging sanitary sewers, thereby backing sewage into basements and causing damage and hazards to public health. In contrast, stormwater drainage problems are defined as damaging inundation which occurs when stormwater runoff en route to streams and watercourses encounters inadequate conveyance or storage facilities and, as a result, causes localized ponding and surcharging of storm and sanitary sewers.

Research of the available historic records indicated the occurrence of 14 known major floods in the Pike River watershed since 1960. These major floods, each of which caused significant damage to property as well as disruption of normal social and economic activities in the watershed, were the floods of March 30, 1960; March 29, 1962; April 11, 1965; June 29, 1969; April 16, 1972; July 14, 1972; September 13, 1972; April 21, 1973; February 21, 1974; March 5, 1976; July 2, 1978; July 21, 1978; August 19, 1978; and September 13, 1978. The March 30, 1960, flood was the largest flood in recent history, having a recurrence interval ranging from about 40 years in the upper reaches of the Pike River to about 60 years at the mouth. The flood of June 29, 1969, was the second most severe flood to occur on the Pike River in recent history.

The principal types of damage experienced in the Pike River watershed have been damage to croplands and damage to structures—private residences and commercial buildings—and to their contents as a result of overland and attendant secondary flooding. Bridges and culverts and sections of roadways have also been damaged by the erosive action of rapidly moving floodwaters so as to require extensive repair.

A costly type of disruption associated with major flood events in the Pike River watershed has been the interruption of business activities not only during the flood events but also during the post-flood cleanup and repair period. In the public sector, the routine operations of governmental units usually are disrupted during flood events as public officials attempt to provide immediate relief to affected areas. Another form of disruption directly attributable to major flood events is the temporary closure of highways that have been inundated at a relatively low place, or as a result of damage to a river crossing. Although floodland recreational areas and facilities, such as ballfields, golf courses, and picnic grounds, typically incur little physical damage as a result of flooding, use is temporarily curtailed by inundation.

The stream reaches having potential for the heaviest flood damages are shown on Map 93, along with the estimated average annual flood damages under both existing and probable future land use conditions, as well as such damages for a flood having a recurrence interval of about 100 years. For the watershed as a whole, the average annual flood damages under existing land use and channel conditions are estimated to approximate $125,000. Damages from a 100-year recurrence interval flood over the entire watershed under existing land use and channel conditions are estimated to approximate $806,000. The reaches of heaviest flood damage include the reach along Pike Creek between CTH K and STH 50, where the average annual and 100-year recurrence interval flood damages under existing land use and channel conditions are estimated to approximate $34,000 and $39,400, respectively; the reach along the Pike Creek between CTH L and STH 158, where the average annual and 100-year recurrence interval flood damages are estimated to approximate $29,500 and $160,000, respectively; and the reach along the Pike River from CTH A and extending downstream from the Chicago & North Western Railway about one-quarter mile, where the average annual and 100-year recurrence interval flood damages are estimated to approximate $12,800 and $25,000, respectively. On an average annual basis over the entire watershed, these damages could be expected to almost double under planned land use and existing channel conditions.

For the watershed as a whole under existing land use and channel conditions, a total of 81 existing structures—comprised of 71 residential structures and 10 nonresidential structures—would be subject to flood damages under a 100-year recurrence interval flood event. Under planned year 2000 land use and existing conditions, the number of existing structures which may be expected to be affected by flooding would increase to 151—consisting of 137 residential structures and 14 nonresidential structures.

There is a tendency to consider and evaluate the damage and disruption normally accompanying flooding without due regard to the risk to human life and health that exists during every major flood event. Public officials and interested citizens should be aware of this danger as one factor to be weighed in making decisions that are directly or indirectly related to riverine areas. The historic record for the Pike River watershed contains accounts of two incidents in which a total of three people were drowned during flood events.

While the threat of flooding to human life can be readily illustrated by reference to historic accounts of flood-related rescues and deaths, the threat to health is not so apparent. Nevertheless, it does exist. Floodwaters can be the medium for transporting potentially harmful substances, such as toxic materials from industrial operations and pathogenic—that is, disease-producing—organisms from sanitary and combined sewers, septic tanks, and animal waste storage areas into residences and other structures where there is the possibility of contact with, and harm to, the residents.

In addition to potential physiological harm, the occurrence of floods, as well as the ever-present threat of flooding, can adversely affect the psychological health and well being of riverine area residents. Owners or tenants of flood prone structures and properties are burdened with the need to be in a constant state of readiness, particularly in the urbanized areas of the watershed where major floods can occur almost any time of the year and with little warning. These owners or tenants occasionally must contend with the unpleasant task of cleaning contaminated, flood-borne sediment and debris from their homes and places of business. Finally, even after the flood has passed and the cleanup and repairs have been completed, lingering odors and other evidence of the recent inundation will impose an additional psychological stress on the occupants of riverine area property.

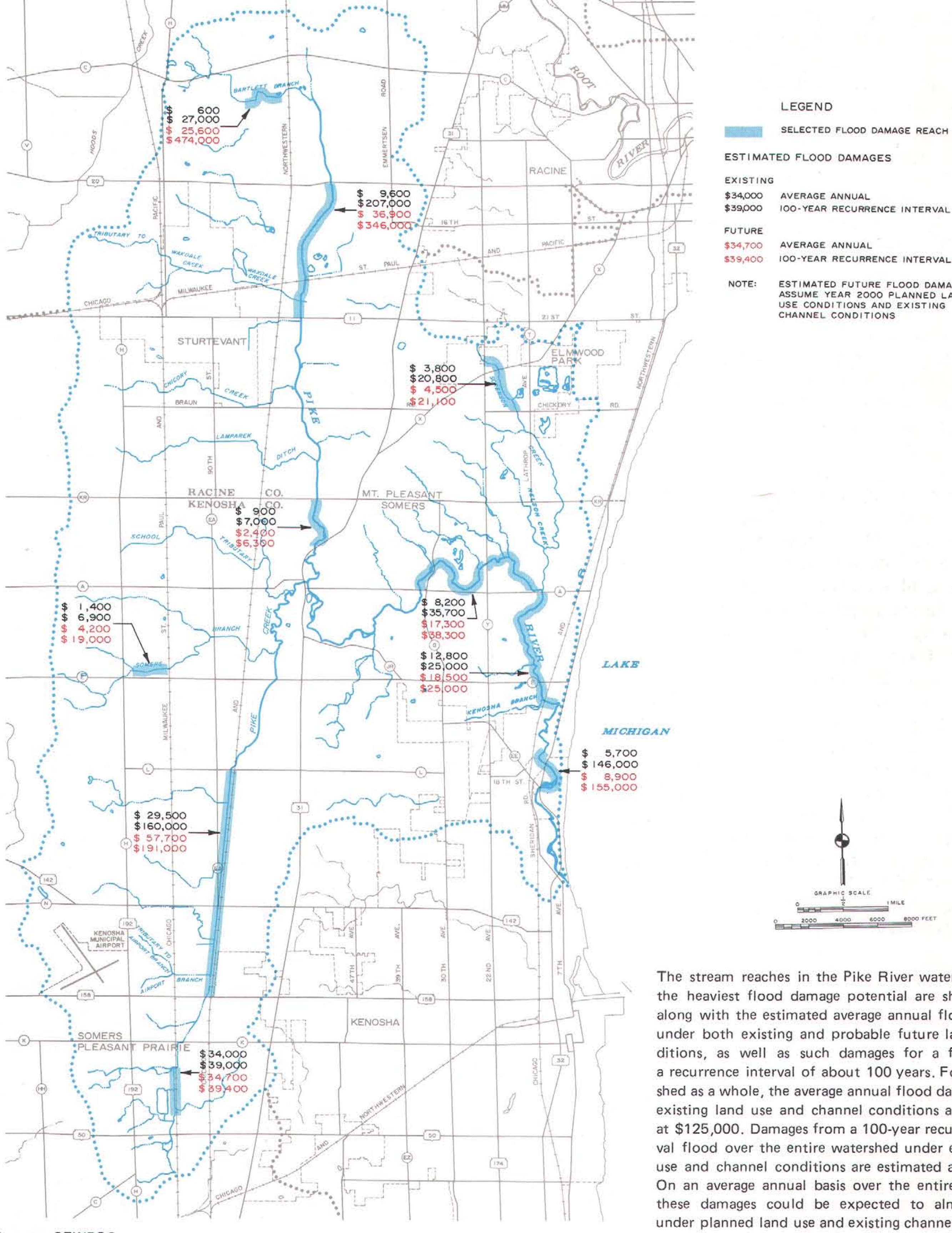
Surface Water Quality and Pollution

The term "water quality" encompasses the physical, chemical, and biological characteristics of the water. Water is deemed to be polluted when foreign substances caused by or related to human activity are in such a form and concentration so as to render the water unsuitable for a desired beneficial use.

An assessment of a variety of data sources dating back to 1955 indicated that the water quality of the Pike River watershed ranged from generally poor from 1955 to 1964, to generally fair from

Map 93

EXISTING AND POTENTIAL AVERAGE ANNUAL AND 100-YEAR RECURRENCE INTERVAL FLOOD DAMAGES ALONG SELECTED STREAM REACHES IN THE PIKE RIVER WATERSHED



Source: SEWRPC.

The stream reaches in the Pike River watershed having the heaviest flood damage potential are shown above, along with the estimated average annual flood damages under both existing and probable future land use conditions, as well as such damages for a flood having a recurrence interval of about 100 years. For the watershed as a whole, the average annual flood damages under existing land use and channel conditions are estimated at $125,000. Damages from a 100-year recurrence interval flood over the entire watershed under existing land use and channel conditions are estimated at $806,000. On an average annual basis over the entire watershed, these damages could be expected to almost double under planned land use and existing channel conditions.

1965 to 1975. However, many forms of pollution—toxic, organic, nutrient, pathogenic, sediment, and aesthetic—are known to exist in the watershed. The available studies indicate that the highest concentrations of pollution and the worst stream water quality conditions are more likely to occur during periods of wet weather—that is, on days when 0.1 inch or more of precipitation occurs—and high streamflows than during periods of dry weather and low streamflows. This may be attributed to the accumulation of pollutants on the surface of the watershed between runoff events and the subsequent transport of those pollutants to the stream system during runoff.

The most serious type of pollution present in the watershed is pathogenic, as evidenced by the widespread occurrence of high fecal coliform counts. Other less extensive pollution problems include the presence of toxic and hazardous materials, depressed dissolved oxygen levels and excessive nutrient concentrations, particularly phosphorus, under wet weather conditions.

Pollutant loading analyses conducted under the Commission's areawide water quality management planning program, and confirmed under the watershed study, indicate that nonpoint sources of pollution—both rural and urban—together account for the majority of pollutants that are transported to the surface water system. Commission inventories indicated that an estimated 96 percent of the nitrogen, 93 percent of the phosphorus, 95 percent of biochemical oxygen demand, 46 percent of the fecal coliform, and virtually all of the suspended solids are contributed to the surface water system of the watershed annually by these nonpoint sources of water pollution. These pollutant loadings will occur during wet weather conditions when surface water runoff acts to transport pollutants to the stream system of the watershed.

Point source pollution also exists in the Pike River watershed. The sources of pollution identified as point sources consist of one municipal sewage treatment plant, five municipal sanitary sewerage system flow-relief devices, and eight industrial wastewater discharge outfalls.

About 40 percent of the urban area, and 11 percent of the total area of the Pike River watershed is provided with engineered urban stormwater drainage facilities. Therefore, much of the runoff from urban areas, which is grossly polluted, enters the surface water system directly through storm sewer outfalls located along the major stream system with the remaining direct runoff entering the surface water system through open stormwater channels or as sheet flow—that is, overland flow not occurring in well-defined channels. Runoff from rural areas enters the surface water system through open stormwater channels, agricultural drainage systems, or as sheet flow. As already noted, water quality surveys indicate that high concentrations of pollutants, such as biochemical oxygen demand, nitrogen, phosphorus, and fecal coliform bacteria, are most likely to occur during wet weather conditions—that is the conditions in which the surface water runoff from urban and rural lands provides the dominant flow and pollutant loading to the river system.

The limited data available also indicate that excessive concentrations of toxic and hazardous substances, including mercury, DDT, DDE, heptachlor epoxide, and dieldrin, may exist in the surface water system of the Pike River watershed.

The quality of the surface waters in the Pike River watershed does not satisfy the standards in the support of the adopted water use objectives. Improvement of surface water quality in the Pike River watershed so as to achieve the water use objectives will require a watershedwide water quality management effort aimed at abatement of both point and nonpoint sources of pollution.

WATERSHED DEVELOPMENT OBJECTIVES

The primary objective of the Pike 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 Pike River basin by developing a workable plan to guide the staged development of multipurpose water resource 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, a framework of watershed development objectives and supporting principles and standards was established to guide the design of the alternative floodland management measures and the water quality management plan for the watershed and to provide a basis for evaluation of the relative merits of these alternatives. This framework of watershed development objectives and standards envisions a future watershed environment that is safe, healthful, and attractive, as well as more orderly and efficient.

With respect to water use objectives, the Wisconsin Department of Natural Resources currently has placed the waters of the Pike River stream system into four different categories, as shown on Map 40, page 287, of this report. The main stem of the Pike River from the mouth at Lake Michigan upstream to the Kenosha County line, Sorenson Creek, Nelson Creek, Bartlett Branch, Chicory Creek, Lamparek Ditch, and the School Tributary have all been assigned the highest water use objectives, providing for the maintenance of a warmwater fishery and full recreational use. The Pike River upstream from the Racine-Kenosha County line and the Pike Creek upstream from the confluence with the Somers Branch have been assigned the most limited water use objective, providing only for restricted recreational use and minimum standards. Waxdale Creek from the confluence with the Pike River upstream to the Chicago, Milwaukee, St. Paul & Pacific railroad crossing, and Pike Creek from the confluence with the Pike River upstream to the confluence with the Somers Branch, have been assigned water use objectives providing for the maintenance of an intermediate fishery and limited recreational use; while Waxdale Creek upstream from the Chicago, Milwaukee, St. Paul & Pacific railroad crossing and Somers Branch have been assigned water use objectives providing for the maintenance of marginal aquatic life and limited recreational use. The standards supporting these water use objectives are identified in Table 71, page 288, of this report.

In conformance with the national water quality objectives set forth in the Federal Water Pollution Control Act, all of the surface waters of the Pike River watershed were initially assigned water use objectives and supporting standards that would provide fully "fishable and swimmable" conditions. This would mean that the waters would be suitable for full body contact recreational use and would support a healthy warmwater fishery and related aquatic life. Given the recommendations contained in the plan relating to flood control and the improvement of the fishery of the watershed, however, the recommended water use objectives for the surface waters of the Pike River watershed—which are set forth on Map 91, page 528, of this report—were scaled back from that initial idealized set. The water quality objectives and supporting standards providing for maintenance of a warmwater fishery and full recreational use were retained for the main stem of the Pike River upstream to the confluence with Pike Creek; for Pike Creek from the confluence with the Pike River upstream to the confluence with Somers Branch; Somers Branch from the confluence with Pike Creek upstream to the Chicago & North Western Railway crossing; the School Tributary from the confluence with Pike Creek upstream to the Chicago & North Western Railway crossing; Sorenson Creek from the confluence with the Pike River upstream to Lathrop Avenue; and Nelson Creek from the confluence with Sorenson Creek upstream to the Kenosha County line. All of the remaining stream reaches in the watershed were assigned water use objectives and supporting standards providing for the maintenance of a limited fishery and limited recreational use.

ALTERNATIVE PLANS

The comprehensive plan for the Pike River watershed was prepared within the context of an existing set of adopted regional plan elements, including importantly, the adopted regional land use plan, the adopted regional park and open space plan, and the adopted regional water quality management plan. Accordingly, the major focus of the watershed study in terms of alternative plan preparation, test, and evaluation was on the floodland management plan element. The land use and park and open space element of the watershed plan constituted a refinement of the adopted regional land use and park and open space plans. The water quality management element of the watershed plan similarly constituted a refinement of the adopted regional water quality management plan, although with some changes in the water use objectives.

In developing alternative floodland management plans, both structural and nonstructural measures were considered. Seven structural floodland measures were identified for possible application either individually or in various combinations to specific flood-prone reaches of the watershed: 1) structure floodproofing and elevation, 2) detention storage, 3) diking, 4) diversion, 5) bridge or culvert modification or replacement, 6) channelization, and 7) onsite storage. In addition, two alternatives were identified with respect to floodland management problems at the mouth of the Pike River on Lake Michigan, namely, dredging and jetty construction. The nonstructural measures identified for possible inclusion in the floodland management plan element were: 1) reservation of floodlands for recreational and related open space uses, 2) floodland regulation, 3) channel maintenance, 4) flood insurance, 5) lending institution policies, 6) realtor policies, 7) community utility policies, and 8) emergency flood warning programs.

The various alternative structural floodland management plans prepared and evaluated under the Pike River watershed study are identified in Table 115. For analysis purposes, the Pike River stream system was divided into 16 individual segments. Including the 16 "no action" alternative plans prepared—one for each of the segments—59 separate alternative floodland management plans were prepared and evaluated. Each of these 59 alternatives was evaluated with the assistance of the water resources simulation models described above, assuming planned year 2000 land use conditions and the effect of such conditions on the flood flow regimen of the stream system. The alternative plans are described and evaluated in Chapter XII of this report, including the calculation of benefit-cost ratios.

RECOMMENDED WATERSHED PLAN

A comprehensive watershed plan was synthesized from the previously proposed regional and subregional plan elements, as these elements were refined and detailed in the watershed study, and from the alternative floodland management and fishery development plans prepared under the watershed study. The comprehensive plan consists of a land use and park and open space element, a floodland management element, and a water quality management element. The plan, which is recommended for adoption as a guide for the physical development of the Pike River watershed, contains the following salient proposals.

Land Use and Park and Open Space Element

The recommended land use and park and open space element for the watershed was derived from the previously prepared and adopted regional land use and park and open space plans, as well as a more detailed park and open space plan prepared by the Commission for the City of Kenosha and the Towns of Pleasant Prairie and Somers, and more detailed farmland preservation plans prepared by the Commission for Kenosha and Racine Counties. This recommended plan element proposes the following measures:

1. The guidance of future land use development in the watershed through locally exercised land use controls into a more orderly and economic pattern. This land use pattern is graphically summarized on Map 44, page 348, of this report. By so guiding future development, the intensification of existing, and the creation of new, developmental and environmental problems would be avoided. The primary environmental corridors of the watershed, together with the remaining undeveloped floodlands, would be protected from incompatible urban development, thereby assuring continuing enjoyment of the recreational, aesthetic, ecological, and cultural values associated with the riverine areas, while avoiding intensification of flood damage and water pollution problems. In addition, the plan would seek to preserve, to the greatest extent possible, the prime agricultural lands in the watershed. The recommended plan would accommodate a planned year 2000 population in the watershed of about 56,300 persons, an increase of 32,100 persons over the 1970 level; and a planned employment of about 25,200 jobs, an increase of 16,900 jobs over the 1970 level. To accommodate the increase in population and employment, an additional 15.1 square miles of land would be converted from rural to urban use between 1975 and 2000, bringing the total urban land to 29.3 square miles, or 57 percent of the total area of the watershed. New urban development in the watershed is proposed to occur primarily at medium population densities, with gross residential population densities ranging from about 3,000 to about 8,000 persons per square mile. The new urban development would be located in areas served, or proposed to be served, by a full range of public utilities and essential urban services, particularly public sanitary sewer and water supply services.

2. The eventual public acquisition through purchase, dedication, or gift of the remaining primary environmental corridor lands in the watershed. The primary environmental corridors of the Pike River watershed total about 1,189 acres located generally along the Pike River from the mouth upstream to and within Petrifying Springs County Park; along Sorenson Creek from the confluence with the Pike River upstream to the Kenosha-Racine County line; and along Pike Creek from the confluence with the Pike River upstream to CTH E. Of the total corridor lands, 439 acres, or about 37 percent, are already in public ownership and consist

Table 115

ALTERNATIVE STRUCTURAL FLOODLAND MANAGEMENT PLANS PREPARED AND EVALUATED UNDER THE PIKE RIVER WATERSHED STUDY

Pike River Stream System Segment	No Action	Individual Structural Measures							
		Structure Floodproofing and Elevation	Detention Storage Reservoir	Diking	Diversion Channel	Bridge or Culvert Replacement or Modification	Channelization	Dredging	Jetty Construction
Bartlett Branch	X	X							
Waxdale Creek and Tributary to Waxdale Creek	X		X						
Chicory Creek	X		X						
Lamparek Ditch	X								
Somers Branch—Downstream of CTH EA	X								
Somers Branch—Upstream of CTH EA	X	X	X	X					
Airport Branch and Tributary to Airport Branch	X								
Nelson Creek	X						X		
Sorenson Creek—CTH KR to Abandoned Chicago, North Shore & Milwaukee Railroad	X	X							
Sorenson Creek—Chicory Road to Pleasant Lane	X	X				X			
Sorenson Creek—Taylor Avenue to Meachem Road	X	X							
Kenosha Branch	X								
Pike Creek	X		X						
Upper Pike River	X								
Lower Pike River	X	X		X	X				
Pike River Estuary	X							X	X

Pike River Stream System Segment	Combination Structural Measures									
	Diking and Structure Floodproofing and Elevation	Diking, Channelization, and Bridge or Culvert Replacement or Modification	Diking, Detention Storage Reservoir, and Onsite Storage	Diking, Structure Floodproofing and Elevation, and Onsite Storage	Channelization and Bridge or Culvert Replacement or Modification	Channelization and Onsite Storage	Channelization, Bridge or Culvert Replacement or Modification and Onsite Storage	Structure Floodproofing and Elevation and Onsite Storage	Detention Storage Reservoir and Onsite Storage	Bridge or Culvert Replacement or Modification and Onsite Storage
Bartlett Branch	X				X			X		X
Waxdale Creek and Tributary to Waxdale Creek									X	
Chicory Creek										
Lamparek Ditch										
Somers Branch—Downstream of CTH EA					X					
Somers Branch—Upstream of CTH EA					X				X	
Airport Branch and Tributary to Airport Branch					X	X				
Nelson Creek						X				
Sorenson Creek—CTH KR to Abandoned Chicago, North Shore & Milwaukee Railroad								X		
Sorenson Creek—Chicory Road to Pleasant Lane								X		X
Sorenson Creek—Taylor Avenue to Meachem Road								X		
Kenosha Branch										
Pike Creek		X			X		X		X	
Upper Pike River	X			X	X		X		X	
Lower Pike River			X		X					
Pike River Estuary										

Source: SEWRPC.

largely of lands on the University of Wisconsin-Parkside Campus and in Petrifying Springs County Park. An additional 138 acres, or about 12 percent, consist of lands held in compatible nonpublic open space and outdoor recreational uses, including lands lying on the grounds of the Kenosha Country Club and the Hawthorne Hollow Nature Preserve along the Pike Creek west of STH 31. Accordingly, the plan recommends that the remaining 612 acres, or 51 percent of the total corridor lands, be acquired for public use over time through purchase, dedication, or gift as urbanization in the watershed proceeds.

3. The development of a seven-mile recreation trail along the main stem of the Pike River from Petrifying Springs County Park to Lake Michigan. This trail would be linked to an existing five-mile Kenosha-Racine County bike trail.

4. The continued provision of park and outdoor recreational facilities throughout the watershed, including the maintenance of the Petrifying Springs County Park as the largest, most significant park in the watershed; the expansion of Sanders Park in the Town of Mt. Pleasant through the acquisition of 40 additional acres; the development of additional facilities at Sam Poerio Park in the City of Kenosha; and the acquisition and development of 12 new local neighborhood parks as the need for such parks becomes evident over time.

Floodland Management Plan Element

The recommended floodland management plan element for the Pike River watershed consists of a carefully selected combination of structural and nonstructural measures. As a matter of policy, the Watershed Committee recommended that the design of all structural flood control works be based upon anticipated flood flows and stages under land use development conditions as reflected in the watershed land use plan. Furthermore, the Committee recommended that, should any local unit of government subsequently determine to permit new urban development in those portions of the watershed not recommended for urban development in the watershed land use plan, as a matter of policy such development should be permitted only upon the condition that either onsite stormwater detention be provided to assure that runoff from the developed land not exceed runoff under predevelopment conditions; or it be shown that the development will not increase downstream discharges and stages over those set forth in the watershed plan.

In the development of the floodland management plan, the Watershed Committee also considered a policy approach to floodland management that would attempt to use onsite storage to ensure that runoff from developing areas, as recommended in the land use plan, not exceed runoff under predevelopment conditions. The Committee concluded that, while such a policy may in some site-specific situations have local stormwater drainage and water quality benefits, the flood control benefits would be marginal. In its analyses, the Committee determined that, with the exception of a few tributary streams having very small catchment areas, increases in flood stages attendant to undetained flows from incremental urban development may be expected to be limited to less than one foot, well within the limits of the normal freeboard provisions used in the design of flood control works. Accordingly, the Committee recommended that such a policy be applied only on a case-by-case, site-specific basis whereby individual benefit-cost analyses are undertaken to determine whether or not it is fiscally sound to apply the policy to obtain stormwater drainage and water quality benefits.

While the basic floodland management plan element is nonstructural, consisting of the land use development proposals contained in the land use element of the watershed plan, a number of specific structural measures are recommended for inclusion in the Pike River watershed plan. These measures are best understood by grouping them within the three subwatersheds used in the planning process. These three subwatersheds are shown on Map 30, page 139, and consist of the Pike Creek, Upper Pike River, and Lower Pike River subwatersheds.

Pike Creek Subwatershed: The following structural flood control measures are recommended for the streams in the Pike Creek subwatershed:

1. Channel cleaning and debrushing activities along the 1.8-mile reach of the Pike Creek extending from the confluence with the Pike River in Petrifying Springs County Park upstream to the confluence with Somers Branch, as shown on Map 80, page 502. Such cleaning and debrushing activities

should be undertaken in a manner compatible with preserving to the maximum extent practicable the natural environment along that reach of the Creek.

2. Major channel improvements, consisting of channel widening and deepening, along Pike Creek extending from the confluence with Somers Branch upstream for about 5.7 miles to a point just north of STH 50, as shown on Map 80, page 502. The proposed channel would be turf lined; would have bottom widths ranging from five feet to 20 feet; and would have side slopes of one on three. The proposed improvements lie along reaches of Pike Creek that have been previously channelized and along which there exist no significant wetlands, woodlands, or wildlife habitat areas. The proposed improvements would be designed to carry within the new channel all floods up to and including the 100-year recurrence interval flood. The proposed improvements would resolve existing and potential agricultural and structural flooding problems along Pike Creek. The channel improvements would require the replacement of nine existing bridges across the Pike Creek: STH 142; STH 158; CTH E; CTH K; the Chicago, Milwaukee, St. Paul & Pacific railroad bridge downstream of CTH K; the Town of Somers solid waste transfer station bridge upstream of CTH L; and three farm bridges upstream of STH 142.

3. The floodproofing of three structures and the elevation of two additional structures along the Somers Branch upstream of the Chicago, Milwaukee, St. Paul & Pacific railroad crossing as shown on Map 81, page 504.

4. Major channel improvements, including channel widening and deepening, along both the Airport Branch and the Tributary to Airport Branch, including replacement of the Chicago, Milwaukee, St. Paul & Pacific railroad crossing of the Airport Branch, as shown on Map 82, page 505. This recommendation is conditioned, however, on a finding in the design phase of the proposed industrial park along these branches between STH 31 and the Kenosha Municipal Airport north of STH 158 that the channel improvements are desirable. It may be possible through good industrial park design to develop the remaining area along the Airport Branch and the Tributary to the Airport Branch for industrial use without filling of the floodplain, retaining the floodlands in open uses in which case none of the structural flood control measures would be required. The conditionally proposed channel improvements would consist of new turf-lined channels, with the existing drainageways being deepened by an average of about five feet, and a maximum of about eight feet; with the new channels having a bottom width ranging from 10 feet to 15 feet, and with the new channels having side slopes of one on three. Should it be ultimately determined to be desirable to undertake these channel improvements to facilitate the expansion of the industrial land use complex in this area, the analyses made under the watershed plan preparation indicate that such improvements would not significantly change any of the recommended downstream structural flood control on Pike Creek. Conversely, however, it would not be possible to undertake the tentatively proposed channel improvements on the Airport Branch and the Tributary to the Airport Branch without first having implemented the channelization recommendations on the Pike Creek downstream from the confluence with the Airport Branch.

<u>Upper Pike River Subwatershed:</u> The following structural flood control measures are recommended for the streams in the Upper Pike River subwatershed:

1. Major channel improvements, consisting of channel widening, deepening, and partial realignment, along the Upper Pike River extending from CTH C downstream to the confluence with the Pike Creek in Petrifying Springs County Park, a distance of about 6.9 miles, as shown on Map 84, page 510. The proposed channel would be turf lined, would be lowered by an average of about four feet, and a maximum of about six feet; would have bottom widths ranging from 10 feet to 20 feet; and would have side slopes of one on three. With the exception of the southernmost portion of the reach proposed to be improved, these channel improvements lie along reaches of the Pike River that have been previously channelized and along which there exist no significant

wetlands, woodlands, or wildlife habitat areas. An environmental corridor does exist, however, within the Petrifying Springs County Park at the confluence of the Pike River and Pike Creek and extends upstream along the Pike River to STH 31. The recommended intrusion of channel improvements into the primary environmental corridor is unavoidable, however, if the flooding problems along the Pike River from STH 31 to the confluence with Lamparek Ditch are to be abated. The proposed improvements would be designed to carry within the new channel all floods up to and including the 100-year recurrence interval flood, and would resolve the existing and potential agricultural and structural flooding problems along the Upper Pike River. The channel improvements would include the replacement or modification of 11 existing bridges across the Upper Pike River: STH 11, STH 20, STH 31, CTH KR, Oakes Road, Spring Street, Braun Road, two private bridges upstream of STH 20, a farm bridge downstream of STH 11, and a farm bridge downstream of the confluence with Lamparek Ditch. In addition, the Chicago, Milwaukee, St. Paul & Pacific railroad crossing upstream of STH 11 would be removed since the line has been abandoned.

2. The construction of a dike upstream of Spring Street to protect existing residential development from flooding along the Bartlett Branch, as shown on Map 85, page 513. The dike would have a total length of about 500 feet, an average height of about four feet, and a maximum height of about six feet. Water impounded behind the dike from local drainage would be permitted to be dissipated slowly through infiltration into the groundwater reservoir.

3. The floodproofing of two structures and the elevation of four additional structures along the Bartlett Branch downstream of Spring Street, as shown on Map 85, page 513.

Lower Pike River Subwatershed: The following structural measures for flood control are recommended for streams in the Lower Pike River subwatershed:

1. The floodproofing of the Carthage College Field House and the former Valley Restaurant and Supper Club and the elevation of a residence located just upstream of CTH G, as shown on Map 86, page 516.

2. The possible construction of a system of low level dikes through the Kenosha Country Club grounds along the Pike River from 22nd Avenue downstream to the former Chicago, North Shore & Milwaukee Railroad right-of-way, as shown on Map 87, page 517. The dikes would be designed to provide protection from floods up to and including the 10-year recurrence interval flood and would abate the problems attendant to flooding along the Pike River through the Country Club. Such flooding can not only disrupt normal use of the golf course, but can also damage tees, greens, and traps, and cause maintenance problems, including the deposition of debris over the course. Such a system of dikes would average about four feet in height, and could be either of conventional design, or be constructed in such a manner as to extend back to where the dike elevation intersects with the golf course fairways to facilitate drainage. The recommended system of dikes would not have any adverse effects on regulatory flood flows upstream or downstream of the Country Club site and, if carefully designed, need not entail any significant loss of floodwater storage during a 100-year recurrence interval flood. The dikes would require careful, detailed design by a skilled landscape architect, since the fairways for eight of the holes of the Country Club golf course cross the Pike River. Some tees or greens may have to be elevated, or relocated, to permit construction of the dike system. The benefits of such a system would be limited to those perceived by the members of the Kenosha Country Club, and, therefore, the dikes would be constructed only if the Club determined those perceived benefits exceeded the costs.

3. The possible construction of a series of low level dikes along the main stem of the Lower Pike River, both upstream and downstream of the Kenosha Country Club in order to abate agricultural crop damages, as shown on Map 88, page 519. The plan does not specifically recommend that these dike systems be constructed because of a long-term commitment to convert the lands affected from

rural to urban use. However, such a long-term commitment to urban land use development should not be construed to prohibit farmers along these stream reaches from individually or collectively undertaking the construction of low level dikes to abate agricultural flood damage problems so long as the land continues to be farmed. Such a system of dikes could be designed to prevent flooding from up to and including the 10-year recurrence interval flood. In the long term, however, the plan envisions that the entire 100-year recurrence interval floodplain be maintained in essentially natural, open uses as the lands adjacent to the Lower Pike River become urbanized over the next several decades. In some cases, the nature of the floodplain is such that wetlands will be reestablished along the stream system and the primary environmental corridor along the Lower Pike River will be consequently enriched. Whether or not to construct the low level dikes in the interim for agricultural land protection would be a decision to be made by the farmers involved either individually or collectively.

4. The replacement of the existing Chicory Road crossing of Sorenson Creek with a new clear span bridge having an opening of about 30 feet, as shown on Map 89, page 520. The new bridge would eliminate the backwater effects of the existing hydraulically inadequate crossing and thereby resolve upstream structure flooding problems.

5. The construction of two parallel jetties and the periodic dredging of the channel bottom between the jetties to maintain channel flow capacity at the mouth of the Pike River on the Lake Michigan shoreline, as shown in Figure 64, page 518. These measures would abate the flooding problems that are caused by the formation of a sandbar across the mouth of the Pike River.

Concluding Remarks—Floodland Plan Element: In addition to the foregoing structural measures, the floodland management element of the plan includes recommended standards relative to bridge replacement to ensure that major streets and highways remain operable during flood events. The plan also includes several supplemental measures intended to minimize the monetary losses associated with flooding, including participation in the Federal Flood Insurance Program and continuation of desirable lending institution and realtor policies concerning the sale of riverine properties. Maintenance of a basic cooperative stream gaging program is also recommended.

Finally, the plan recommends that each of the units of government in the watershed carefully review their floodland zoning regulations to ensure that such regulations complement the recommended watershed land use plan element and are coordinated with the structural flood control measures recommended in the plan. In general, those floodlands lying within the 100-year recurrence interval flood hazard lines under year 2000 planned land use conditions that are presently neither developed for urban use nor committed to such development by the recordation of land subdivision plats and the installation of municipal improvements should be zoned so as to prohibit incompatible future urban development. Those existing urban land uses in the floodlands scheduled to be floodproofed, elevated, or protected through future structural flood control measures should be placed in a flood hazard district until implementation of the recommended flood control measures, at which time the lands should be appropriately rezoned.

Water Quality Management Plan Element

Drawing from the previously adopted regional water quality management plan, the recommended watershed plan proposes the abatement of surface water pollution problems within the Pike River watershed through the following measures:

1. The abandonment of the single remaining sewage treatment plant in the watershed which is serving the Town of Somers Utility District No. 1. Abandonment of this treatment plant and connection of its service area to the Kenosha sanitary sewerage system would be effected by an interim connection using a combination gravity flow sewer and pumping station and force main system, as shown on Map 90, page 526.

2. The elimination of three of the five sewage flow relief devices in the City of Kenosha that permit the discharge of raw sewage

from the sanitary sewer system to the storm sewer system and the Pike River. The remaining two flow relief devices would be maintained to function as emergency overflow outlets for pumping stations but only utilized in extreme emergencies when the pumping station would be inoperable.

3. The elimination of the direct or indirect discharge of industrial wastes to the Pike River and its tributaries while allowing the continued discharge of clear water, such as spent cooling water, to the stormwater drainage system.

4. The abatement of pollution from nonpoint sources throughout the Pike River watershed through implementation of a combination of the following land management measures: proper material storage and runoff control on industrial and commercial sites; control of sediment and debris during demolition and construction activities; septic tank system management; public education programs to promote proper use of fertilizers and pesticides; litter and pet waste control; the application of soil conservation practices on rural land; improved timing and efficiency of street sweeping, leaf collection, and catch basin cleaning; and streambank erosion control.

5. The undertaking of a cooperative, continuing water quality monitoring program.

COST ANALYSIS

In order to assist public officials in evaluating the recommended comprehensive Pike 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 in the watershed for major flood control and drainage purposes in order to determine if sufficient monies were likely to be available to implement the floodland management portion of the recommended watershed plan. Similar analyses were not completed for the land use, park and open space, and water quality management recommendations set forth in the watershed plan, since those analyses were performed as part of the regional land use, park and open space, and water quality management plans and do not represent newly developed recommendations nor new costs for the implementation of the Pike River watershed plan.

The schedule of capital and operation and maintenance costs for the recommended watershed plan is set forth in Table 108, page 531. This schedule assumes a 17-year plan implementation period beginning in 1984 and extending through the year 2000. The total capital cost of implementing the entire Pike River watershed plan is estimated at $20.3 million, representing an average annual capital expenditure over the 17-year period of nearly $1.2 million. Of this total, about $5 million, or 25 percent representing an annual average expenditure of $294,600, is required to implement the park and open space element of the plan, including the acquisition of primary environmental corridor lands; about $10.1 million, or 50 percent representing an annual average expenditure of $593,900, is required for implementation of the water quality management element of the plan; and about $5.2 million, or 26 percent of the total representing an annual average expenditure of about $305,600, is required for implementation of the floodland management element of the plan.

Thus the total capital investment and operation and maintenance cost required for plan implementation may be expected to approximate $1.5 million on an average annual basis, or about $37.27 per capita per year over the 17-year plan implementation period. This per capita cost is based on a resident watershed population of about 40,000 persons which is equal to the anticipated average resident population in the watershed between the 1970 population level of about 24,000 persons and the planned year 2000 population level of about 56,000 persons. The average annual cost of implementation of the land use and park and open space element, the water quality management element, and the floodland management element are estimated at, respectively, about $417,900, or $10.38 per capita per year; $744,800, or $18.51 per capita per year; and $337,000, or $8.37 per capita per year.

As noted above, the only significant, newly proposed projects and accompanying expenditures in the Pike River watershed plan are those associated with the floodland management element. Accordingly, an analysis was conducted to determine the level of public expenditures for flood control and related improvements in the watershed in recent years in order to determine whether or not the recommended flood control improvements set forth in the plan could likely be accomplished by continuing the historic pattern of expenditures, or whether a change in that historic pattern would be required. A survey was made of the flood control expenditures by the local units of government in the Pike River watershed over the period 1972 through 1982. The results of this survey are set forth in Table 109, page 533. As indicated in this table, the local units of government in the watershed have collectively expended nearly $1.1 million over the last 11 years for major flood control and drainage improvements, representing an average annual expenditure of about $100,000. As noted above, the estimate of the capital expenditures required to implement the floodland element of the plan over the next 17 years would require an average annual expenditure of slightly over $300,000. Thus, it may be concluded that for full implementation of the flood control recommendations of the plan to occur by the plan design year 2000, an increase in the average annual expenditures would be required from about $100,000 to about $300,000 annually.

The foregoing analysis, however, pertains to the entire set of flood control recommendations set forth in the Pike River watershed plan irrespective of location within the watershed and irrespective of the type of improvement proposed. Of the total estimated capital cost of nearly $5.2 million, about $360,000 represents the capital costs for structure floodproofing and elevation. Since these expenditures would occur on private property, it may be assumed that these measures would be undertaken by the private property owners concerned and would not involve any significant public expenditures. It is useful to view the remaining approximately $4.8 million in capital requirements for flood control by geographic subarea of the watershed. Those expenditures attendant to the channel improvements along the Upper Pike River, to the dike along the Bartlett Branch, and to the replacement bridge at Chicory Road total about $1.5 million. These recommended improvements would all be located in the Town of Mt. Pleasant. Full implementation of these three projects over the 17-year plan implementation period would require an average annual expenditure of about $90,000 per year. At the present time, the Town of Mt. Pleasant is expending monies for major flood control purposes at a rate of about $73,000 per year. By continuing the current rate of expenditure, then, the structural measures set forth in the Pike River watershed plan that pertain to the Town of Mt. Pleasant could be substantially implemented over a period of about 21 years.

The remaining $3.3 million of capital required for flood control works lie in the Kenosha County portion of the watershed. Of this total, nearly $860,000 represents the capital required for implementation of the channel improvements along the Airport Branch and the Tributary to the Airport Branch. As noted above, these improvements need not be undertaken unless it is deemed desirable to undertake such improvements in conjunction with an industrial park development project, and unless it can be shown that the land made available for development would have a value exceeding the cost of the flood control works. Any costs associated with such improvements, accordingly, should be borne as a part of the cost of developing the industrial park and should be recovered through land sales recorded therein, if indeed they are undertaken at all. Of the remaining $2.4 million in expenditures, about half would be required for the low level dike system above, within, and below the Kenosha Country Club. The responsibility for the construction of these dikes would fall to the membership of the Kenosha Country Club and the farmers along the Lower Pike River as the benefited parties may individually or collectively deem it desirable. The remaining $1.2 million in capital requirements, then, represents the public cost of plan implementation in the Kenosha County portion of the watershed. This would require an average annual expenditure over the plan implementation period of about $70,000. This may be compared with the average annual expenditure over the last 11 years of about $23,500. Consequently, it would be necessary to substantially increase the historic rate of expenditures of the Kenosha County portion of the watershed if the recommended improvements to be publicly funded are to be put in place over the next two decades.

The foregoing discussion assumes that all of the costs necessary to implement the floodland management element of the watershed plan would be borne locally. It may be possible to secure some federal funding in partial support of the implementation of one or more of the recommended flood control measures. Although there are no federal or state grant-in-aid programs available at the present time to assist local units of government in undertaking flood control improvements, the U. S. Army Corps of Engineers, as discussed in Chapter XV of this report, administers a federally implemented flood control program. Under this program, the Corps can directly build needed flood control works provided that the local units of government concerned secure all of the lands, easements, and necessary rights-of-way required and further agree to maintain and operate the facilities once constructed. Under the Corps program, all projects must be demonstrated to be economically feasible and environmentally sound. The system level analyses conducted as part of the Pike River watershed study provided an assessment of such economic feasibility and environmental soundness; however, under federal regulations, the Corps must conduct its own detailed feasibility studies and must find in all cases that the benefits associated with the project at least equal the costs.

Based upon the preliminary analyses conducted under the Pike River watershed study, it would appear that at least one of the recommended flood control works may qualify as a U. S. Army Corps of Engineers project under that agency's small-scale, general works project program. This recommended project involves the channelization measures recommended for the Pike Creek in the Town of Somers. The benefit-cost ratio for these recommended channelization measures was estimated at 1.1.

Another flood control measure recommended in the watershed plan which may also qualify as a Corps project is the diking system through the Kenosha Country Club. Because of the rigorous way in which benefits were estimated under the watershed study, it was not possible to take into account the indirect costs incurred by members of the Kenosha Country Club in terms of loss of opportunity to use the facility during the relatively frequent periods of flooding, nor the loss of revenue resulting from the inability to operate the facility during those flooding periods. Under the rules governing the conduct of the Corps feasibility studies, such indirect costs may well qualify for inclusion in a federal benefit-cost analysis. The average annual cost estimated for the diking project through the Kenosha Country Club grounds is about $23,000. Documentation provided by the Club during the conduct of the watershed study did indicate that the Club suffered substantial damages over the four-year period 1975 through 1978 from a number of floods, with such damages averaging from $15,000 to $20,000 annually. With the inclusion of some indirect costs as benefits in a Corps analysis, it may be possible to achieve a positive benefit-cost ratio for that project as well.

Should it be possible to obtain U. S. Army Corps of Engineers involvement in the projects in the Kenosha County portion of the watershed, this would, of course, reduce the local expenditures required for implementation of the plan. As noted above, and not including the Kenosha Country Club project nor the low level agricultural dikes upstream or downstream of the Kenosha Country Club, about $1.2 million in capital costs would be required to implement the Kenosha County portion of the watershed plan. The great majority of that cost, or $1.1 million, is required for the Pike Creek channel improvement project. Since all of the construction costs would be borne by the federal government under a U. S. Army Corps of Engineers project, it may be possible, given that federal involvement, to reduce the local expenditures required to approximate the average annual expenditure found over the last 11 years of about $23,500.

PLAN IMPLEMENTATION

A complete identification of the plan implementation responsibilities by level and unit of government is set forth in Chapter XV of this report. Most of the major recommendations contained in the comprehensive Pike River watershed plan can be undertaken by the existing state, county, and local units of government. If it is determined desirable by those directly affected to construct a system of dikes along the Lower Pike River for recreational and agricultural land protection against flooding, a new special unit of government—namely, a drainage district—would be required. In addition, the Town Board of Somers will need to create a new sanitary district to carry out the flood control recommendations along the Pike Creek.

At the local governmental level, plan implementation entities include Kenosha and Racine Counties; the Cities of Kenosha and Racine; the Villages of Elmwood Park and Sturtevant; the Towns of Mt. Pleasant, Pleasant Prairie, and Somers; and the existing sanitary and utility districts within those three towns. At the state level, implementation entities include the Wisconsin Departments of Natural Resources, Transportation, and Agriculture, Trade and Consumer Protection. At the federal level, plan implementation entities include the U. S. Environmental Protection Agency, the U. S. Geological Survey, the Federal Emergency Management Agency of the U. S. Department of Agriculture, and potentially the U. S. Army Corps of Engineers.

Primary emphasis in implementation of the newly developed recommendations contained in the comprehensive plan for the Pike River watershed, that is those dealing with flood control, is based on actions by the Kenosha County Park Commission, the Town of Mt. Pleasant Stormwater Drainage District, the City of Kenosha Park Commission, the

City of Kenosha Board of Public Works, and the Town Board of the Town of Somers. The specific listing of the detailed plan actions required to implement the watershed plan by level, unit, and agency of government is set forth on pages 568 through 573 of this report.

PUBLIC REACTION TO THE RECOMMENDED PLAN AND SUBSEQUENT ACTION OF THE PIKE RIVER WATERSHED COMMITTEE

A formal public hearing was held upon completion of the preliminary plan for the watershed. The hearing was conducted on behalf of the Regional Planning Commission by the Pike River Watershed Committee with the Chairman of the Watershed Committee presiding. The purpose of the hearing was to present the preliminary findings and recommendations of the watershed study for review and consideration by public officials and interested citizens. The hearing was announced through news releases sent to all media serving the watershed area, through letters to the heads of the local units of government in the watershed, and through publication and distribution of a Commission Newsletter summarizing the preliminary findings and recommendations of the study.[3] The hearing was held at 7:30 p.m., on December 16, 1982, at the Somers Town Hall.

Minutes of the public hearing were published by the Commission and provided to both the Pike River Watershed Committee and the Regional Planning Commission for review and consideration prior to final adoption of the recommended plan.[4] The minutes of the public hearing contain a complete record of all comments made at the hearing. In addition, the document includes written comments submitted at or after the public hearing.

The record of the public hearing indicated a generally favorable reaction to the plan with, however, concerns being expressed by a number of individuals, organizations, and agencies with respect to the following four matters:

1. The primary environmental corridor preservation recommendations along the main stem of the Pike River downstream of the Petrifying Springs County Park, including the alignment of the recommended recreational trail through the grounds of the Kenosha Country Club.

2. The proposed low-level dikes to protect agricultural lands along the Lower Pike River both upstream and downstream of the Kenosha Country Club.

3. The proposed channelization projects along the Pike Creek and the Upper Pike River, with respect to the potential affects of such projects on the adjacent wetlands and the aquatic habitat and fishery, and upon the water use objectives for these stream reaches.

4. Several specific urban floodland management measures, particularly the proposed dike along Bartlett Branch, the proposed jetties at the mouth of the Pike River, and the proposed dikes through the grounds of the Kenosha Country Club.

Each of these four areas of concern is discussed below, together with the Advisory Committee's response thereto. Any changes to the preliminary plan as proposed by the Advisory Committee and presented in Chapter XIV of this report are specifically noted.

Primary Environmental Corridor and Related Concerns

Several landowners living along the Lower Pike River expressed concern over the plan recommendation to ultimately acquire the remaining undeveloped primary environmental corridor lands downstream of Petrifying Springs County Park, and in particular over the development of a recreational trail along that corridor. Some of these concerns related to the costs involved, while other concerns related to the lack of detail with respect to the specific lands that would be acquired and the specific location and alignment of any recreational trail. Representatives of the Kenosha Country Club indicated that the Club objected to the alignment of any recreational trail along the Pike River through its grounds.

In response to these concerns, the Committee reviewed that element of the plan dealing with the primary environmental corridor along the Lower

[3] *See SEWRPC Newsletter, Volume 22, No. 5, September-November 1982.*

[4] *See Minutes of Public Hearing, A Comprehensive Plan for the Pike River Watershed.*

Pike River. The Committee reaffirmed its position that the lands lying along the Lower Pike River are among the most significant in terms of remaining wetlands, woodlands, and wildlife habitat in the entire watershed and, accordingly, should continue to be recommended for preservation through public acquisition for open space, outdoor recreation, and flood control purposes. In taking this position, the Committee noted that this particular recommendation is not new, having previously been made in the comprehensive plan for the Kenosha Planning District completed in the mid-1960s, and reaffirmed in the park and open space plan for the City of Kenosha and Towns of Pleasant Prairie and Somers completed in 1980.

The Committee further noted that some of the concerns expressed by residents over the lack of precision in the plan would be addressed at such time as the designated implementing agency—the Kenosha County Park Commission—was to undertake the detailed identification of the lands that should be acquired either through public purchase or through dedication at such time as some of the major parcels lying along the Lower Pike River may be developed for urban purposes. The Committee noted that there will be opportunity for further public participation in such a plan refinement process and any site-specific concerns can be addressed at that time by the implementing agency.

With respect to the alignment of the recreational trail along the Pike River from Petrifying Springs County Park to the Kenosha Country Club and a junction at that point with the existing trail along the alignment of the abandoned Chicago, North Shore and Milwaukee Railroad, the Committee noted that the Pike River watershed plan is a system level plan and that further, more detailed studies will be required to identify alignments for such facilities as recreational trails. The responsibility for such studies also lies in this instance with the Kenosha County Park Commission. The Committee recognized, however, the rights of the Kenosha Country Club to restrict access to its lands along the Pike River to members only, as well as the potential conflicts during the summer months of users of a recreational trail through the Country Club grounds and users of the Country Club golf course. Accordingly, the Committee directed that the plan be changed to reflect a general alignment of the proposed recreational trail that would deviate from the alignment of the Pike River from the point where the Pike River flows immediately adjacent to CTH A just west of 22nd Avenue, thence along CTH A easterly for a distance of about one-half mile to the intersection of the existing recreational trail on the abandoned North Shore railway right-of-way with CTH A.

Lower Pike River Agricultural Dikes Concerns

Several citizens commented on the preliminary plan recommendation pertaining to the construction of low-level flood control dikes along the main stem of the Lower Pike River both upstream and downstream of the Kenosha Country Club for the purpose of abating agricultural crop damages. These individuals were concerned over the potential impacts of these dikes on a farm-by-farm basis, and further objected to the plan implementation recommendation that would have the individual farmers bearing the cost of the dike construction either individually or collectively through a new drainage district. A suggestion was offered that the plan be changed to include a recommendation that would have Kenosha County pay for the construction of the proposed dikes.

In response to these concerns and comments, the Advisory Committee reviewed the proposal for these low-level flood control dikes and reconfirmed its position. The Committee noted that the dike system could be implemented on a farm-by-farm basis and that such an approach to implementation should not have adverse effects on neighboring landowners because of the very small amount of floodwater storage that would be removed under floods up to and including the 10-year recurrence interval event. The Committee further noted that in any case the dikes would be subject to overtopping during floods exceeding a 10-year recurrence interval flood, and thus the entire natural floodplain would be available for floodwater storage during major floods with no adverse impacts on neighboring landowners.

With respect to the suggestion that Kenosha County be identified as the implementing agency for the proposed dikes, the Committee concluded that such an approach would have a very low potential for political acceptance given the equity considerations inherent in the matter, and that a process already exists in the Wisconsin Statutes to address agricultural flood damage problems collectively through the formation of drainage districts. The Committee concluded that the landowners and farmers directly involved along the Lower Pike River voluntarily seek to produce crops on natural floodplain lands and, accordingly, knowingly take on the risks associated with such activities. Since only these individual landowners and farmers would stand to directly benefit from the construction of the dikes, and since these dikes can be constructed individually by each farmer or landowner, or collectively through a drainage district approach, the Committee could find no rationale for recommending that all county taxpayers share in the cost burden of the dike construction project. Accordingly, the plan was left unchanged in this respect by the Advisory Committee.

Channelization and Water Quality Concerns

Certain of the comments received at and after the public hearing dealt with a series of interrelated concerns over the proposed channelization projects on the Pike Creek and the Upper Pike River, and the potential impact of those projects upon the existing aquatic habitat along those stream reaches, as well as the proposed water use objectives for those stream reaches. Several written comments were filed taking note of the fact that the plan was devoid of any specific recommendations that might enhance the aquatic habitat of the Pike River watershed. Comments to this effect were filed by the Wisconsin Environmental Decade, the Racine-Kenosha Group of the John Muir Chapter of the Sierra Club, and by one private citizen. The Wisconsin Department of Natural Resources (DNR) expressed concern over the impact that the proposed channelization projects would have upon the existing wetlands and aquatic habitat in the watershed, as well as the specific impact that the channelization project on the Upper Pike River would have on a short reach of the River within, and immediately upstream of, Petrifying Springs County Park. This latter stream reach is the only proposed channelization project in the watershed that would occur within a designated primary environmental corridor. The DNR noted in particular that inventories conducted under the watershed study indicated a relatively high potential for the restoration of the fishery habitat along certain reaches of the Upper Pike River and the Pike Creek, and suggested that a way be found to approach the proposed channelization projects in a manner that would be sensitive to the restoration and possible enhancement of the existing aquatic habitat along those stream reaches. The DNR also expressed concern over the proposal in the plan to recommend limited recreational use objectives for the Pike Creek and the Upper Pike River, such recommendations representing a departure from the recommended recreational use objectives for these stream reaches set forth in the adopted regional water quality management plan. Finally, one citizen commented at the public hearing on the need for more explicit recognition in the plan for the control of the stream bank erosion along the Pike Creek.

In response to this series of interrelated comments and concerns, the Advisory Committee reconsidered the preliminary plan recommendations relating to channelization of the Pike Creek and the Upper Pike River and to the water use objectives for the Pike Creek and the Upper Pike River. Based upon this reconsideration, the Committee concluded the following:

1. There remains a need to undertake major channelization projects for flood control and for rural and urban stormwater drainage purposes along both the Pike Creek and the Upper Pike River. Furthermore, while some damage to the existing natural environment may occur along that portion of the Upper Pike River lying within a primary environmental corridor in, and immediately upstream of, Petrifying Springs County Park, the proposed channelization project as a practical matter cannot be terminated at the Racine-Kenosha County line and still substantially achieve the desired flood control and drainage objectives within the Racine County portion of the watershed. Termination of the channelization project upstream of STH 31 would not resolve the agricultural flood damage problems along the Pike River at and immediately above that location nor along the Lamparek Ditch. Accordingly, the Committee reaffirmed its position that major channelization projects are warranted along both the Pike Creek and the Upper Pike River, including improvement of the Upper Pike River channel all the way to the confluence with the Pike Creek in Petrifying Springs County Park.

2. The Committee took cognizance, in particular, of the DNR concern over the potential impacts on the aquatic habitat through the loss of vegetation, pools, riffles, and runs that might be attendant to a traditional stream channelization project. After carefully reconsidering this matter, the Committee recommended that consideration be given to designing and constructing the channelization projects in such a manner so as to reestablish and possibly enhance the aquatic habitat in the stream. The Committee, in this respect, took note of the stream

channel rehabilitation techniques identified by the Regional Planning Commission in the adopted regional water quality management plan.[5] Basically, the approach suggested for rehabilitation of modified stream channels involves improving the biological potential of such a channel by providing protective areas where a suitable sediment substrate may at least temporarily accumulate, by increasing vegetative growth, and by eliminating barriers to aquatic migration. The types of measures which could be used to increase the biological potential of modified stream channels in the Pike River are summarized in Table 116. Figure 65 shows a possible design for a rehabilitated channelized stream section. In addition to providing suitable habitat for aquatic life, such stream channel rehabilitation measures can enhance the aesthetic qualities of the stream and—through temporary sediment storage, aeration, increased shading, and biological nutrient uptake—can improve the water quality of the stream. While most of these rehabilitation measures by their very nature would tend to decrease the hydraulic efficiency of the stream channel, such efficiency could be maintained at a level that would not preclude achievement of flood control objectives, at, however, an increase in maintenance, as well as in construction, costs.

Accordingly, the Advisory Committee recommended that the Mt. Pleasant Stormwater Drainage District—for that reach of the Upper Pike River extending from the confluence with Pike Creek upstream to STH 20—and the Town Board of the Town of Somers—for that reach extending along the Pike Creek from the confluence with Somers Branch upstream to CTH L—work with the DNR to determine the practicality and feasibility of including in any channelization projects along these stream reaches the design and installation of the types of biological habitat rehabilitation measures set forth in Table 116. There does not exist an extensive amount of data that would indicate the range of costs associated with undertaking such measures. However, based upon recent experiences by the DNR, it is believed that such costs would range from $15,000 to $30,000 per channelized stream mile. Accordingly, it may be concluded that the additional capital costs for undertaking such measures—should they be found to be practical and feasible as the channelization projects are designed—could be expected to range from $80,000 to $160,000 along about 5.3 miles of the Upper Pike River and from $23,000 to $46,000 along about 1.5 miles of the Pike Creek.

[5]*See pages 72 through 76, SEWRPC Planning Report No. 30, A Regional Water Quality Plan for Southeastern Wisconsin: 2000, Volume Two, Alternative Plans.*

3. The Advisory Committee recommended that the previous recommendations set forth in the adopted regional water quality management plan to establish full recreational water use objectives for certain portions of the Upper Pike River and the Pike Creek be restored. Accordingly, the final Advisory Committee recommendations with respect to the recommended water use objectives for the Pike River watershed are summarized on Map 94. Full recreational use standards are again recommended for that portion of the Upper Pike River extending upstream to STH 20; for that portion of the Pike Creek extending upstream to CTH L; and for Chicory Creek, Lamparek Ditch, School Tributary, Somers Branch, and that portion of Waxdale Creek upstream to the limits of the Village of Sturtevant. Since the general public would be the beneficiary of any aquatic life enhancement measures found necessary, it is recommended that the cost of such enhancement measures be borne by federal and state governments.

Specific Floodland Management Project Concerns

In commenting on the floodland management element of the preliminary plan, the DNR noted that, under rules adopted by the Wisconsin Natural Resources Board and set forth in Chapter NR 116 of the Wisconsin Administrative Code, any dike or levy shall be set at a minimum height so as to provide three feet of freeboard beyond the elevation of the 100-year recurrence interval flood. As presented at the public hearing on the preliminary plan, the proposed dike to abate flooding along the Bartlett Branch was recommended to be constructed to provide for two feet of freeboard. In considering this matter, the Committee noted that Chapter NR 116 does provide for an exception to the freeboard requirement where a dike is not used for the protection of human life. Since the proposed Bartlett Branch dike would be designed only

Table 116

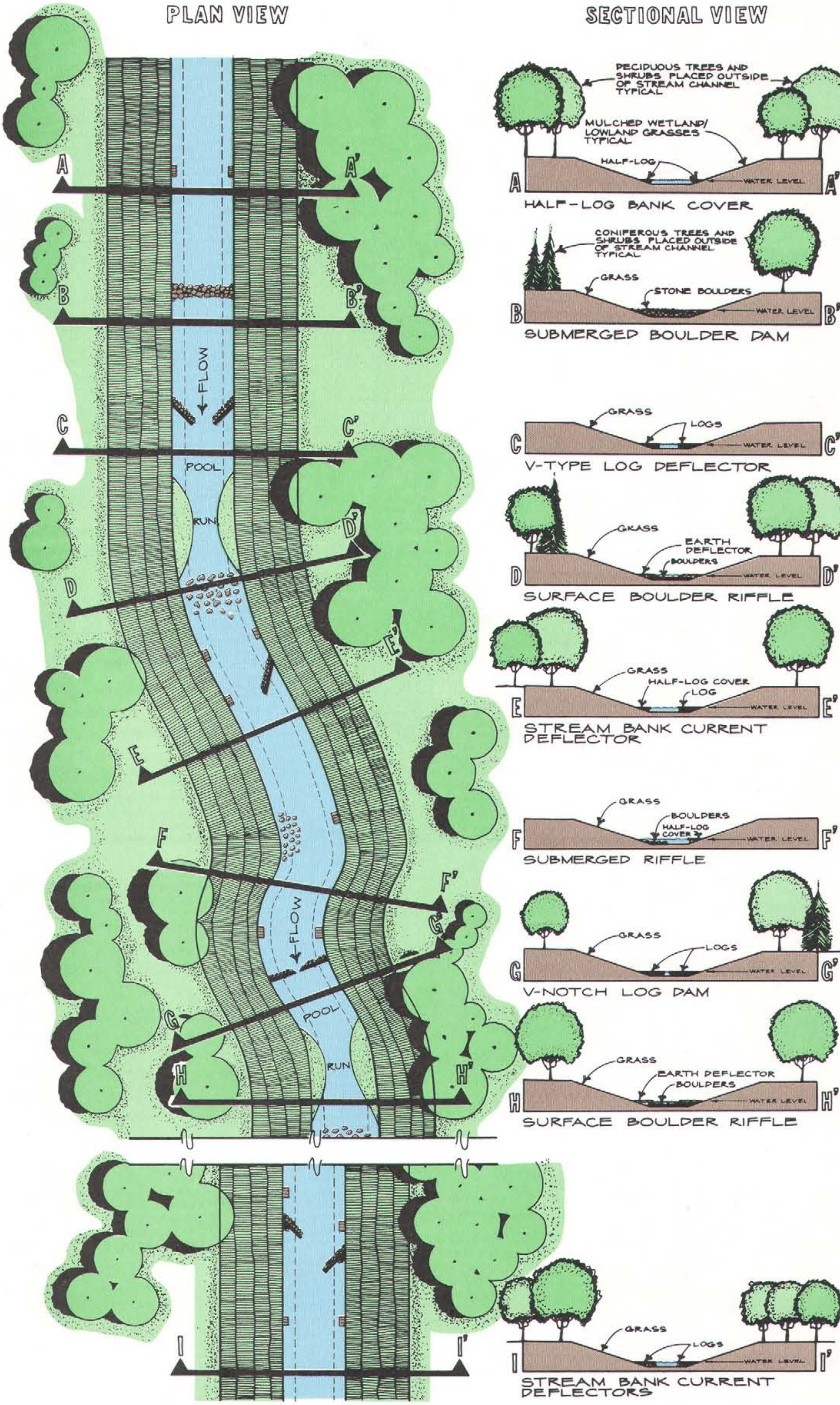
SELECTED BIOLOGICAL LIFE HABITAT REHABILITATION MEASURES FOR EXISTING AND PLANNED CHANNEL MODIFICATIONS

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

Source: SEWRPC.

Figure 65

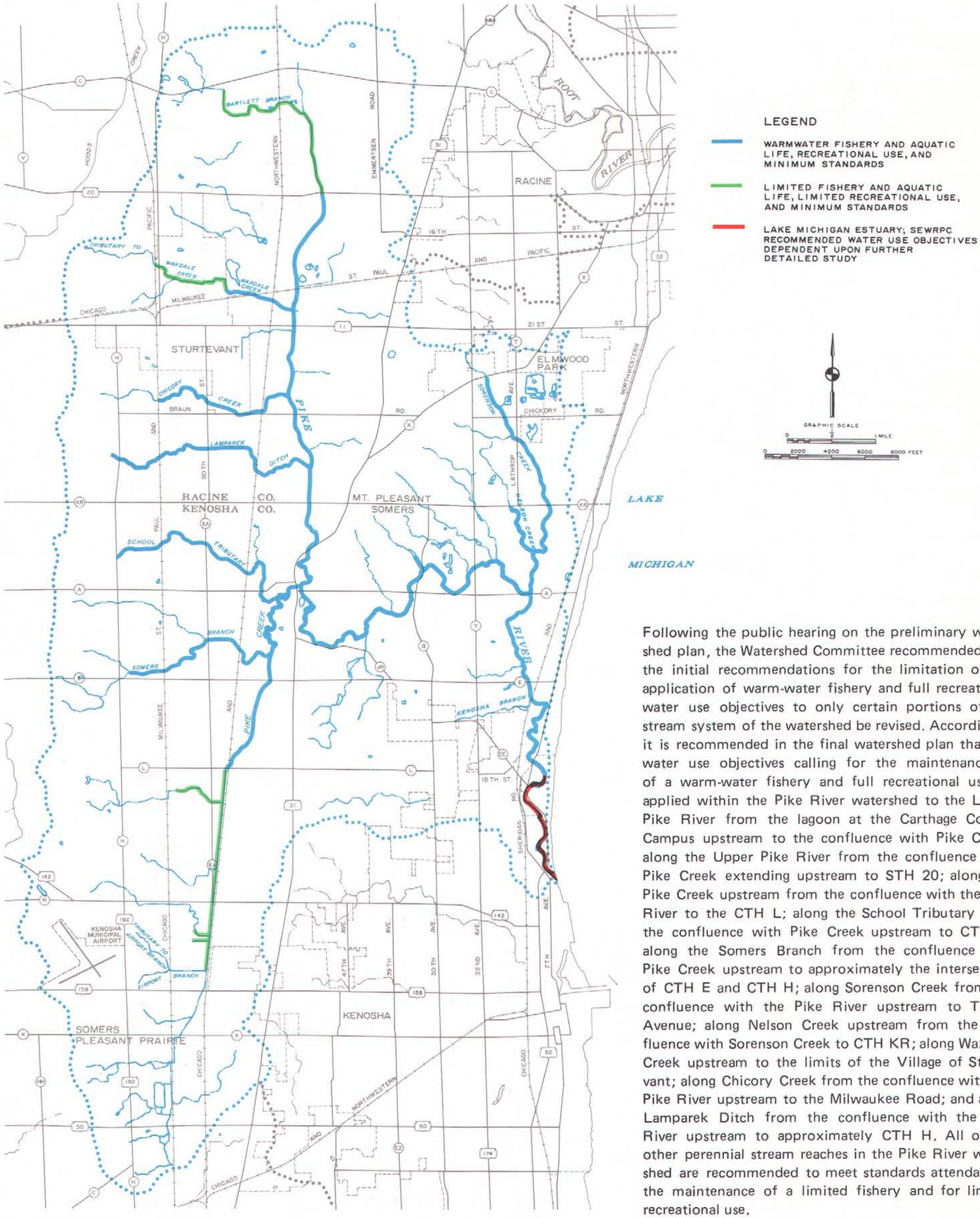
TYPICAL BIOLOGICAL HABITAT REHABILITATION TECHNIQUES TO BE CONSIDERED FOR THE CHANNELIZED STREAMS IN THE PIKE RIVER WATERSHED



Source: SEWRPC.

Map 94

POST-PUBLIC HEARING-RECOMMENDED WATER USE OBJECTIVES FOR SURFACE WATERS IN THE PIKE RIVER WATERSHED: 2000



Source: SEWRPC.

Following the public hearing on the preliminary watershed plan, the Watershed Committee recommended that the initial recommendations for the limitation of the application of warm-water fishery and full recreational water use objectives to only certain portions of the stream system of the watershed be revised. Accordingly, it is recommended in the final watershed plan that the water use objectives calling for the maintenance of of a warm-water fishery and full recreational use be applied within the Pike River watershed to the Lower Pike River from the lagoon at the Carthage College Campus upstream to the confluence with Pike Creek; along the Upper Pike River from the confluence with Pike Creek extending upstream to STH 20; along the Pike Creek upstream from the confluence with the Pike River to the CTH L; along the School Tributary from the confluence with Pike Creek upstream to CTH H; along the Somers Branch from the confluence with Pike Creek upstream to approximately the intersection of CTH E and CTH H; along Sorenson Creek from the confluence with the Pike River upstream to Taylor Avenue; along Nelson Creek upstream from the confluence with Sorenson Creek to CTH KR; along Waxdale Creek upstream to the limits of the Village of Sturtevant; along Chicory Creek from the confluence with the Pike River upstream to the Milwaukee Road; and along Lamparek Ditch from the confluence with the Pike River upstream to approximately CTH H. All of the other perennial stream reaches in the Pike River watershed are recommended to meet standards attendant to the maintenance of a limited fishery and for limited recreational use.

to protect against property damage—the depths of inundation during a 100-year recurrence interval flood in the protected area averaging only about one foot—the Committee determined to leave the plan unchanged in this respect, suggesting that the Mt. Pleasant Stormwater Drainage District seek a variance from the DNR.

The DNR also commented on the preliminary plan proposal to construct jetties at the mouth of the Pike River in Kenosha. The DNR noted that the jetties will not eliminate the need for periodic maintenance dredging at the mouth of the Pike River and would have a tendency to accelerate the potential for down drift beach erosion in Pennoyer Park.

In considering this matter, the Advisory Committee reaffirmed its position that the construction of jetties at the mouth of the Pike River represents the most cost-effective solution to this problem. The Committee noted that the preliminary plan recognizes the need for periodic maintenance dredging between the jetties; indeed, the plan includes cost estimates for such maintenance dredging. In addition, the Committee recognizes that there may be some down drift beach erosion in Pennoyer Park, but that such problems were likely to be minimal. Finally, the Committee noted that the recommended implementing agency for this project—the City of Kenosha Park Commission which has jurisdiction over Pennoyer Park—could judge for itself whether or not the potential erosion problems in Pennoyer Park would be offset by the resolution of the flooding problems caused by sand buildup at the mouth of the Pike River. Accordingly, the Committee did not change the preliminary plan with respect to the jetty construction proposal.

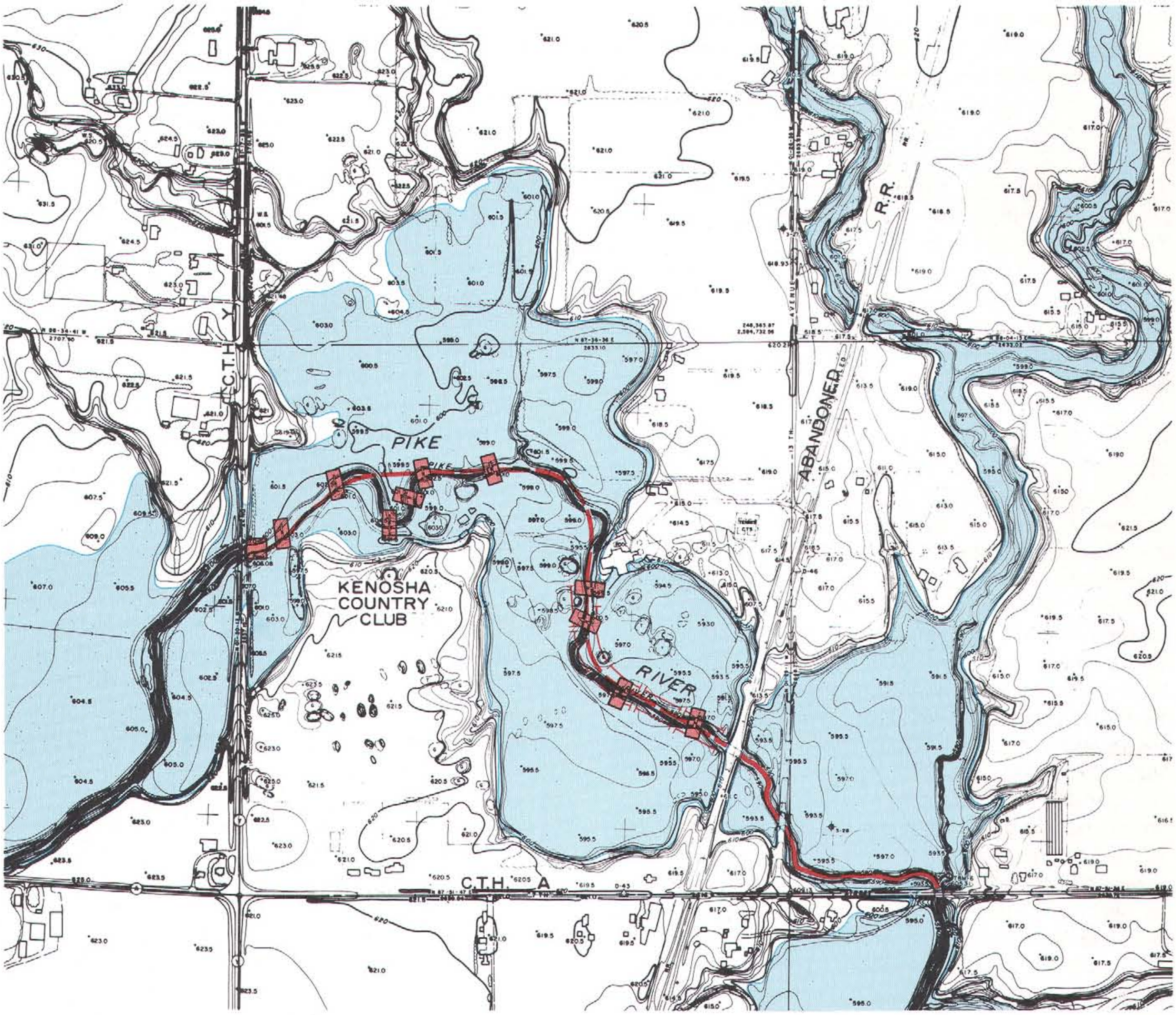
The final floodland management concern addressed by the Advisory Committee in response to the concerns expressed at the public hearing involved the preliminary proposal to construct a system of low-level dikes through the Kenosha Country Club grounds. Such dikes would provide protection from floods up to and including the 10-year recurrence interval flood. This alternative was taken to public hearing along with a second basic alternative that would involve the undertaking of major channel improvements through and downstream of the Country Club grounds in such a manner so as to eliminate flooding problems for floods up to and including the 100-year recurrence interval flood. Considerable concern over both these alternative plan recommendations had been voiced by the Kenosha Country Club membership during informational meetings leading up to the public hearing. The Advisory Committee was concerned in particular over the practicality of either of the alternatives given the substantial costs involved. Accordingly, the Advisory Committee directed that the staff review this entire matter, developing such additional alternatives as may be necessary to help the Committee reach a decision.

In discussing this matter with the Kenosha Country Club officials, it was determined to prepare and present for Advisory Committee review two alternatives in addition to the alternatives previously presented. The first additional alternative would involve the construction of a new Pike River channel through the Country Club grounds in an attempt to carry and convey within its banks all floods up to and including the 10-year recurrence interval flood. This alternative plan is shown on Map 95. Pertinent data pertaining to this alternative are set forth in Table 117. Under this alternative, the existing Pike River channel from the confluence with Sorensen Creek upstream to the abandoned Chicago, North Shore and Milwaukee Railroad right-of-way—where the Pike River exits the Kenosha Country Club grounds—would be lowered by a depth of from one to two feet. From that point upstream through the Country Club grounds to CTH Y, the Pike River channel would be realigned, deepened, and widened so as to contain the entire 10-year recurrence interval flood discharge. Through the Country Club grounds, the existing stream bottom would be lowered from two feet at the Chicago, North Shore and Milwaukee Railroad right-of-way to about five feet at CTH Y. A drop structure would be installed at CTH Y. The proposed channel through the Country Club grounds would be turf-lined, would have a bottom width of about 50 feet, and side slopes of one on three. In addition to the channel construction, earth berms from one to six feet in height would be required along both sides of the channel upstream from the North Shore Railroad right-of-way to just below the clubhouse. A total of 10 bridges on the golf course grounds would have to be reconstructed to accommodate the larger channel. It would not be necessary to modify the existing structure on the North Shore right-of-way.

The estimated capital cost of this alternative is $515,000. Using an annual interest rate of 6 percent and an amortization period of 50 years, the average annual cost of this alternative is $37,000.

Map 95

MAJOR CHANNELIZATION ALTERNATIVE FOR THE PIKE RIVER THROUGH THE GROUNDS OF THE KENOSHA COUNTRY CLUB



LEGEND

- 100-YEAR RECURRENCE INTERVAL FLOODLANDS--PLANNED LAND USE AND EXISTING CHANNEL CONDITIONS
- EXISTING CHANNEL
- PROPOSED MAJOR CHANNELIZATION
- PROPOSED CHANNEL DEEPENING
- PROPOSED DIKE
- PROPOSED DROP STRUCTURE
- PROPOSED BRIDGE REPLACEMENT

GRAPHIC SCALE
0 200 400 800 FEET

Following the public hearing on the preliminary watershed plan, a major channelization alternative flood control plan was prepared and evaluated to determine if such a measure would provide a technically feasible and economically sound solution to the flood problem along the Pike River through the grounds of the Kenosha Country Club. Under this alternative, the existing Pike River channel would be modified from the confluence with Sorenson Creek upstream to CTH Y. In addition, earthen berms would be constructed along both sides of the channel upstream from the old North Shore electric railway right-of-way to just below the clubhouse, and a total of 10 bridges on the golf course grounds would be reconstructed to accommodate the larger channel. Under this alternative flood control plan, damages would be prevented from floods having a recurrence interval of up to and including 10 years. While technically feasible, this alternative was found to be economically unsound.

Source: SEWRPC.

Table 117

PRINCIPAL FEATURES, COSTS, AND BENEFITS OF FLOODLAND MANAGEMENT ALTERNATIVES FOR THE PIKE RIVER THROUGH THE GROUNDS OF THE KENOSHA COUNTRY CLUB

Alternative		Technically Feasible	Economic Analysis[a]									
			Capital Cost		Annual Amortized Capital Cost (thousands)	Annual Operation and Maintenance Cost (thousands)	Total Annual Cost (thousands)	Annual Benefits (thousands)	Excess of Annual Benefits Over Cost (thousands)	Benefit-Cost Ratio	Benefit-Cost Ratio Greater Than 1.0
Name	Description		Item	(thousands)							
Major Channelization	● 0.8 mile of major channelization (50-foot bottom width, one on three slopes) ● Replace 10 bridges ● Construct drop structure ● Construct berms	Yes	Channelization Bridge replacement Drop structure Berms Subtotal	$305.0 100.0 20.0 90.0 $515.0	$33.0	$1.0	$37.0	$20.0	$- 17.0	0.59	No
Detention Storage Reservoir	● Two reservoirs	Yes	Land acquisition Highway elevation Outlet control structures Subtotal	$450.0 260.0 140.0 $850.0	$53.9	--	$53.9	$20.0	$- 33.9	0.37	No

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

Source: SEWRPC.

The average annual flood abatement benefit is estimated at $20,000, resulting in a benefit-cost ratio of 0.54.

This alternative would reduce flooding problems attendant to floods up to and including the 10-year recurrence interval floods that occur on the Kenosha Country Club grounds. It would not, however, totally eliminate the flooding problems. In addition, this alternative would have the same detrimental effects to the golf course that the previously considered channelization and diking alternatives would have, although to a somewhat lesser extent.

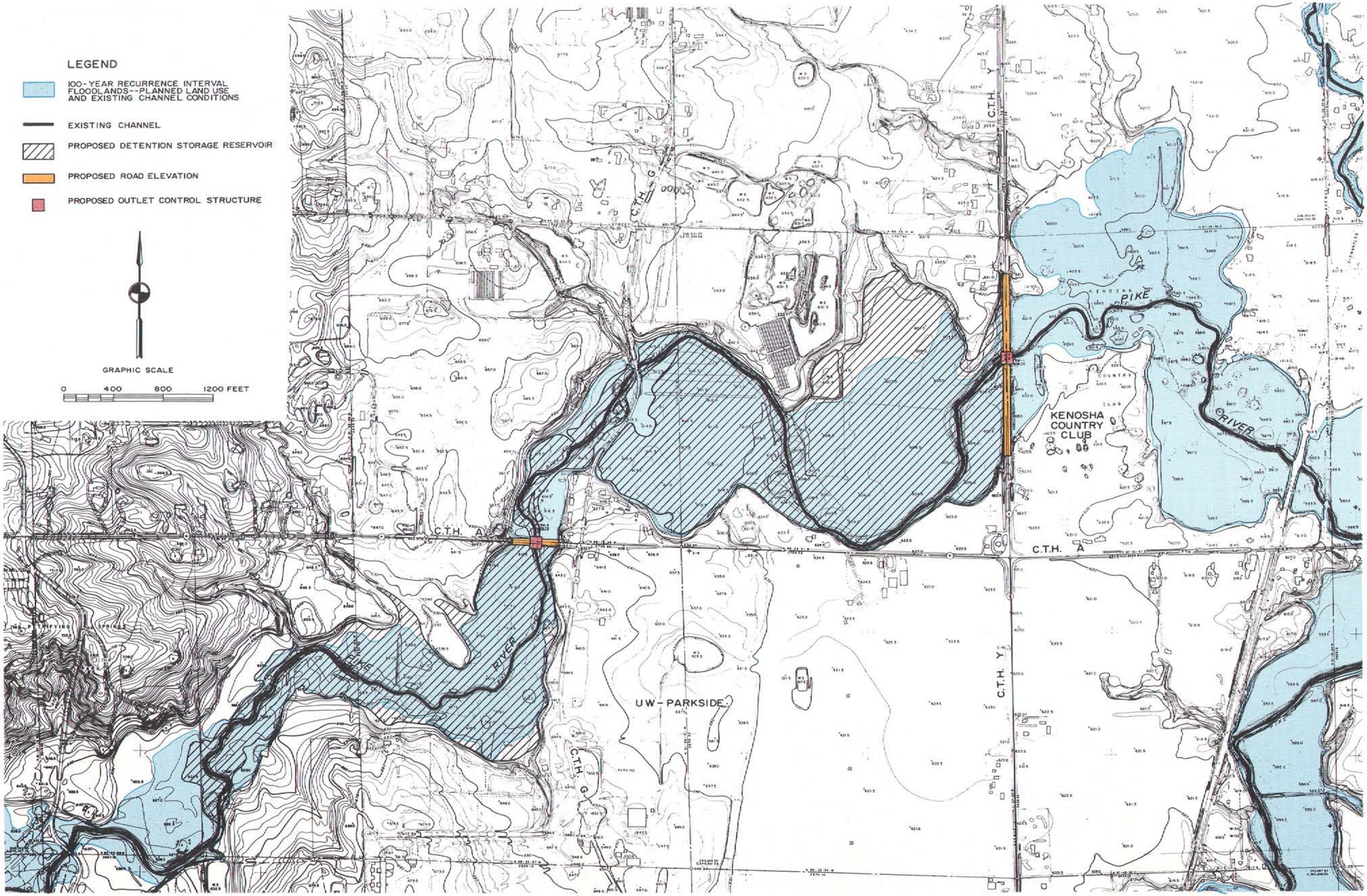
The second new alternative considered by the Advisory Committee was also designed in an attempt to resolve flooding problems for floods up to and including the 10-year recurrence interval flood. Data pertaining to this alternative are set forth in Table 117. This alternative examined potential detention storage reservoirs immediately upstream of the Country Club grounds. Under this alternative, two locations were selected as potential reservoir sites (see Map 96). One of these sites is located immediately upstream of CTH Y. Assuming that CTH Y would be raised about 10 feet, the impoundment created would have a capacity of about 400 acre-feet over a 90-acre area. The second reservoir site would be located immediately upstream of CTH A primarily on the University of Wisconsin-Parkside grounds. Assuming that CTH A would be raised about 10 feet, the impoundment created would have a capacity of about 300 acre-feet over a 60-acre area.

Analyses indicated that to contain a two-year recurrence interval flood under planned land use and channel conditions at the Kenosha Country Club location on the Pike River would require a storage volume of about 600 acre-feet. Accordingly, the use of both potential reservoir sites would provide enough storage to contain the floods that have a recurrence interval of two years or less. It would be necessary under these assumptions to operate the outlet control structures of the two potential reservoirs during flood events in such a manner as to utilize the storage potential of both reservoirs while preventing the overtopping of either CTH Y or CTH A.

The estimated capital cost of this alternative is $850,000, including the cost of land acquisition, the elevation of CTH Y and CTH A, and the installation of outlet control structures at those locations. Using an annual interest rate of 6 percent

Map 96

DETENTION STORAGE RESERVOIR ALTERNATIVE FOR THE PIKE RIVER THROUGH THE GROUNDS OF THE KENOSHA COUNTRY CLUB



Following the public hearing on the preliminary watershed plan, a detention storage reservoir alternative flood control plan was prepared and evaluated to determine if such a measure would provide a technically feasible and economically sound solution to the flood problem along the Pike River through the grounds of the Kenosha Country Club. Under this alternative, two potential reservoir sites were identified. One of these sites is located immediately upstream of CTH Y. Assuming that CTH Y would be raised about 10 feet, the impoundment created would have a capacity of about 400 acre-feet over a 90-acre area. The second reservoir site would be located immediately upstream of CTH A primarily on the University of Wisconsin-Parkside grounds. Assuming that CTH A would be raised about 10 feet, the impoundment created would have a capacity of about 300 acre-feet over a 60-acre area. Under this alternative flood control plan, damages would be prevented from floods having a recurrence interval of up to and including two years. While technically feasible, this alternative was found to be economically unsound.

Source: SEWRPC.

and an amortization period of 50 years, the average annual cost of this alternative is estimated at \$53,900. With an annual flood abatement benefit of about \$20,000, the resulting benefit-cost ratio is 0.37.

Further analysis of this alternative indicated that there does exist the potential to provide additional storage upstream of CTH A in order to contain all flows for floods up to and including the 10-year recurrence interval flood. However, such storage of floodwaters would result in the flooding of the golf course at the Petrifying Springs County Park and would cause damages at that golf course similar to the ones proposed to be eliminated at the Kenosha Country Club.

Although the detention storage reservoir alternative considered would have a beneficial effect in terms of eliminating overbank flooding and attendant damages through the Kenosha Country Club for floods having a recurrence interval of two years or less, the alternative would have no significant effect on upstream flood stages and relatively little effect on downstream flood stages of floods of greater magnitude. The 100-year recurrence interval peak flood flow of about 3,600 cfs at CTH Y under planned year 2000 land use and channel conditions could be expected to be reduced to about 3,200 cfs with the operation of both reservoir sites. This reduction, however, would result in only about a one-half foot reduction in the 100-year recurrence interval profile between CTH A and the mouth of the Pike River.

After considering all of the alternatives attendant to the resolution of flooding problems on the grounds of the Kenosha Country Club and taking into account the fact that none of the alternatives considered has a benefit-cost ratio of greater than one, the Advisory Committee concluded after conferring with Country Club officials that no structural flood control measures should be recommended for inclusion in the final comprehensive plan for the watershed. Rather, the Committee concluded that the Country Club should continue its efforts to improve local drainage on the golf course grounds to facilitate play on the golf course after flooding events. The Committee noted that most of the floods along the Pike River are of relatively short duration and that the problems at the Kenosha Country Club are largely those attendant to standing water left in low-lying pockets once the flood crests have receded. Many of these problems can be resolved by regrading the course and installing drainage facilities. It was concluded, then, that an approach that would attempt to "live with" the flooding problems along the Pike River through the Country Club grounds probably represents the most realistic and practical approach to this problem.

The Committee also noted that the membership of the Kenosha Country Club could for various reasons, including the flooding problem, choose at some future time to sell the current Country Club grounds and to relocate the club facilities to another site. The Committee recommended that, should such an action occur, the Kenosha County Park Commission could at that time consider the acquisition of at least the floodplain lands through the Country Club grounds for public park, outdoor recreation, and open space uses. The Committee further noted that, in such an event it would be possible to relocate the recommended recreational trail along the Pike River channel.

Concluding Remarks

Based upon the foregoing, the Advisory Committee made the following changes to the comprehensive plan for the Pike River watershed as that plan was presented at the public hearing:

1. The alignment of the proposed recreational trail was adjusted to bypass the grounds of the Kenosha Country Club.

2. The proposed channelization projects along the Pike Creek from the confluence with the Somers Branch upstream to CTH L and along the Upper Pike River from the confluence with Pike Creek upstream to STH 20 were modified to include recommendations—pending a determination as to site-specific feasibility and practicality—to reestablish and possibly enhance in conjunction with the channelization projects the aquatic habitat in the stream and along the stream banks.

3. That recommendations be added to the plan to modify the existing dams located on the Kenosha Country Club grounds and within Petrifying Springs County Park by providing fish ladders or creating riffle areas at each dam, and that the Kenosha County Park Commission assume responsibility for implementing these recommendations.

4. That the recommended water use objectives for the Pike River and the Pike Creek be adjusted in the manner reflected on Map 94.

This would mean that the entire main stem of the Pike River from the mouth upstream to STH 20 and the Pike Creek from the confluence with the Pike River upstream to CTH L, together with Nelson Creek, that portion of Sorenson Creek upstream to Lathrop Avenue, Somers Branch, School Tributary, Lamparek Ditch, Chicory Creek, and that portion of Waxdale Creek upstream to the Village of Sturtevant limits, are recommended to be assigned water use objectives associated with full recreational use.

5. That an exception be sought for the proposed dike along the Bartlett Branch with respect to meeting the minimum freeboard requirements set forth in Chapter NR 116 of the Wisconsin Administrative Code, since the proposed dike would not be designed to protect human life.

6. That the plan as it pertains to the Lower Pike River contain no recommended structural flood control measures to protect the Kenosha Country Club; but rather, that the Club be encouraged to pursue improved local drainage on the golf course so as to minimize the adverse effects caused by flooding along the Pike River.

CONCLUSIONS

Adoption and implementation of the recommended comprehensive plan for the Pike River watershed may be expected to result in the substantial achievement of the adopted watershed development objectives and supporting standards. Consequently, implementation of the plan may be expected to provide a safer, more healthful, and more pleasant, as well as more orderly and efficient, environment for all life in the watershed. Implementation of the recommended plan would abate the most serious and costly environmental problems of the watershed, including flooding and water pollution, and would minimize development of new problems of this kind. Failure to implement the watershed plan will result in the further intensification of developmental and environmental problems and potentially the creation of new problems which will be even more expensive to resolve.

APPENDICES

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Appendix A

PIKE RIVER WATERSHED COMMITTEE

George E. Melcher, Chairman	Director, Office of Planning and Zoning Administration, Kenosha County
Jerome Konicek, Vice-Chairman	Chairman, Mt. Pleasant Drainage District
Kurt W. Bauer, Secretary	Executive Director, Southeastern Wisconsin Regional Planning Commission
Les Aspin	Member of Congress, First Congressional District, State of Wisconsin
Eual W. Bodenbach	Coordinator, Town of Mt. Pleasant
Peter Boscha	Supervisor, Town of Mt. Pleasant
Mary M. Carrington	Chairman, Town of Mt. Pleasant
Arnold L. Clement	Planning Director and Zoning Administrator, Racine County
Myron L. Herman	Natural Resources Agent, Kenosha County
Donald K. Holland	Director of Public Works, City of Kenosha
Karl B. Holzwarth	Park Director, Racine County
Abe Kirkorian	President, Village of Sturtevant
Niels E. Ladine	Director of Parks, Kenosha County
Leverett F. Leet	Retired Farmer, Town of Somers
Richard J. Lindl	Chairman, Town of Somers
Chelvadurai Manogaran	Associate Professor, Department of Geography, University of Wisconsin-Parkside
Raymond J. Moyer	Supervisor, Racine County; Commissioner, Southeastern Wisconsin Regional Planning Commission
O. Fred Nelson	Manager, Kenosha Water Utility
Francis J. Pitts	Supervisor, Kenosha County; Commissioner, Southeastern Wisconsin Regional Planning Commission
Stanley Renick	Member, Kenosha Country Club
Karl Schroeder	Horticulture and Natural Resources Agent, Racine County
Bernard G. Schultz	Assistant District Director, Southeast District, Wisconsin Department of Natural Resources
Larry S. Toney	District Conservationist, U. S. Soil Conservation Service, Racine County

Appendix B

RESULTS OF FISH SURVEY IN THE PIKE RIVER WATERSHED BY STATION: AUGUST 1980

		Species and Population per Species According to Their Relative Tolerance to Organic Pollution																				
		Very Tolerant						Tolerant								Intolerant						
						Population								Population					Population			
Station Number	Stream	Black Bullhead (Ictalurus melas)	White Sucker (Catastomus commersoni)	Fathead Minnow (Pimephales promelas)	Number of Species	Number	Percent of Station Total	Green Sunfish (Lepomis cyanellus)	Creek Chub (Semotilus atromaculatus)	Bluegill (Lepomis macrochirus)	Brook Stickleback (Culaea inconstans)	Bigmouth Shiner (Notropis dorsalis)	Number of Species	Number	Percent of Station Total	Least Darter (Etheostoma microperca)	Black Nosed Dace (Rhinichthys atratulus)	Number of Species	Number	Percent of Station Total	Total Number of Species	Total Population
1	Pike River—Main Stem	--	1	354	2	355	82	1	3	--	76	--	3	80	18	--	--	--	--	--	5	435
2	Pike River—Main Stem	--	--	4	1	4	67	1	--	--	--	1	2	2	33	--	--	--	--	--	3	6
3	Pike River—Main Stem	--	--	4	1	4	27	--	2	--	--	9	2	11	73	--	--	--	--	--	3	15
4	Pike River—Main Stem	--	2	5	2	7	58	--	2	1	--	2	3	5	42	--	--	--	--	--	5	12
5	Pike River—Main Stem	--	--	16	1	16	89	--	--	--	--	2	1	2	11	--	--	--	--	--	2	18
6	Pike River—Main Stem	--	2	4	2	6	40	--	--	--	2	7	2	9	60	--	--	--	--	--	4	15
7	Pike River—Main Stem	1	1	6	3	8	18	--	1	--	--	35	2	36	82	--	--	--	--	--	5	44
8	Pike River—Main Stem	--	3	7	2	10	62	--	--	--	--	6	1	6	38	--	--	--	--	--	3	16
9	Waxdale Creek	--	--	3	1	3	100	--	--	--	--	--	--	--	--	--	--	--	--	--	1	3
10	Lamparek Ditch	--	--	44	1	44	73	--	--	--	16	--	1	16	27	--	--	--	--	--	2	60
11	Sorenson Creek	--	--	15	1	15	39	3	12	--	2	3	4	20	53	3	--	1	3	8	6	38
12	Pike Creek	--	2	2	2	4	100	--	--	--	--	--	--	--	--	--	--	--	--	--	2	4
13	Pike Creek	--	--	--	--	--	--	--	4	--	--	3	2	7	47	--	8	1	8	53	3	15
14	Pike Creek	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
15	Somers Branch	--	--	20	1	20	87	--	3	--	--	--	1	3	13	--	--	--	--	--	2	23
Total		1	11	484	3	496	70	5	27	1	96	68	5	197	28	3	8	2	11	2	10	704

Source: SEWRPC.

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

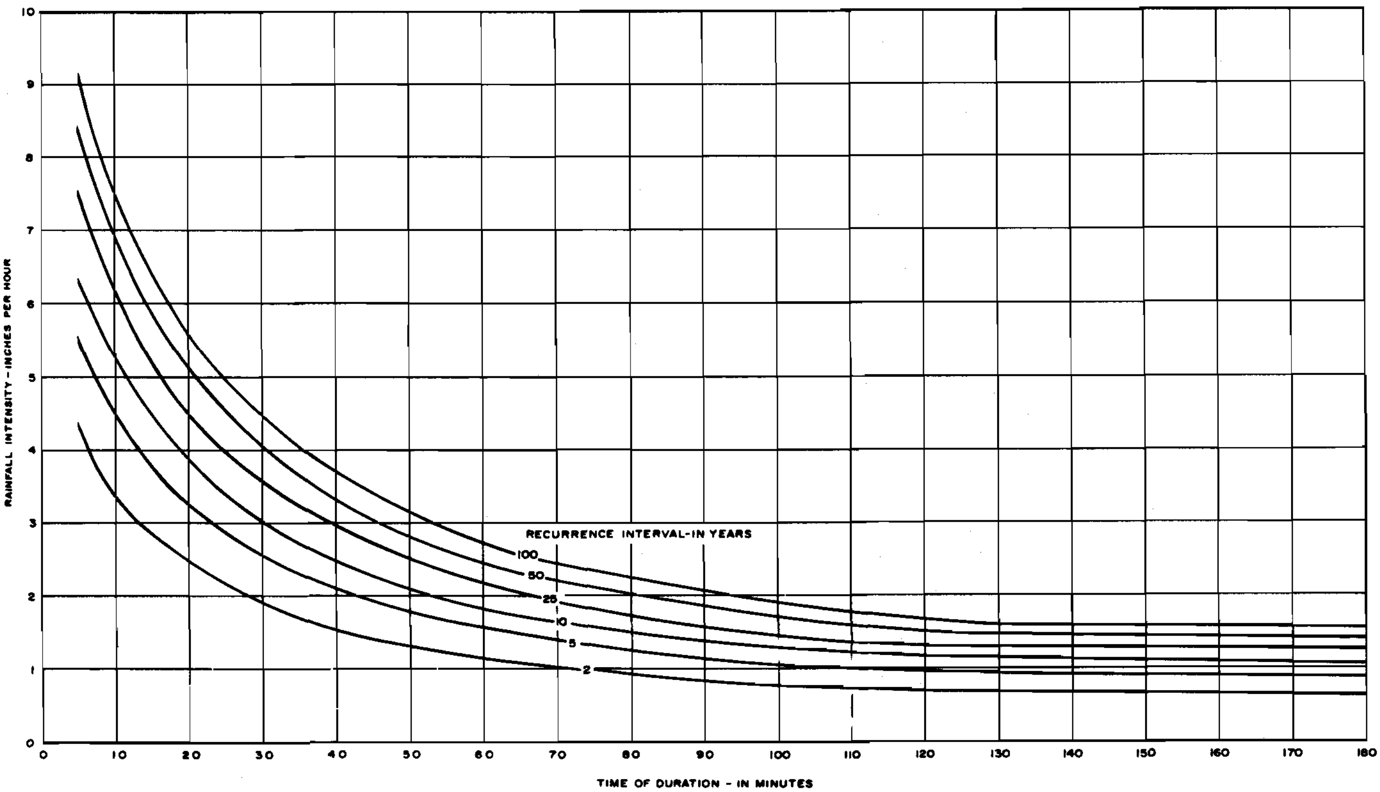
WEIGHTED RUNOFF COEFFICIENTS FOR USE IN THE RATIONAL FORMULA

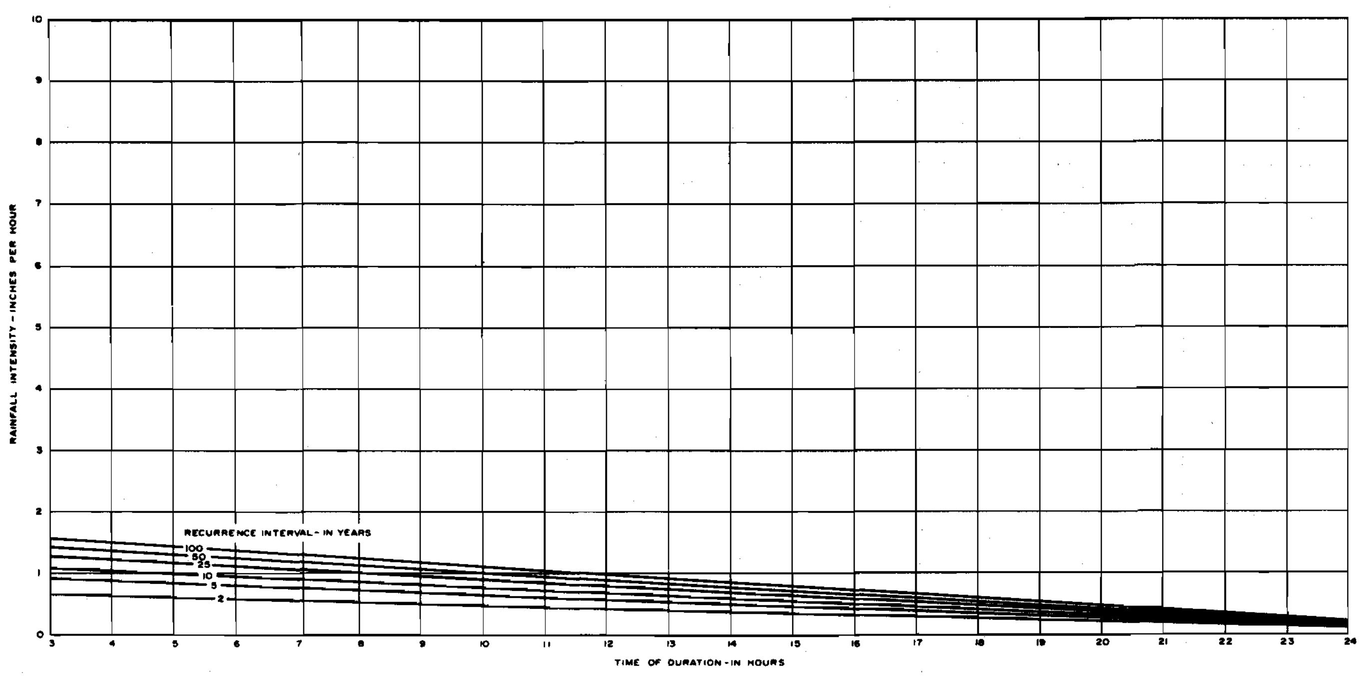
Land Use	Percent Impervious Area	Hydrologic Soil Group A: Slope Range (percent) 0 - 2	A: 2 - 6	A: 6 & Over	B: 0 - 2	B: 2 - 6	B: 6 & Over	C: 0 - 2	C: 2 - 6	C: 6 & Over	D: 0 - 2	D: 2 - 6	D: 6 & Over
Industrial.	90	0.67 0.85	0.68 0.85	0.68 0.86	0.68 0.85	0.68 0.86	0.69 0.86	0.68 0.86	0.69 0.86	0.69 0.87	0.69 0.86	0.69 0.86	0.70 0.88
Commercial . . .	95	0.71 0.88	0.71 0.89	0.72 0.89	0.71 0.89	0.72 0.89	0.72 0.89	0.72 0.89	0.72 0.89	0.72 0.90	0.72 0.89	0.72 0.89	0.72 0.90
High-Density Residential. . . .	60	0.47 0.58	0.49 0.60	0.50 0.61	0.48 0.59	0.50 0.61	0.52 0.64	0.49 0.60	0.51 0.62	0.54 0.66	0.51 0.62	0.53 0.64	0.56 0.69
Medium-Density Residential. . . .	30	0.25 0.33	0.28 0.37	0.31 0.40	0.27 0.35	0.30 0.39	0.35 0.44	0.30 0.38	0.33 0.42	0.38 0.49	0.33 0.41	0.36 0.45	0.42 0.54
Low-Density Residential. . . .	15	0.14 0.22	0.19 0.26	0.22 0.29	0.17 0.24	0.21 0.28	0.26 0.34	0.20 0.28	0.25 0.32	0.31 0.40	0.24 0.31	0.28 0.35	0.35 0.46
Agriculture. . . .	5	0.08 0.14	0.13 0.18	0.16 0.22	0.11 0.16	0.15 0.21	0.21 0.28	0.14 0.20	0.19 0.25	0.26 0.34	0.18 0.24	0.23 0.29	0.31 0.41
Open Space . . .	2	0.05 0.11	0.10 0.16	0.14 0.20	0.08 0.14	0.13 0.19	0.19 0.26	0.12 0.18	0.17 0.23	0.24 0.32	0.16 0.22	0.21 0.27	0.28 0.39
Freeways and Expressways. . .	70	0.57 0.70	0.59 0.71	0.60 0.72	0.58 0.71	0.60 0.72	0.61 0.74	0.59 0.72	0.61 0.73	0.63 0.76	0.60 0.73	0.62 0.75	0.64 0.78

Source: SEWRPC.

Figure C-1

POINT RAINFALL INTENSITY-DURATION-FREQUENCY CURVES FOR MILWAUKEE, WISCONSIN[a] (ARITHMETIC SCALES)



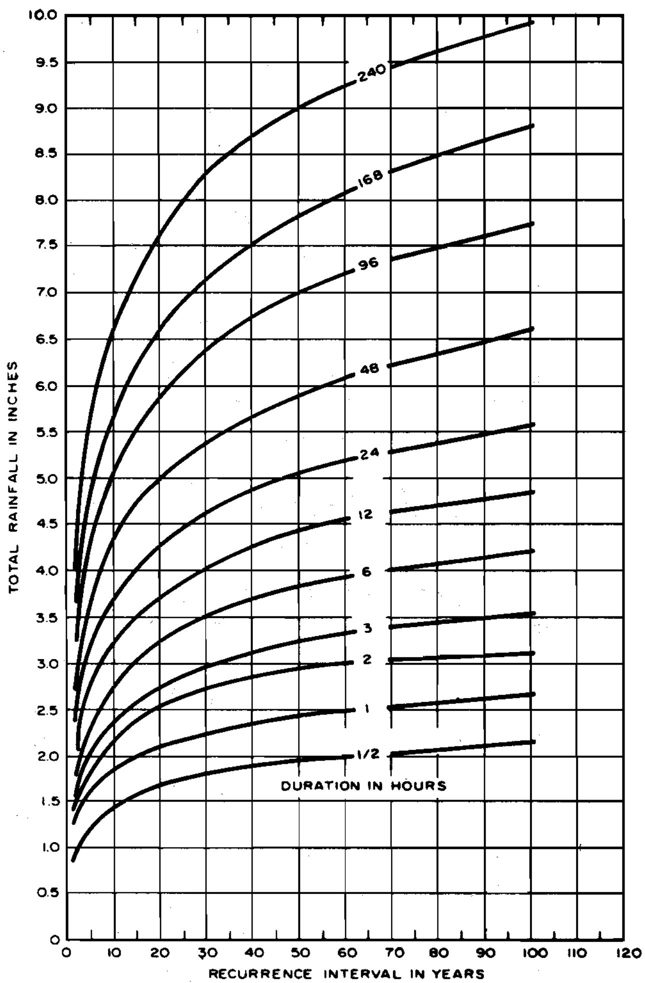


[a] The curves are based on Milwaukee rainfall data for the 64-year period of 1903 to 1966. These curves are applicable within an accuracy of ± 10 percent to the entire Southeastern Wisconsin Planning Region.

Source: SEWRPC.

Figure C-2

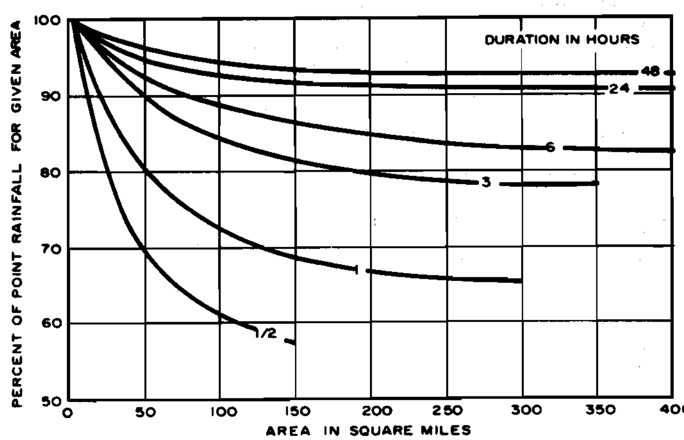
POINT RAINFALL DEPTH-DURATION-FREQUENCY RELATIONSHIPS IN THE REGION AND THE PIKE RIVER WATERSHED



Source: National Weather Service and SEWRPC.

Figure C-3

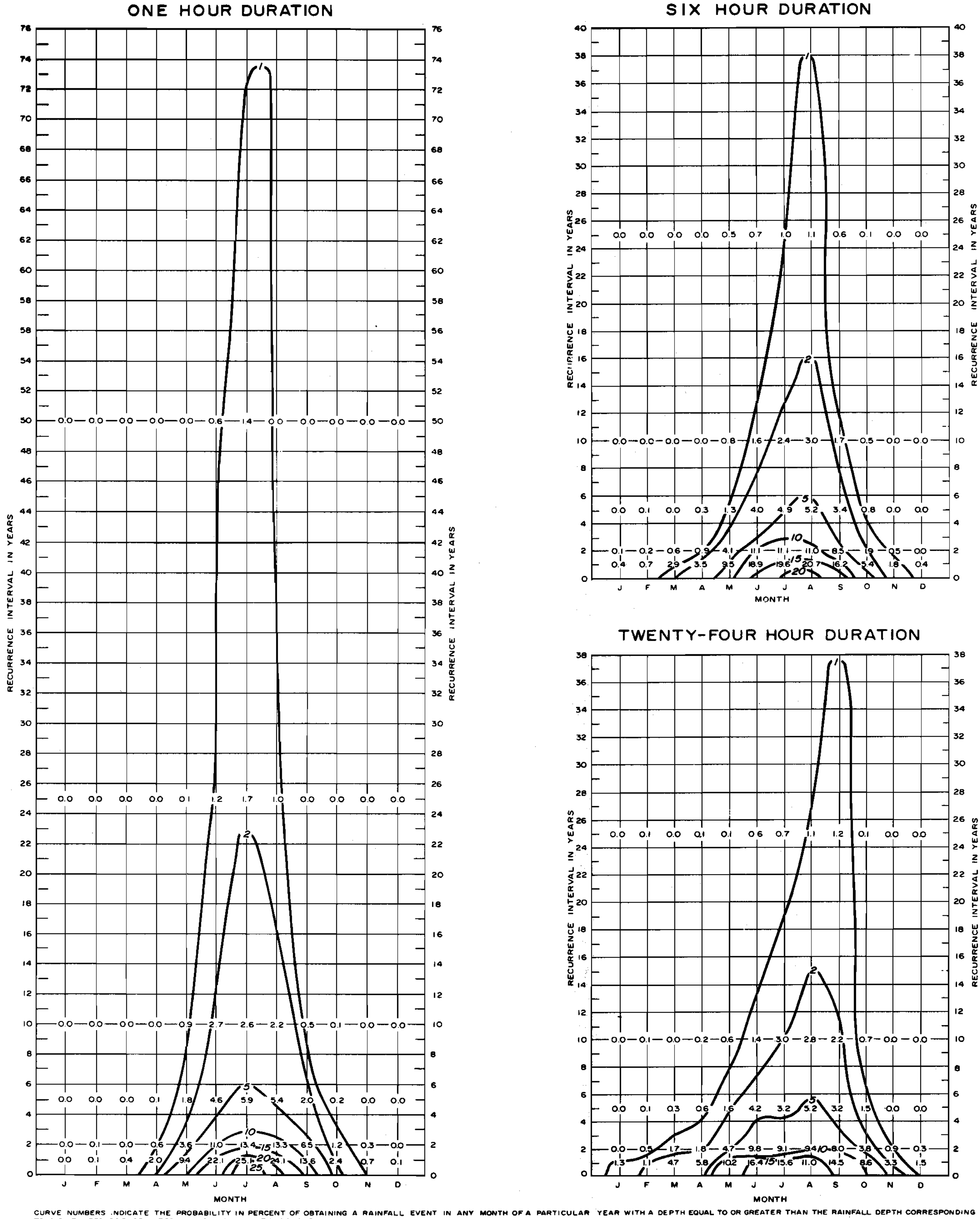
RAINFALL DEPTH-DURATION-AREA RELATIONSHIPS IN THE REGION AND THE PIKE RIVER WATERSHED



Source: National Weather Service and SEWRPC.

Figure C-4

SEASONAL VARIATION OF RAINFALL EVENT DEPTH IN THE REGION AND THE PIKE RIVER WATERSHED

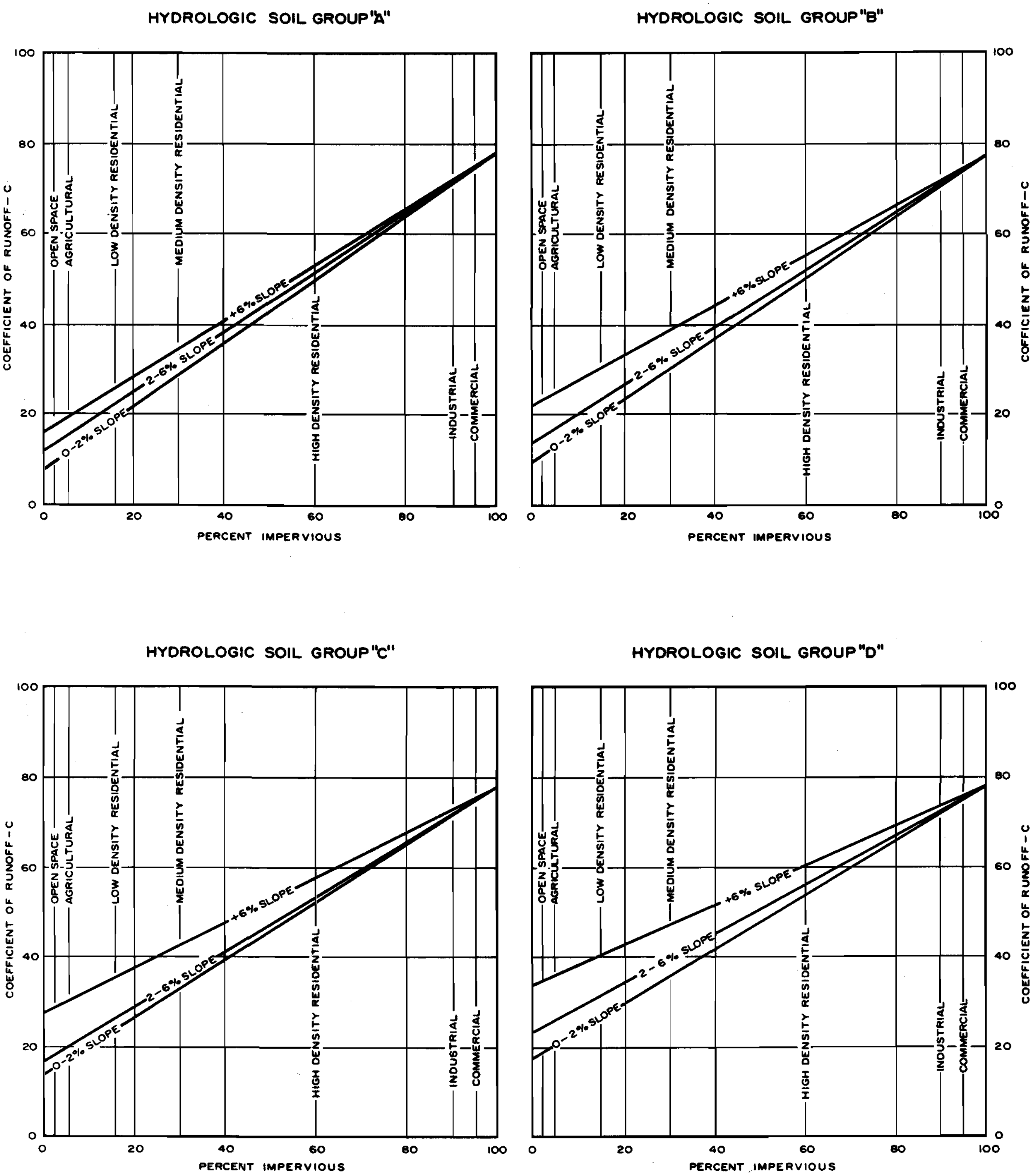


CURVE NUMBERS INDICATE THE PROBABILITY IN PERCENT OF OBTAINING A RAINFALL EVENT IN ANY MONTH OF A PARTICULAR YEAR WITH A DEPTH EQUAL TO OR GREATER THAN THE RAINFALL DEPTH CORRESPONDING TO A GIVEN RECURRENCE INTERVAL AS SHOWN IN FIGURE B-3.

Source: National Weather Service and SEWRPC.

Figure C-5

COEFFICIENT OF RUNOFF CURVES FOR HYDROLOGIC SOIL GROUPS



Source: SEWRPC.

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Appendix D

HYDROLOGIC-HYDRAULIC SUMMARY FOR STRUCTURES ON THE PIKE RIVER AND SELECTED MAJOR TRIBUTARIES: EXISTING LAND USE AND EXISTING CHANNEL CONDITIONS

Table D-1

HYDROLOGIC-HYDRAULIC SUMMARY—LOWER PIKE RIVER: EXISTING LAND USE AND EXISTING CHANNEL CONDITIONS

Structure Identification and Selected Characteristics						10-Year Recurrence Interval Flood						50-Year Recurrence Interval Flood						100-Year Recurrence Interval Flood					
Number	Name	River Mile	Structure Type and Hydraulic Significance[a]	Recommended Design Frequency (years)	Adequate Hydraulic Capacity[b]	Instantaneous Peak Discharge (cfs)	Upstream Stage[d] (feet above msl)	Downstream Stage[d] (feet above msl)	Backwater[c] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)	Instantaneous Peak Discharge (cfs)	Upstream Stage[d] (feet above msl)	Downstream Stage[d] (feet above msl)	Backwater[c] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)	Instantaneous Peak Discharge (cfs)	Upstream Stage[d] (feet above msl)	Downstream Stage[d] (feet above msl)	Backwater[c] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)
100	STH 32/Alford Park Drive	0.21	1S	50	Yes	1,920	581.6	581.0	0.6	--	--	3,060	582.7	581.1	1.6	--	--	3,720	583.6	581.1	2.5	--	--
105	STH 32/Sheridan Road	1.35	1S	50	Yes	1,880	585.5	584.4	1.1	--	--	3,060	585.9	585.4	0.5	--	--	3,820	586.6	586.2	0.4	--	--
110	Footbridge	1.52	1I	--	--	1,880	--	--	--	--	--	3,060	--	--	--	--	--	3,820	--	--	--	--	--
115	Drive to Carthage College	1.70	1S	10	Yes	1,880	586.1	585.8	0.3	--	--	3,060	587.2	586.6	0.6	--	--	3,820	588.2	587.3	0.9	--	--
120	STH 32/S. 32nd Street	1.79	1S	50	Yes	1,880	586.8	586.1	0.7	--	--	3,060	588.4	587.2	1.2	--	--	3,820	589.6	588.2	1.4	--	--
125	Footbridge	2.46	1I	--	--	1,880	--	--	--	--	--	3,130	--	--	--	--	--	3,850	--	--	--	--	--
125A	Footbridge	2.69	1I	--	--	1,880	--	--	--	--	--	3,130	--	--	--	--	--	3,850	--	--	--	--	--
130	Chicago & North Western Transportation Company	3.04	1S	100	Yes	1,920	590.9	590.7	0.2	--	--	3,200	592.2	591.9	0.3	--	--	3,880	592.8	592.5	0.3	--	--
135	CTH E/12th Street	3.27	1S	50	Yes	1,920	592.9	592.4	0.5	--	--	3,200	594.8	593.7	1.1	--	--	3,880	595.7	594.3	2.4	--	--
140	CTH A/7th Street	4.61	1S	50	Yes	1,860	598.1	597.6	0.5	--	--	3,120	599.7	599.0	0.7	--	--	3,740	600.4	599.6	0.8	--	--
145	Lathrop Avenue	4.79	1S	50	No	1,700	598.7	598.2	0.5	0.9	--	2,900	600.2	599.9	0.3	2.4	--	3,450	600.9	600.7	0.2	3.1	--
150	Chicago, North Shore & Milwaukee Railroad (abandoned)	4.88	1S	--	--	1,700	599.0	598.7	0.3	--	--	2,900	600.9	600.2	0.7	--	--	3,450	601.8	600.9	0.9	--	--
155	Private Bridge	4.92	1I	--	--	1,700	--	--	--	--	--	2,900	--	--	--	--	--	3,450	--	--	--	--	--
160	Private Bridge	5.00	1I	--	--	1,660	--	--	--	--	--	2,830	--	--	--	--	--	3,400	--	--	--	--	--
165	Private Bridge	5.04	1I	--	--	1,660	--	--	--	--	--	2,830	--	--	--	--	--	3,400	--	--	--	--	--
170	Private Bridge	5.12	1I	--	--	1,660	--	--	--	--	--	2,830	--	--	--	--	--	3,400	--	--	--	--	--
175	Private Bridge	5.31	1I	--	--	1,660	--	--	--	--	--	2,830	--	--	--	--	--	3,400	--	--	--	--	--
177	Kenosha Country Club Dam	5.31	2S	--	--	1,660	--	--	--	--	--	2,830	--	--	--	--	--	3,400	--	--	--	--	--
180	Private Bridge	5.37	1I	--	--	1,660	--	--	--	--	--	2,830	--	--	--	--	--	3,400	--	--	--	--	--
185	Private Bridge	5.40	1I	--	--	1,660	--	--	--	--	--	2,830	--	--	--	--	--	3,400	--	--	--	--	--
190	Private Bridge	5.44	1I	--	--	1,600	--	--	--	--	--	2,760	--	--	--	--	--	3,420	--	--	--	--	--
195	Private Bridge	5.52	1I	--	--	1,600	--	--	--	--	--	2,760	--	--	--	--	--	3,420	--	--	--	--	--
200	Private Bridge	5.59	1I	--	--	1,600	--	--	--	--	--	2,760	--	--	--	--	--	3,420	--	--	--	--	--
205	CTH Y/22nd Avenue	5.63	1S	50	Yes	1,600	602.8	602.3	0.5	--	--	2,760	605.0	603.1	1.9	--	--	3,380	606.4	603.5	2.9	--	--
210	CTH G/Wood Road	6.60	1S	50	Yes	1,600	614.6	614.0	0.6	--	--	2,780	616.4	615.3	1.1	--	--	3,420	617.1	616.0	1.1	--	--
215	CTH A/7th Street	6.96	1S	50	Yes	1,600	616.5	615.8	0.7	--	--	2,780	618.4	617.4	1.0	--	--	3,420	619.3	618.1	1.2	--	--
220	Petrifying Springs Park Road	8.26	1S	10	Yes	1,600	630.1	629.6	0.5	--	--	2,780	631.1	629.8	1.3	--	--	3,420	631.6	630.1	1.5	--	--
225	Footbridge	8.34	1I	--	--	1,600	--	--	--	--	--	2,780	--	--	--	--	--	3,420	--	--	--	--	--
230	Footbridge	8.48	1I	--	--	1,570	--	--	--	--	--	2,710	--	--	--	--	--	3,320	--	--	--	--	--
235	Footbridge	8.61	1I	--	--	1,570	--	--	--	--	--	2,170	--	--	--	--	--	3,320	--	--	--	--	--
245	Footbridge	8.80	1I	--	--	1,570	--	--	--	--	--	2,710	--	--	--	--	--	3,320	--	--	--	--	--
245A	Footbridge	8.93	1I	--	--	1,570	--	--	--	--	--	2,710	--	--	--	--	--	3,320	--	--	--	--	--
250	Park Drive, Footbridge and Control Structure	9.07	2S	--	--	1,570	--	--	--	--	--	2,710	--	--	--	--	--	3,320	--	--	--	--	--
255	Petrifying Springs Park Drive	9.39	1S	10	Yes	1,570	639.3	638.8	0.5	--	--	2,710	641.0	640.2	0.8	--	--	3,320	642.2	640.8	1.4	0.8	--
260	CTH A/7th Street	9.55	1S	50	Yes	1,570	641.0	640.7	0.3	--	--	2,710	643.2	642.5	0.7	--	--	3,320	644.4	643.5	0.9	0.8	--

[a]*Structure codes are as follows: 1—bridge or culvert; 2—dam, sill, or weir. 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]*Backwater is defined as the change in stage from the upstream side of the hydraulic structure to the downstream side.*

[d]*The flood stage indicated represents the water surface elevation approximately 100 feet from the bridge.*

Source: SEWRPC.

Table D-2

HYDROLOGIC-HYDRAULIC SUMMARY—UPPER PIKE RIVER: EXISTING LAND USE AND EXISTING CHANNEL CONDITIONS

Structure Identification and Selected Characteristics						10-Year Recurrence Interval Flood						50-Year Recurrence Interval Flood						100-Year Recurrence Interval Flood					
Number	Name	River Mile	Structure Type and Hydraulic Significance[a]	Recommended Design Frequency (years)	Adequate Hydraulic Capacity[b]	Instantaneous Peak Discharge (cfs)	Upstream Stage[d] (feet above msl)	Downstream Stage[d] (feet above msl)	Backwater[c] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)	Instantaneous Peak Discharge (cfs)	Upstream Stage[d] (feet above msl)	Downstream Stage[d] (feet above msl)	Backwater[c] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)	Instantaneous Peak Discharge (cfs)	Upstream Stage[d] (feet above msl)	Downstream Stage[d] (feet above msl)	Backwater[c] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)
265	STH 31/ Green Bay Road	10.38	1S	50	Yes	1,150	650.0	648.8	1.2	--	--	2,050	652.3	650.2	2.1	--	--	2,550	653.5	650.8	2.7	--	--
270	CTH KR/ County Line Road	11.15	1S	50	No	1,080	655.8	655.0	0.8	--	--	1,980	657.3	656.3	1.0	1.2	--	2,440	657.7	656.9	0.8	1.6	0.2
272	Private Bridge	11.56	1I	--	--	1,080	--	--	--	--	--	1980	--	--	--	--	--	2,440	--	--	--	--	--
275	Braun Road	12.23	1S	50	Yes	880	662.0	661.6	0.4	--	--	1,700	665.5	663.8	1.7	--	--	2,020	666.6	664.3	2.3	--	--
280	Private Bridge	12.99	1I	--	--	760	--	--	--	--	--	1,550	--	--	--	--	--	1,800	--	--	--	--	--
285	STH 11/Durand Road	13.29	1S	50	Yes	670	665.9	665.9	0.0	--	--	1,410	668.7	668.5	0.2	--	--	1,660	669.2	669.0	0.2	--	--
290	Chicago, Milwaukee, St. Paul & Pacific Railroad Company	13.72	1I	100	Yes	460	--	--	--	--	--	1,100	--	--	--	--	--	1,300	--	--	--	--	--
295	Oakes Road	14.51	1S	10	Yes	380	674.5	669.9	4.6	--	--	930	678.8	673.2	5.6	2.2	1.5	1,100	679.1	673.9	5.2	2.5	1.8
300	STH 20/S. 20th Street	14.94	1S	50	Yes	320	676.0	675.9	0.1	--	--	830	680.1	679.7	0.4	--	--	980	680.6	680.1	0.5	--	--
305	Private Bridge	15.00	1S	--	--	320	676.4	676.0	0.4	--	--	830	681.4	680.1	1.3	0.3	0.3	980	682.0	680.6	1.4	0.9	0.9
310	Footbridge	15.15	1I	--	--	300	--	--	--	--	--	760	--	--	--	--	--	900	--	--	--	--	--
315	Private Bridge	15.29	1S	--	--	300	678.4	678.2	0.2	--	--	760	683.8	682.6	1.2	--	--	900	684.8	683.3	1.5	--	--
320	Private Bridge	15.77	1I	--	--	250	--	--	--	--	--	600	--	--	--	--	--	700	--	--	--	--	--
370	Spring Street	16.24	1S	10	Yes	140	681.6	680.7	0.9	--	--	320	686.5	684.1	2.4	--	--	450	687.6	685.0	2.6	0.5	0.3

[a] *Structure codes are as follows: 1—bridge or culvert; 2—dam, sill, or weir. 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] *Backwater is defined as the change in stage from the upstream side of the hydraulic structure to the downstream side.*

[d] *The flood stage indicated represents the water surface elevation approximately 100 feet from the bridge.*

Source: SEWRPC.

Table D-3

HYDROLOGIC-HYDRAULIC SUMMARY—KENOSHA BRANCH: EXISTING LAND USE AND EXISTING CHANNEL CONDITIONS

Structure Identification and Selected Characteristics						10-Year Recurrence Interval Flood						50-Year Recurrence Interval Flood						100-Year Recurrence Interval Flood					
Number	Name	River Mile	Structure Type and Hydraulic Significance[a]	Recommended Design Frequency (years)	Adequate Hydraulic Capacity[b]	Instantaneous Peak Discharge (cfs)	Upstream Stage[d] (feet above msl)	Downstream Stage[d] (feet above msl)	Backwater[c] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)	Instantaneous Peak Discharge (cfs)	Upstream Stage[d] (feet above msl)	Downstream Stage[d] (feet above msl)	Backwater[c] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)	Instantaneous Peak Discharge (cfs)	Upstream Stage[d] (feet above msl)	Downstream Stage[d] (feet above msl)	Backwater[c] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)
1200	20th Avenue	0.76	1S	50	No	245	607.4	602.2	5.2	--	--	455	610.3	602.8	7.5	0.5	0.5	525	610.6	603.0	7.6	0.8	0.8
1205	Private Bridge	0.82	1I	--	--	245	--	--	--	--	--	455	--	--	--	--	--	525	--	--	--	--	--
1210	Chicago, North Shore & Milwaukee Railroad (abandoned)	0.87	1S	--	--	120	608.3	607.5	0.8	--	--	325	611.9	610.4	1.5	--	--	395	613.0	610.7	2.3	--	--
1215	CTH Y/22nd Avenue	0.90	1S	50	Yes	120	608.8	608.3	0.5	--	--	325	614.8	611.9	2.9	--	--	395	617.3	613.0	4.3	--	--
1220	25th Avenue	1.1	1I	--	--	120	--	--	--	--	--	325	--	--	--	--	--	395	--	--	--	--	--

[a] *Structure codes are as follows: 1—bridge or culvert; 2—dam, sill, or weir. 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] *Backwater is defined as the change in stage from the upstream side of the hydraulic structure to the downstream side.*

[d] *The flood stage indicated represents the water surface elevation approximately 100 feet from the bridge.*

Source: SEWRPC.

Table D-4

HYDROLOGIC-HYDRAULIC SUMMARY—SORENSON CREEK: EXISTING LAND USE AND EXISTING CHANNEL CONDITIONS

Structure Identification and Selected Characteristics						10-Year Recurrence Interval Flood						50-Year Recurrence Interval Flood						100-Year Recurrence Interval Flood					
Number	Name	River Mile	Structure Type and Hydraulic Significance[a]	Recommended Design Frequency (years)	Adequate Hydraulic Capacity[b]	Instantaneous Peak Discharge (cfs)	Upstream Stage[d] (feet above msl)	Downstream Stage[d] (feet above msl)	Backwater[c] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)	Instantaneous Peak Discharge (cfs)	Upstream Stage[d] (feet above msl)	Downstream Stage[d] (feet above msl)	Backwater[c] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)	Instantaneous Peak Discharge (cfs)	Upstream Stage[d] (feet above msl)	Downstream Stage[d] (feet above msl)	Backwater[c] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)
1000	Private Bridge	0.03	1I	--	--	360	--	--	--	--	--	740	--	--	--	--	--	860	--	--	--	--	--
1005	Private Bridge	0.92	1I	--	--	400	--	--	--	--	--	790	--	--	--	--	--	940	--	--	--	--	--
1010	CTH KR/ County Line Road	1.56	1S	50	Yes	400	611.6	610.4	1.2	--	--	790	615.5	611.2	4.3	--	--	940	617.0	611.2	5.8	0.1	0.1
1015	Private Bridge	1.67	1S	--	--	400	613.2	612.6	0.6	--	--	790	615.8	615.6	0.2	2.3	2.3	940	617.1	617.0	0.1	3.6	3.6
1020	Chicago, North Shore & Milwaukee Railroad (abandoned)	1.96	1S	--	--	400	614.7	613.9	0.8	--	--	750	617.2	616.2	1.0	--	--	880	619.4	617.4	2.0	--	--
1025	Private Bridge	2.37	1S	--	--	400	621.2	619.4	1.8	--	--	700	623.3	620.9	2.4	0.9	0.9	810	623.6	621.6	2.0	1.2	1.2
1030	Lathrop Avenue	2.62	1S	50	Yes	400	626.0	623.3	2.7	--	--	700	628.1	625.0	3.1	--	--	810	628.8	625.4	3.4	--	--
1035	Chicory Road	2.93	1S	50	Yes	390	636.8	630.2	6.6	--	--	650	637.0	631.3	5.7	--	--	740	637.2	631.7	5.5	0.7	0.7
1040	Private Bridge	3.03	1S	--	--	390	636.9	636.8	0.1	1.3	1.3	610	637.4	637.1	0.3	1.8	1.8	680	637.6	637.2	0.4	2.0	2.0
1045	Pleasant Lane	3.15	1S	10	No	390	638.6	637.2	1.4	0.4	0.4	610	638.9	637.7	1.2	0.7	0.7	680	638.9	637.9	1.0	0.7	0.7
1050	Taylor Avenue	3.49	1S	50	No	385	650.4	645.5	4.9[e]	--	--	570	652.2	646.3	5.9[e]	--	0.1	620	652.4	646.5	5.9[e]	0.2	0.2

[a]*Structure codes are as follows: 1—bridge or culvert; 2—dam, sill, or weir. 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]*Backwater is defined as the change in stage from the upstream side of the hydraulic structure to the downstream side.*

[d]*The flood stage indicated represents the water surface elevation approximately 100 feet from the bridge.*

[e]*There is a difference in streambed elevation of approximately 4.5 feet between the upstream side and the downstream side of the Taylor Avenue bridge.*

Source: SEWRPC.

Table D-5

HYDROLOGIC-HYDRAULIC SUMMARY—NELSON CREEK: EXISTING LAND USE AND EXISTING CHANNEL CONDITIONS

Structure Identification and Selected Characteristics						10-Year Recurrence Interval Flood						50-Year Recurrence Interval Flood						100-Year Recurrence Interval Flood					
Number	Name	River Mile	Structure Type and Hydraulic Significance[a]	Recommended Design Frequency (years)	Adequate Hydraulic Capacity[b]	Instantaneous Peak Discharge (cfs)	Upstream Stage[d] (feet above msl)	Downstream Stage[d] (feet above msl)	Backwater[c] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)	Instantaneous Peak Discharge (cfs)	Upstream Stage[d] (feet above msl)	Downstream Stage[d] (feet above msl)	Backwater[c] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)	Instantaneous Peak Discharge (cfs)	Upstream Stage[d] (feet above msl)	Downstream Stage[d] (feet above msl)	Backwater[c] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)
1100	Private Bridge	0.05	1S	--	--	70	602.8	597.8	5.0	0.2	--	125	603.0	599.2	3.8	0.4	0.2	145	603.1	599.5	3.6	0.5	0.3
1105	Chicago, North Shore & Milwaukee Railroad (abandoned)	0.12	1S	--	--	70	602.9	602.8	0.1	--	--	125	603.3	603.0	0.3	--	--	145	603.5	603.1	0.4	--	--
1110	Private Bridge	0.15	1I	--	--	70	--	--	--	--	--	125	--	--	--	--	--	145	--	--	--	--	--
1115	Lathrop Avenue	0.44	1S	50	Yes	70	608.6	606.9	1.7	--	--	125	609.7	607.3	2.4	--	--	145	610.1	607.4	2.7	--	--
1120	Lathrop Avenue	0.55	1S	50	Yes	70	610.9	608.8	2.1	--	--	125	612.0	609.8	2.2	--	--	145	612.7	610.2	2.5	--	--
1125	Lathrop Avenue	0.62	1S	50	No	70	614.6	610.9	3.7	0.2	0.2	125	615.0	612.0	3.0	0.6	0.6	145	615.1	612.7	2.4	0.7	0.7
1130	CTH KR/ County Line Road	0.80	1S	50	Yes	65	617.0	614.8	2.2	--	--	115	617.4	615.3	2.1	--	--	130	617.6	615.4	2.2	--	--
1135	Private Bridge	1.27	1I	--	--	60	--	--	--	--	--	100	--	--	--	--	--	110	--	--	--	--	--
1140	Private Bridge	1.63	1I	--	--	60	--	--	--	--	--	95	--	--	--	--	--	105	--	--	--	--	--
1145	Private Bridge	1.67	1I	--	--	60	--	--	--	--	--	95	--	--	--	--	--	105	--	--	--	--	--

[a]*Structure codes are as follows: 1—bridge or culvert; 2—dam, sill, or weir. 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]*Backwater is defined as the change in stage from the upstream side of the hydraulic structure to the downstream side.*

[d]*The flood stage indicated represents the water surface elevation approximately 100 feet from the bridge.*

Source: SEWRPC.

Table D-6

HYDROLOGIC-HYDRAULIC SUMMARY—PIKE CREEK: EXISTING LAND USE AND EXISTING CHANNEL CONDITIONS

Structure Identification and Selected Characteristics						10-Year Recurrence Interval Flood						50-Year Recurrence Interval Flood						100-Year Recurrence Interval Flood					
Number	Name	River Mile	Structure Type and Hydraulic Significance[a]	Recommended Design Frequency (years)	Adequate Hydraulic Capacity[b]	Instantaneous Peak Discharge (cfs)	Upstream Stage[d] (feet above msl)	Downstream Stage[d] (feet above msl)	Backwater[c] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)	Instantaneous Peak Discharge (cfs)	Upstream Stage[d] (feet above msl)	Downstream Stage[d] (feet above msl)	Backwater[c] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)	Instantaneous Peak Discharge (cfs)	Upstream Stage[d] (feet above msl)	Downstream Stage[d] (feet above msl)	Backwater[c] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)
500	STH 31/Green Bay Road	0.05	1S	50	No	600	641.6	641.4	0.2	--	--	1,000	643.9	643.6	0.3	0.4	--	1,150	644.8	644.7	0.1	1.3	0.8
505	Private Bridge	0.89	1I	--	--	620	--	--	--	--	--	1,060	--	--	--	--	--	1,270	--	--	--	--	--
510	Private Bridge	1.42	1I	--	--	650	--	--	--	--	--	1,160	--	--	--	--	--	1,400	--	--	--	--	--
515	CTH E/12th Street	2.13	1S	50	Yes	600	661.6	661.3	0.3	--	--	1,040	663.3	662.7	0.6	--	--	1,250	664.0	663.1	0.9	--	--
520	Town of Somers Transfer Station	3.17	1S	10	No	600	670.3	669.1	1.2	1.0	1.0	1,040	671.3	670.6	0.7	2.0	2.0	1,250	671.5	671.0	0.5	2.2	2.2
525	Chicago & North Western Transportation Company	3.29	1S	100	Yes	600	670.5	670.4	0.1	--	--	1,040	671.6	671.5	0.1	--	--	1,250	672.0	671.8	0.2	--	--
530	CTH L/Lichter Road	3.34	1S	50	Yes	600	670.7	670.6	0.1	--	--	1,040	672.1	671.8	0.3	--	--	1,250	672.5	672.1	0.4	--	--
535	Private Bridge	3.98	1I	--	--	450	--	--	--	--	--	770	--	--	--	--	--	940	--	--	--	--	--
540	Private Bridge	4.12	1I	--	--	450	--	--	--	--	--	770	--	--	--	--	--	940	--	--	--	--	--
545	Private Bridge	4.24	1S	--	--	450	673.0	672.9	0.1	0.6	--	770	674.0	673.9	0.1	1.6	0.9	940	674.2	674.1	0.1	1.8	1.1
550	STH 142/S. 43rd Street	4.86	1S	50	Yes	360	674.5	673.9	0.6	--	--	600	676.5	675.0	1.5	--	--	740	676.9	675.4	1.5	0.5	--
555	Footbridge	4.90	1I	--	--	360	--	--	--	--	--	600	--	--	--	--	--	740	--	--	--	--	--
560	STH 158/52nd Street	5.90	1S	50	Yes	230	675.6	674.7	0.9	--	--	380	679.0	676.5	2.5	--	--	420	679.9	676.9	3.0	--	--
565	CTH K/60th Street	6.45	1S	50	No	250	682.2	680.3	1.9	0.6	--	510	682.4	681.2	1.2	0.8	--	610	682.5	681.4	1.1	0.9	0.1
570	Chicago, Milwaukee, St. Paul & Pacific Railroad Company	6.85	1S	100	No	250	685.0	682.2	2.8	0.2	0.2	510	685.1	682.5	2.6	0.3	0.3	610	685.1	682.5	2.6	0.3	0.3

[a]*Structure codes are as follows: 1—bridge or culvert; 2—dam, sill, or weir. 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]*Backwater is defined as the change in stage from the upstream side of the hydraulic structure to the downstream side.*

[d]*The flood stage indicated represents the water surface elevation approximately 100 feet from the bridge.*

Source: SEWRPC.

Table D-7

HYDROLOGIC-HYDRAULIC SUMMARY—SOMERS BRANCH: EXISTING LAND USE AND EXISTING CHANNEL CONDITIONS

Structure Identification and Selected Characteristics						10-Year Recurrence Interval Flood						50-Year Recurrence Interval Flood						100-Year Recurrence Interval Flood					
Number	Name	River Mile	Structure Type and Hydraulic Significance[a]	Recommended Design Frequency (years)	Adequate Hydraulic Capacity[b]	Instantaneous Peak Discharge (cfs)	Upstream Stage[d] (feet above msl)	Downstream Stage[d] (feet above msl)	Backwater[c] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)	Instantaneous Peak Discharge (cfs)	Upstream Stage[d] (feet above msl)	Downstream Stage[d] (feet above msl)	Backwater[c] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)	Instantaneous Peak Discharge (cfs)	Upstream Stage[d] (feet above msl)	Downstream Stage[d] (feet above msl)	Backwater[c] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)
800	Private Bridge	0.06	1I	--	--	90	--	--	--	--	--	170	--	--	--	--	--	215	--	--	--	--	--
805	Private Bridge	0.53	1I	--	--	85	--	--	--	--	--	170	--	--	--	--	--	215	--	--	--	--	--
810	Chicago & North Western Transportation Company	0.69	1S	100	Yes	80	669.0	668.8	0.2	--	--	160	670.3	669.8	0.5	--	--	210	670.8	669.9	0.9	--	--
815	CTH EA/90th Street	1.11	1S	50	Yes	85	673.4	673.4	0.0	--	--	170	674.6	674.5	0.1	--	--	220	675.1	675.0	0.1	--	--
820	Private Bridge	1.43	1I	--	--	10	--	--	--	--	--	20	--	--	--	--	--	45	--	--	--	--	--
825	Private Bridge	1.77	1S	--	--	10	688.6	688.1	0.5	--	--	20	689.2	688.6	0.6	--	--	45	690.2	689.4	0.8	--	--
830	Private Bridge	1.94	1I	--	--	10	--	--	--	--	--	20	--	--	--	--	--	40	--	--	--	--	--
835	Chicago, Milwaukee, St. Paul & Pacific Railroad Company	1.95	1S	100	Yes	45	691.7	690.8	0.9	--	--	115	692.4	691.1	1.3	--	--	160	693.4	691.4	2.0	--	--
840	Private Bridge	2.31	1I	--	--	45	--	--	--	--	--	115	--	--	--	--	--	160	--	--	--	--	--

[a]*Structure codes are as follows: 1—bridge or culvert; 2—dam, sill, or weir. 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]*Backwater is defined as the change in stage from the upstream side of the hydraulic structure to the downstream side.*

[d]*The flood stage indicated represents the water surface elevation approximately 100 feet from the bridge.*

Source: SEWRPC.

Table D-8

HYDROLOGIC-HYDRAULIC SUMMARY—AIRPORT BRANCH: EXISTING LAND USE AND EXISTING CHANNEL CONDITIONS

Structure Identification and Selected Characteristics						10-Year Recurrence Interval Flood						50-Year Recurrence Interval Flood						100-Year Recurrence Interval Flood					
Number	Name	River Mile	Structure Type and Hydraulic Significance[a]	Recommended Design Frequency (years)	Adequate Hydraulic Capacity[b]	Instantaneous Peak Discharge (cfs)	Upstream Stage[d] (feet above msl)	Downstream Stage[d] (feet above msl)	Backwater[c] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)	Instantaneous Peak Discharge (cfs)	Upstream Stage[d] (feet above msl)	Downstream Stage[d] (feet above msl)	Backwater[c] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)	Instantaneous Peak Discharge (cfs)	Upstream Stage[d] (feet above msl)	Downstream Stage[d] (feet above msl)	Backwater[c] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)
900	Private Bridge	0.18	1I	- -	- -	190	- -	- -	- -	- -	- -	315	- -	- -	- -	- -	- -	355	- - -	- -	- -	- -	- -
905	Private Bridge	0.39	1I	- -	- -	190	- -	- -	- -	- -	- -	315	- -	- -	- -	- -	- -	355	- -	- -	- -	- -	- -
910	Chicago, Milwaukee, St. Paul & Pacific Railroad Company	0.14	1S	100	Yes	260	676.2	674.7	1.5	- -	- -	550	677.9	676.5	1.4	- -	- -	655	679.3	676.9	2.4	- -	- -

[a]*Structure codes are as follows: 1—bridge or culvert; 2—dam, sill, or weir. 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]*Backwater is defined as the change in stage from the upstream side of the hydraulic structure to the downstream side.*

[d]*The flood stage indicated represents the water surface elevation approximately 100 feet from the bridge.*

Source: SEWRPC.

Table D-9

HYDROLOGIC-HYDRAULIC SUMMARY—LAMPAREK DITCH: EXISTING LAND USE AND EXISTING CHANNEL CONDITIONS

Structure Identification and Selected Characteristics						10-Year Recurrence Interval Flood						50-Year Recurrence Interval Flood						100-Year Recurrence Interval Flood					
Number	Name	River Mile	Structure Type and Hydraulic Significance[a]	Recommended Design Frequency (years)	Adequate Hydraulic Capacity[b]	Instantaneous Peak Discharge (cfs)	Upstream Stage[d] (feet above msl)	Downstream Stage[d] (feet above msl)	Backwater[c] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)	Instantaneous Peak Discharge (cfs)	Upstream Stage[d] (feet above msl)	Downstream Stage[d] (feet above msl)	Backwater[c] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)	Instantaneous Peak Discharge (cfs)	Upstream Stage[d] (feet above msl)	Downstream Stage[d] (feet above msl)	Backwater[c] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)
700	Private Bridge	0.54	1S	- -	- -	25	664.7	662.5	2.2	- -	- -	140	668.0	664.2	3.8	- -	- -	205	669.6	664.9	4.7	- -	- -
705	Chicago & North Western Transportation Company	0.77	1S	100	Yes	25	669.6	667.5	2.1	- -	- -	140	673.5	669.0	4.5	- -	- -	205	673.8	670.2	3.6	- -	- -
710	90th Street	1.56	1S	50	Yes	20	680.8	680.4	0.4	- -	- -	120	682.4	682.1	0.3	- -	- -	170	683.0	682.6	0.4	- -	- -
715	Private Bridge	2.12	1I	- -	- -	20	- -	- -	- -	- -	- -	110	- -	- -	- -	- -	- -	155	- -	- -	- -	- -	- -
720	Chicago, Milwaukee, St. Paul & Pacific Railroad Company	2.26	1S	100	Yes	20	699.0	697.2	1.8	- -	- -	100	702.5	698.8	3.7	- -	- -	140	703.2	699.4	3.8	- -	- -
725	Private Bridge	2.61	1I	- -	- -	20	- -	- -	- -	- -	- -	90	- -	- -	- -	- -	- -	130	- -	- -	- -	- -	- -
730	Private Bridge	2.73	1S	- -	- -	15	709.6	709.0	0.6	- -	- -	80	711.3	710.5	0.8	- -	- -	115	712.0	711.1	0.9	- -	- -

[a]*Structure codes are as follows: 1—bridge or culvert; 2—dam, sill, or weir. 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]*Backwater is defined as the change in stage from the upstream side of the hydraulic structure to the downstream side.*

[d]*The flood stage indicated represents the water surface elevation approximately 100 feet from the bridge.*

Source: SEWRPC.

Table D-10

HYDROLOGIC-HYDRAULIC SUMMARY—CHICORY CREEK: EXISTING LAND USE AND EXISTING CHANNEL CONDITIONS

Structure Identification and Selected Characteristics						10-Year Recurrence Interval Flood						50-Year Recurrence Interval Flood						100-Year Recurrence Interval Flood					
Number	Name	River Mile	Structure Type and Hydraulic Significance[a]	Recommended Design Frequency (years)	Adequate Hydraulic Capacity[b]	Instantaneous Peak Discharge (cfs)	Upstream Stage[d] (feet above msl)	Downstream Stage[d] (feet above msl)	Backwater[c] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)	Instantaneous Peak Discharge (cfs)	Upstream Stage[d] (feet above msl)	Downstream Stage[d] (feet above msl)	Backwater[c] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)	Instantaneous Peak Discharge (cfs)	Upstream Stage[d] (feet above msl)	Downstream Stage[d] (feet above msl)	Backwater[c] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)
600	Private Bridge	0.20	1I	--	--	35	--	--	--	--	--	95	--	--	--	--	--	140	--	--	--	--	--
605	Chicago & North Western Transportation Company	0.46	1S	100	Yes	35	673.3	671.5	1.8	--	--	95	674.2	672.3	1.9	--	--	140	674.7	672.6	2.1	--	--
610	Private Bridge	0.54	1S	--	--	35	675.9	673.3	2.6	--	--	85	677.6	674.2	3.4	0.8	0.8	125	677.8	674.7	3.1	1.0	1.0
615	Private Bridge	0.62	1S	--	--	35	677.2	675.9	1.3	--	--	85	679.7	677.6	2.1	1.7	0.1	125	679.8	677.8	2.0	1.8	0.2
620	90th Street	1.13	1S	50	Yes	35	684.7	683.8	0.9	--	--	80	685.5	684.0	1.5	--	--	115	686.0	684.2	1.8	--	--

[a] *Structure codes are as follows: 1—bridge or culvert; 2—dam, sill, or weir. 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] *Backwater is defined as the change in stage from the upstream side of the hydraulic structure to the downstream side.*

[d] *The flood stage indicated represents the water surface elevation approximately 100 feet from the bridge.*

Source: SEWRPC.

Table D-11

HYDROLOGIC-HYDRAULIC SUMMARY—WAXDALE CREEK AND THE TRIBUTARY TO WAXDALE CREEK: EXISTING LAND USE AND EXISTING CHANNEL CONDITIONS

Structure Identification and Selected Characteristics						10-Year Recurrence Interval Flood						50-Year Recurrence Interval Flood						100-Year Recurrence Interval Flood					
Number	Name	River Mile	Structure Type and Hydraulic Significance[a]	Recommended Design Frequency (years)	Adequate Hydraulic Capacity[b]	Instantaneous Peak Discharge (cfs)	Upstream Stage[d] (feet above msl)	Downstream Stage[d] (feet above msl)	Backwater[c] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)	Instantaneous Peak Discharge (cfs)	Upstream Stage[d] (feet above msl)	Downstream Stage[d] (feet above msl)	Backwater[c] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)	Instantaneous Peak Discharge (cfs)	Upstream Stage[d] (feet above msl)	Downstream Stage[d] (feet above msl)	Backwater[c] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)
400	Chicago & North Western Transportation Company	0.27	1S	100	Yes	130	666.4	666.2[e]	0.2	--	--	230	668.9[e]	668.9[e]	0.0	--	--	250	669.5[e]	669.5[e]	0.0	--	--
405	Willow Road	0.29	1S	50	Yes	130	666.5	666.4	0.1	--	--	230	668.9[e]	668.9[e]	0.0	--	--	250	669.5[e]	669.5[e]	0.0	--	--
410	Chicago, Milwaukee, St. Paul & Pacific Railroad Company	0.47	1S	100	Yes	270	667.2	666.8	0.4	--	--	510	669.6	668.9	0.7	--	--	570	670.0	669.5	0.5	--	--
415	Buried Conduit	0.51	1S	--	--	270	676.4	667.2	9.2	--	--	510	677.3	669.6	7.7	--	0.8	570	677.4	670.0	7.4	--	0.9
420	Private Bridge	1.11	1I	--	--	210	--	--	--	--	--	400	--	--	--	--	--	460	--	--	--	--	--
425	90th Street	1.23	1S	50	No	170	685.6	684.0	1.6	--	--	360	690.7	685.2	5.5	0.7	0.7	420	690.9	685.4	5.5	0.9	0.9
430	CTH H/Wisconsin Street	1.89	1S	50	No	80	707.2	704.4	2.8	--	--	240	710.6	704.6	6.0	1.0	--	300	710.9	704.8	6.1	1.3	0.1

[a] *Structure codes are as follows: 1—bridge or culvert; 2—dam, sill, or weir. 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] *Backwater is defined as the change in stage from the upstream side of the hydraulic structure to the downstream side.*

[d] *The flood stage indicated represents the water surface elevation approximately 100 feet from the bridge.*

[e] *The flood stage indicated represents the water surface elevation of the Pike River at the confluence with Waxdale Creek.*

Source: SEWRPC.

Table D-12

HYDROLOGIC-HYDRAULIC SUMMARY—BARTLETT BRANCH: EXISTING LAND USE AND EXISTING CHANNEL CONDITIONS

Structure Identification and Selected Characteristics						10-Year Recurrence Interval Flood						50-Year Recurrence Interval Flood						100-Year Recurrence Interval Flood					
Number	Name	River Mile	Structure Type and Hydraulic Significance[a]	Recommended Design Frequency (years)	Adequate Hydraulic Capacity[b]	Instantaneous Peak Discharge (cfs)	Upstream Stage[d] (feet above msl)	Downstream Stage[d] (feet above msl)	Backwater[c] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)	Instantaneous Peak Discharge (cfs)	Upstream Stage[d] (feet above msl)	Downstream Stage[d] (feet above msl)	Backwater[c] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)	Instantaneous Peak Discharge (cfs)	Upstream Stage[d] (feet above msl)	Downstream Stage[d] (feet above msl)	Backwater[c] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)
325	Private Bridge	0.12	1S	--	--	200	680.3	680.1	0.2	--	--	310	684.3	683.9	0.4	0.3	0.3	360	685.0	684.9	0.1	1.0	1.0
330	Private Bridge	0.32	1S	--	--	200	680.6	680.4	0.2	--	--	310	684.3	684.3	0.0	--	1.9	360	685.0	685.0	0.0	4.4	2.6
335	Chicago & North Western Transportation Company	0.34	1S	100	Yes	200	680.9	680.6	0.3	--	--	310	684.8	684.3	0.5	--	--	360	685.7	685.0	0.7	--	--
340	Stuart Road	0.53	1S	50	Yes	230	681.8	681.3	0.5	--	--	385	686.0	684.9	1.1	--	--	465	687.3	685.8	1.5	--	--
345	Footbridge	0.67	1I	--	--	210	--	--	--	--	--	365	--	--	--	--	--	440	--	--	--	--	--
350	Clinton Lane Extended	0.79	1S	10	Yes	160	684.3	681.9	2.4	--	--	240	686.2	686.2	0.0	1.4	--	275	687.5	687.5	0.0	2.7	0.7
355	Private Bridge	1.07	1I	--	--	145	--	--	--	--	--	210	--	--	--	--	--	240	--	--	--	--	--
360	Footbridge	1.16	1I	--	--	145	--	--	--	--	--	210	--	--	--	--	--	240	--	--	--	--	--
365	Spring Street	1.21	1S	10	Yes	125	685.1	684.5	0.6	--	--	175	687.6	686.3	1.3	--	--	195	689.0	687.5	1.5	--	--

[a] *Structure codes are as follows: 1—bridge or culvert; 2—dam, sill, or weir. 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] *Backwater is defined as the change in stage from the upstream side of the hydraulic structure to the downstream side.*

[d] *The flood stage indicated represents the water surface elevation approximately 100 feet from the bridge.*

Source: SEWRPC.

Appendix E

HYDROLOGIC-HYDRAULIC SUMMARY FOR STRUCTURES ON THE PIKE RIVER AND SELECTED TRIBUTARIES: YEAR 2000 PLANNED LAND USE AND EXISTING CHANNEL CONDITIONS

Table E-1

HYDROLOGIC-HYDRAULIC SUMMARY—LOWER PIKE RIVER: YEAR 2000 PLANNED LAND USE AND EXISTING CHANNEL CONDITIONS

Structure Identification and Selected Characteristics						10-Year Recurrence Interval Flood						50-Year Recurrence Interval Flood						100-Year Recurrence Interval Flood					
Number	Name	River Mile	Structure Type and Hydraulic Significance[a]	Recommended Design Frequency (years)	Adequate Hydraulic Capacity[b]	Instantaneous Peak Discharge (cfs)	Upstream Stage[d] (feet above msl)	Downstream Stage[d] (feet above msl)	Backwater[c] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)	Instantaneous Peak Discharge (cfs)	Upstream Stage[d] (feet above msl)	Downstream Stage[d] (feet above msl)	Backwater[c] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)	Instantaneous Peak Discharge (cfs)	Upstream Stage[d] (feet above msl)	Downstream Stage[d] (feet above msl)	Backwater[c] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)
100	STH 32/Alford Park Drive	0.21	1S	50	Yes	2,505	582.1	581.1	1.0	- -	- -	3,490	583.2	581.1	2.1	- -	- -	3,945	584.0	581.1	2.9	- -	- -
105	STH 32/Sheridan Road	1.35	1S	50	Yes	2,505	585.5	584.8	0.7	- -	- -	3,490	586.3	585.9	0.4	- -	- -	3,945	586.7	586.5	0.2	- -	- -
110	Footbridge	1.52	1I	- -	- -	2,505	- -	- -	- -	- -	- -	3,490	- -	- -	- -	- -	- -	3,935	- -	- -	- -	- -	- -
115	Drive to Carthage College	1.70	1S	10	Yes	2,505	586.6	586.1	0.5	- -	- -	3,490	587.8	587.0	0.8	- -	- -	3,935	588.3	587.4	0.9	- -	- -
120	STH 32/S. 32nd Street	1.79	1S	50	Yes	2,505	587.6	586.6	1.0	- -	- -	3,490	589.1	587.8	1.3	- -	- -	3,935	589.8	588.3	1.5	- -	- -
125	Footbridge	2.46	1I	- -	- -	2,505	- -	- -	- -	- -	- -	3,470	- -	- -	- -	- -	- -	3,900	- -	- -	- -	- -	- -
125A	Footbridge	2.69	1I	- -	- -	2,505	- -	- -	- -	- -	- -	3,470	- -	- -	- -	- -	- -	3,900	- -	- -	- -	- -	- -
130	Chicago & North Western Transportation Company	3.04	1S	100	Yes	2,510	591.5	591.3	0.2	- -	- -	3,455	592.4	592.1	0.3	- -	- -	3,870	592.9	592.5	0.4	- -	- -
135	CTH E/12th Street	3.27	1S	50	Yes	2,510	593.8	593.0	0.8	- -	- -	3,455	595.1	593.9	1.2	- -	- -	3,870	595.7	594.2	1.5	- -	- -
140	CTH A/7th Street	4.61	1S	50	Yes	2,430	598.8	598.3	0.5	- -	- -	3,365	600.0	599.2	0.8	- -	- -	3,650	600.4	599.6	0.8	0.2	- -
145	Lathrop Avenue	4.79	1S	50	No	2,335	599.4	598.9	0.5	1.6	- -	3,340	600.6	600.2	0.4	2.8	- -	3,710	601.0	600.6	0.4	3.2	- -
150	Chicago, North Shore & Milwaukee Railroad (abandoned)	4.88	1S	- -	- -	2,335	599.9	599.4	0.5	- -	- -	3,340	601.4	600.6	0.8	- -	- -	3,710	601.9	601.0	0.9	- -	- -
155	Private Bridge	4.92	1I	- -	- -	2,335	- -	- -	- -	- -	- -	3,340	- -	- -	- -	- -	- -	3,710	- -	- -	- -	- -	- -
160	Private Bridge	5.00	1I	- -	- -	2,280	- -	- -	- -	- -	- -	3,260	- -	- -	- -	- -	- -	3,655	- -	- -	- -	- -	- -
165	Private Bridge	5.04	1I	- -	- -	2,280	- -	- -	- -	- -	- -	3,260	- -	- -	- -	- -	- -	3,655	- -	- -	- -	- -	- -
170	Private Bridge	5.12	1I	- -	- -	2,280	- -	- -	- -	- -	- -	3,260	- -	- -	- -	- -	- -	3,655	- -	- -	- -	- -	- -
175	Private Bridge	5.31	1I	- -	- -	2,280	- -	- -	- -	- -	- -	3,260	- -	- -	- -	- -	- -	3,655	- -	- -	- -	- -	- -
177	Kenosha Country Club Dam	5.31	2S	- -	- -	2,280	- -	- -	- -	- -	- -	3,260	- -	- -	- -	- -	- -	3,655	- -	- -	- -	- -	- -
180	Private Bridge	5.37	1I	- -	- -	2,280	- -	- -	- -	- -	- -	3,260	- -	- -	- -	- -	- -	3,655	- -	- -	- -	- -	- -
185	Private Bridge	5.40	1I	- -	- -	2,280	- -	- -	- -	- -	- -	3,260	- -	- -	- -	- -	- -	3,655	- -	- -	- -	- -	- -
190	Private Bridge	5.44	1I	- -	- -	2,240	- -	- -	- -	- -	- -	3,205	- -	- -	- -	- -	- -	3,645	- -	- -	- -	- -	- -
195	Private Bridge	5.52	1I	- -	- -	2,240	- -	- -	- -	- -	- -	3,205	- -	- -	- -	- -	- -	3,645	- -	- -	- -	- -	- -
200	Private Bridge	5.59	1I	- -	- -	2,240	- -	- -	- -	- -	- -	3,205	- -	- -	- -	- -	- -	3,645	- -	- -	- -	- -	- -
205	CTH Y/22nd Avenue	5.63	1S	50	Yes	2,240	603.8	602.7	1.1	- -	- -	3,205	605.9	603.4	2.5	- -	- -	3,645	606.7	603.6	3.1	- -	- -
210	CTH G/Wood Road	6.60	1S	50	Yes	2,270	615.7	614.8	0.9	- -	- -	3,250	617.0	615.7	1.3	- -	- -	3,700	617.2	616.0	1.2	0.7	- -
215	CTH A/7th Street	6.96	1S	50	Yes	2,270	617.6	616.8	0.8	- -	- -	3,250	619.1	618.0	1.1	- -	- -	3,700	619.6	618.3	1.3	- -	- -
220	Petrifying Springs Park Road	8.26	1S	10	Yes	1,300	629.8	629.4	0.4	- -	- -	1,600	631.6	630.1	1.5	- -	- -	1,730	631.9	630.3	1.6	- -	- -
225	Footbridge	8.34	1I	- -	- -	1,300	- -	- -	- -	- -	- -	1,600	- -	- -	- -	- -	- -	1,730	- -	- -	- -	- -	- -
230	Footbridge	8.48	1I	- -	- -	2,225	- -	- -	- -	- -	- -	3,145	- -	- -	- -	- -	- -	3,555	- -	- -	- -	- -	- -
235	Footbridge	8.61	1I	- -	- -	2,225	- -	- -	- -	- -	- -	3,145	- -	- -	- -	- -	- -	3,555	- -	- -	- -	- -	- -
245	Footbridge	8.80	1I	- -	- -	2,225	- -	- -	- -	- -	- -	3,145	- -	- -	- -	- -	- -	3,555	- -	- -	- -	- -	- -
245A	Footbridge	8.93	1I	- -	- -	2,225	- -	- -	- -	- -	- -	3,145	- -	- -	- -	- -	- -	3,555	- -	- -	- -	- -	- -
250	Park Drive, Footbridge, and Control Structure	9.07	2S	- -	- -	2,225	- -	- -	- -	- -	- -	3,145	- -	- -	- -	- -	- -	3,555	- -	- -	- -	- -	- -
255	Petrifying Springs Park Drive	9.39	1S	10	Yes	2,225	640.3	639.7	0.6	- -	- -	3,145	641.6	640.6	1.0	- -	- -	3,555	642.5	641.0	1.5	1.1	- -
260	CTH A/7th Street	9.55	1S	50	Yes	2,225	642.3	641.8	0.5	- -	- -	3,145	644.1	643.1	1.0	- -	- -	3,555	644.8	643.8	1.0	1.2	- -

[a] *Structure codes are as follows: 1—bridge or culvert; 2—dam, sill, or weir. 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] *Backwater is defined as the change in stage from the upstream side of the hydraulic structure to the downstream side.*

[d] *The flood stage indicated represents the water surface elevation approximately 100 feet from the bridge.*

Source: SEWRPC.

Table E-2

HYDROLOGIC-HYDRAULIC SUMMARY—UPPER PIKE RIVER: YEAR 2000 PLANNED LAND USE AND EXISTING CHANNEL CONDITIONS

Structure Identification and Selected Characteristics						10-Year Recurrence Interval Flood						50-Year Recurrence Interval Flood						100-Year Recurrence Interval Flood					
Number	Name	River Mile	Structure Type and Hydraulic Significance[a]	Recommended Design Frequency (years)	Adequate Hydraulic Capacity[b]	Instantaneous Peak Discharge (cfs)	Upstream Stage[d] (feet above msl)	Downstream Stage[d] (feet above msl)	Backwater[c] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)	Instantaneous Peak Discharge (cfs)	Upstream Stage[d] (feet above msl)	Downstream Stage[d] (feet above msl)	Backwater[c] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)	Instantaneous Peak Discharge (cfs)	Upstream Stage[d] (feet above msl)	Downstream Stage[d] (feet above msl)	Backwater[c] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)
265	STH 31/ Green Bay Road	10.38	1S	50	Yes	1,560	651.1	649.5	1.6	--	--	2,160	652.6	650.4	2.2	--	--	2,430	653.2	650.7	2.5	--	--
270	CTH KR/ County Line Road	11.15	1S	50	No	1,560	656.8	655.8	1.0	0.7	--	2,160	657.4	656.5	0.9	1.3	--	2,430	657.6	656.8	0.8	1.5	0.1
272	Private Bridge	11.56	1I	--	--	1,560	--	--	--	--	--	2,415	--	--	--	--	--	2,680	--	--	--	--	--
275	Braun Road	12.23	1S	50	No	1,560	665.0	663.6	1.4	--	--	2,415	667.3	664.7	2.6	0.8	0.7	2,680	667.6	664.9	2.7	1.1	1.0
280	Private Bridge	12.99	1I	--	--	1,495	--	--	--	--	--	2,415	--	--	--	--	--	2,680	--	--	--	--	--
285	STH 11/Durand Road	13.29	1S	50	No	1,320	668.5	668.3	0.2	--	--	2,195	670.2	669.8	0.4	0.5	--	2,470	670.5	670.2	0.3	0.8	--
290	Chicago, Milwaukee, St. Paul & Pacific Railroad Company	13.72	1I	100	Yes	1,130	--	--	--	--	--	1,665	--	--	--	--	--	1,835	--	--	--	--	--
295	Oakes Road	14.51	1S	10	No	930	678.8	673.2	5.6	2.2	1.5	1,405	679.4	675.0	4.4	2.8	2.1	1,555	679.6	675.1	4.5	3.0	2.3
300	STH 20/S. 20th Street	14.94	1S	50	Yes	785	680.0	679.7	0.3	--	--	1,255	681.6	680.7	0.9	--	--	1,385	682.0	681.0	1.0	--	--
305	Private Bridge	15.00	1S	--	--	785	681.2	680.0	1.2	--	--	1,255	682.7	681.6	1.1	1.6	1.6	1,385	682.9	682.0	0.9	1.8	1.8
310	Footbridge	15.15	1I	--	--	735	--	--	--	--	--	1,150	--	--	--	--	--	1,270	--	--	--	--	--
315	Private Bridge	15.29	1S	--	--	735	683.5	682.4	1.1	--	--	1,150	685.4	684.1	1.3	0.4	0.4	1,270	685.6	684.4	1.2	0.6	0.6
320	Private Bridge	15.77	1I	--	--	615	--	--	--	--	--	910	--	--	--	--	--	990	--	--	--	--	--
370	Spring Street	16.24	1S	10	Yes	225	685.1	683.9	1.2	--	--	320	687.4	685.5	1.9	0.2	0.1	335	687.5	685.7	1.8	0.3	0.2

[a]*Structure codes are as follows: 1—bridge or culvert; 2—dam, sill, or weir. 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]*Backwater is defined as the change in stage from the upstream side of the hydraulic structure to the downstream side.*

[d]*The flood stage indicated represents the water surface elevation approximately 100 feet from the bridge.*

Source: SEWRPC.

Table E-3

HYDROLOGIC-HYDRAULIC SUMMARY—KENOSHA BRANCH: YEAR 2000 PLANNED LAND USE AND EXISTING CHANNEL CONDITIONS

Structure Identification and Selected Characteristics						10-Year Recurrence Interval Flood						50-Year Recurrence Interval Flood						100-Year Recurrence Interval Flood					
Number	Name	River Mile	Structure Type and Hydraulic Significance[a]	Recommended Design Frequency (years)	Adequate Hydraulic Capacity[b]	Instantaneous Peak Discharge (cfs)	Upstream Stage[d] (feet above msl)	Downstream Stage[d] (feet above msl)	Backwater[c] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)	Instantaneous Peak Discharge (cfs)	Upstream Stage[d] (feet above msl)	Downstream Stage[d] (feet above msl)	Backwater[c] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)	Instantaneous Peak Discharge (cfs)	Upstream Stage[d] (feet above msl)	Downstream Stage[d] (feet above msl)	Backwater[c] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)
1200	20th Avenue	0.76	1S	50	No	485	610.3	602.9	7.4	0.5	0.5	785	611.6	603.5	8.1	1.8	1.8	865	611.8	603.6	8.2	2.0	2.0
1205	Private Bridge	0.82	1I	--	--	485	--	--	--	--	--	785	--	--	--	--	--	865	--	--	--	--	--
1210	Chicago, North Shore & Milwaukee Railroad (abandoned)	0.87	1S	--	--	355	612.2	610.4	1.8	--	--	650	619.0	611.7	7.3	0.6	0.3	735	619.4	612.0	7.4	1.0	0.7
1215	CTH Y/22nd Avenue	0.90	1S	50	No	355	615.7	612.2	3.5	--	--	650	620.9	619.0	1.9	0.7	0.7	735	620.9	619.4	1.5	0.7	0.7
1220	25th Avenue	1.1	1I	--	--	355	--	--	--	--	--	650	--	--	--	--	--	735	--	--	--	--	--

[a]*Structure codes are as follows: 1—bridge or culvert; 2—dam, sill, or weir. 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]*Backwater is defined as the change in stage from the upstream side of the hydraulic structure to the downstream side.*

[d]*The flood stage indicated represents the water surface elevation approximately 100 feet from the bridge.*

Source: SEWRPC.

Table E-4

HYDROLOGIC-HYDRAULIC SUMMARY—SORENSON CREEK: YEAR 2000 PLANNED LAND USE AND EXISTING CHANNEL CONDITIONS

Structure Identification and Selected Characteristics						10-Year Recurrence Interval Flood						50-Year Recurrence Interval Flood						100-Year Recurrence Interval Flood					
Number	Name	River Mile	Structure Type and Hydraulic Significance[a]	Recommended Design Frequency (years)	Adequate Hydraulic Capacity[b]	Instantaneous Peak Discharge (cfs)	Upstream Stage[d] (feet above msl)	Downstream Stage[d] (feet above msl)	Backwater[c] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)	Instantaneous Peak Discharge (cfs)	Upstream Stage[d] (feet above msl)	Downstream Stage[d] (feet above msl)	Backwater[c] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)	Instantaneous Peak Discharge (cfs)	Upstream Stage[d] (feet above msl)	Downstream Stage[d] (feet above msl)	Backwater[c] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)
1000	Private Bridge	0.03	1I	--	--	630	--	--	--	--	--	1,010	--	--	--	--	--	1,080	--	--	--	--	--
1005	Private Bridge	0.92	1I	--	--	720	--	--	--	--	--	1,150	--	--	--	--	--	1,240	--	--	--	--	--
1010	CTH KR/ County Line Road	1.56	1S	50	No	720	614.7	611.1	3.6	--	--	1,150	617.2	611.5	5.7	0.3	0.3	1,240	617.2	611.6	5.6	0.3	0.3
1015	Private Bridge	1.67	1S	--	--	720	615.1	614.8	0.3	1.6	1.6	1,150	617.4	617.2	0.2	3.9	3.9	1,240	617.4	617.3	0.1	3.9	3.9
1020	Chicago, North Shore & Milwaukee Railroad (abandoned)	1.96	1S	--	--	610	616.4	615.7	0.7	--	--	1,040	620.5	617.7	2.8	--	--	1,120	621.1	617.8	3.3	--	--
1025	Private Bridge	2.37	1S	--	--	530	622.3	620.2	2.1	--	--	905	623.9	622.2	1.7	1.5	1.5	980	624.0	622.6	1.4	1.6	1.6
1030	Lathrop Avenue	2.62	1S	50	Yes	530	626.9	624.1	2.8	--	--	905	629.4	625.6	3.8	--	--	980	629.8	625.8	4.0	--	--
1035	Chicory Road	2.93	1S	50	No	512	637.0	630.8	6.2	0.6	0.5	770	637.2	631.8	5.4	0.8	0.7	835	637.2	632.0	5.2	0.8	0.7
1040	Private Bridge	3.03	1S	--	--	450	637.2	637.0	0.2	1.6	1.6	660	637.6	637.3	0.3	2.0	2.0	715	637.7	637.3	0.4	2.1	2.1
1045	Pleasant Lane	3.15	1S	10	No	450	638.7	637.4	1.3	0.5	0.5	660	638.9	637.9	1.0	0.7	0.7	715	639.0	638.0	1.0	0.8	0.8
1050	Taylor Avenue	3.49	1S	50	No	445	651.2	645.8	5.4[e]	--	--	615	652.4	646.5	5.9[e]	0.2	0.2	650	652.7	646.6	6.1[e]	0.7	0.5

[a] *Structure codes are as follows: 1—bridge or culvert; 2—dam, sill, or weir. 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] *Backwater is defined as the change in stage from the upstream side of the hydraulic structure to the downstream side.*

[d] *The flood stage indicated represents the water surface elevation approximately 100 feet from the bridge.*

[e] *There is a difference in streambed elevation of approximately 4.5 feet between the upstream side and the downstream side of the Taylor Avenue bridge.*

Source: SEWRPC.

Table E-5

HYDROLOGIC-HYDRAULIC SUMMARY—NELSON CREEK: YEAR 2000 PLANNED LAND USE AND EXISTING CHANNEL CONDITIONS

Structure Identification and Selected Characteristics						10-Year Recurrence Interval Flood						50-Year Recurrence Interval Flood						100-Year Recurrence Interval Flood					
Number	Name	River Mile	Structure Type and Hydraulic Significance[a]	Recommended Design Frequency (years)	Adequate Hydraulic Capacity[b]	Instantaneous Peak Discharge (cfs)	Upstream Stage[d] (feet above msl)	Downstream Stage[d] (feet above msl)	Backwater[c] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)	Instantaneous Peak Discharge (cfs)	Upstream Stage[d] (feet above msl)	Downstream Stage[d] (feet above msl)	Backwater[c] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)	Instantaneous Peak Discharge (cfs)	Upstream Stage[d] (feet above msl)	Downstream Stage[d] (feet above msl)	Backwater[c] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)
1100	Private Bridge	0.05	1S	--	--	119	603.2	598.9	3.6	0.6	0.4	208	603.2	599.9	3.3	0.6	0.4	236	603.3	600.0	3.3	0.7	0.5
1105	Chicago, North Shore & Milwaukee Railroad (abandoned)	0.12	1S	--	--	119	603.4	603.2	0.2	--	--	208	604.0	603.2	0.8	--	--	236	604.3	603.3	1.0	--	--
1110	Private Bridge	0.15	1I	--	--	119	--	--	--	--	--	208	--	--	--	--	--	236	--	--	--	--	--
1115	Lathrop Avenue	0.44	1S	50	Yes	119	609.6	607.2	2.4	--	--	208	611.2	607.7	3.5	--	--	236	611.6	607.8	3.8	--	--
1120	Lathrop Avenue	0.55	1S	50	No	119	612.1	609.7	2.4	--	--	208	614.5	611.2	3.3	0.2	0.2	236	614.6	611.6	3.0	0.3	0.3
1125	Lathrop Avenue	0.62	1S	50	No	119	615.0	612.1	2.9	0.6	0.6	208	615.4	614.5	0.9	1.0	1.0	236	615.5	614.6	0.9	1.1	1.1
1130	CTH KR/ County Line Road	0.80	1S	50	Yes	140	617.8	615.4	2.4	--	--	225	618.9	616.0	2.9	--	--	255	619.3	616.1	3.2	--	--
1135	Private Bridge	1.27	1I	--	--	150	--	--	--	--	--	255	--	--	--	--	--	285	--	--	--	--	--
1140	Private Bridge	1.63	1I	--	--	160	--	--	--	--	--	265	--	--	--	--	--	310	--	--	--	--	--
1145	Private Bridge	1.67	1I	--	--	160	--	--	--	--	--	265	--	--	--	--	--	310	--	--	--	--	--

[a] *Structure codes are as follows: 1—bridge or culvert; 2—dam, sill, or weir. 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] *Backwater is defined as the change in stage from the upstream side of the hydraulic structure to the downstream side.*

[d] *The flood stage indicated represents the water surface elevation approximately 100 feet from the bridge.*

Source: SEWRPC.

Table E-6

HYDROLOGIC-HYDRAULIC SUMMARY—PIKE CREEK: YEAR 2000 PLANNED LAND USE AND EXISTING CHANNEL CONDITIONS

Structure Identification and Selected Characteristics						10-Year Recurrence Interval Flood						50-Year Recurrence Interval Flood						100-Year Recurrence Interval Flood					
Number	Name	River Mile	Structure Type and Hydraulic Significance[a]	Recommended Design Frequency (years)	Adequate Hydraulic Capacity[b]	Instantaneous Peak Discharge (cfs)	Upstream Stage[d] (feet above msl)	Downstream Stage[d] (feet above msl)	Backwater[c] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)	Instantaneous Peak Discharge (cfs)	Upstream Stage[d] (feet above msl)	Downstream Stage[d] (feet above msl)	Backwater[c] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)	Instantaneous Peak Discharge (cfs)	Upstream Stage[d] (feet above msl)	Downstream Stage[d] (feet above msl)	Backwater[c] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)
500	STH 31/Green Bay Road	0.05	1S	50	No	880	642.9	642.6	0.3	- -	- -	1,340	644.6	644.4	0.2	1.1	0.6	1,650	645.2	645.0	0.2	1.7	1.2
505	Private Bridge	0.89	1I	- -	- -	880	- -	- -	- -	- -	- -	1,340	- -	- -	- -	- -	- -	1,650	- -	- -	- -	- -	- -
510	Private Bridge	1.42	1I	- -	- -	900	- -	- -	- -	- -	- -	1,400	- -	- -	- -	- -	- -	1,800	- -	- -	- -	- -	- -
515	CTH E/12th Street	2.13	1S	50	Yes	830	662.6	662.1	0.5	- -	- -	1,310	664.1	663.2	0.9	- -	- -	1,580	664.9	663.7	1.2	- -	- -
520	Town of Somers Transfer Station	3.17	1S	10	No	820	670.8	669.8	1.0	1.5	1.5	1,290	671.6	671.1	0.5	2.3	2.3	1,530	671.9	671.5	0.4	2.6	2.6
525	Chicago & North Western Transportation Company	3.29	1S	100	Yes	820	671.1	671.0	0.1	- -	- -	1,290	672.1	671.8	0.3	- -	- -	1,530	672.5	672.2	0.3	- -	- -
530	CTH L/Lichter Road	3.34	1S	50	Yes	820	671.5	671.2	0.3	- -	- -	1,290	672.6	672.2	0.4	- -	- -	1,530	673.1	672.7	0.4	- -	- -
535	Private Bridge	3.98	1I	- -	- -	780	- -	- -	- -	- -	- -	1,220	- -	- -	- -	- -	- -	1,400	- -	- -	- -	- -	- -
540	Private Bridge	4.12	1I	- -	- -	780	- -	- -	- -	- -	- -	1,220	- -	- -	- -	- -	- -	1,400	- -	- -	- -	- -	- -
545	Private Bridge	4.24	1S	- -	- -	780	673.9	673.8	0.1	1.5	0.8	1,220	674.5	674.5	0.0	2.1	1.4	1,400	674.8	674.8	0.0	2.4	1.7
550	STH 142/S. 43rd Street	4.86	1S	50	No	780	676.9	675.3	1.6	0.5	- -	1,220	677.2	676.1	1.1	0.8	- -	1,400	677.3	676.4	0.9	0.9	- -
555	Footbridge	4.90	1I	- -	- -	780	- -	- -	- -	- -	- -	1,220	- -	- -	- -	- -	- -	1,400	- -	- -	- -	- -	- -
560	STH 158/52nd Street	5.90	1S	50	Yes	330 ~~[illegible]~~	678.8	676.9	1.9	- -	- -	460	680.9	677.3	3.6	- -	- -	480	681.4	677.4	4.0	- -	- -
565	CTH K/60th Street	6.45	1S	50	No	390	682.4	680.8	1.6	0.8	0.0	700	682.6	681.8	0.8	1.0	0.2	810	682.6	682.0	0.6	1.0	0.2
570	Chicago, Milwaukee, St. Paul & Pacific Railroad Company	6.85	1S	100	No	390	685.0	682.4	2.6	0.2	0.2	700	685.1	682.6	2.5	0.3	0.3	810	685.2	682.7	2.5	0.4	0.4

[a] *Structure codes are as follows: 1—bridge or culvert; 2—dam, sill, or weir. 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] *Backwater is defined as the change in stage from the upstream side of the hydraulic structure to the downstream side.*

[d] *The flood stage indicated represents the water surface elevation approximately 100 feet from the bridge.*

Source: SEWRPC.

Table E-7

HYDROLOGIC-HYDRAULIC SUMMARY—SOMERS BRANCH: YEAR 2000 PLANNED LAND USE AND EXISTING CHANNEL CONDITIONS

Structure Identification and Selected Characteristics						10-Year Recurrence Interval Flood						50-Year Recurrence Interval Flood						100-Year Recurrence Interval Flood					
Number	Name	River Mile	Structure Type and Hydraulic Significance[a]	Recommended Design Frequency (years)	Adequate Hydraulic Capacity[b]	Instantaneous Peak Discharge (cfs)	Upstream Stage[d] (feet above msl)	Downstream Stage[d] (feet above msl)	Backwater[c] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)	Instantaneous Peak Discharge (cfs)	Upstream Stage[d] (feet above msl)	Downstream Stage[d] (feet above msl)	Backwater[c] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)	Instantaneous Peak Discharge (cfs)	Upstream Stage[d] (feet above msl)	Downstream Stage[d] (feet above msl)	Backwater[c] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)
800	Private Bridge	0.06	1I	- -	- -	110	- -	- -	- -	- -	- -	255	- -	- -	- -	- -	- -	320	- -	- -	- -	- -	- -
805	Private Bridge	0.53	1I	- -	- -	110	- -	- -	- -	- -	- -	255	- -	- -	- -	- -	- -	320	- -	- -	- -	- -	- -
810	Chicago & North Western Transportation Company	0.69	1S	100	Yes	110	669.4	669.1	0.3	- -	- -	255	671.5	670.1	1.4	- -	- -	320	672.6	670.3	2.3	- -	- -
815	CTH EA/90th Street	1.11	1S	50	Yes	115	673.9	673.8	0.1	- -	- -	270	675.5	675.3	0.2	- -	- -	320	675.8	675.5	0.3	- -	- -
820	Private Bridge	1.43	1I	- -	- -	70	- -	- -	- -	- -	- -	110	- -	- -	- -	- -	- -	120	- -	- -	- -	- -	- -
825	Private Bridge	1.77	1S	- -	- -	60	690.7	689.8	0.9	- -	- -	95	691.6	690.3	1.3	- -	- -	110	692.3	690.5	1.8	- -	- -
830	Private Bridge	1.94	1I	- -	- -	55	- -	- -	- -	- -	- -	80	- -	- -	- -	- -	- -	90	- -	- -	- -	- -	- -
835	Chicago, Milwaukee, St. Paul & Pacific Railroad Company	1.95	1S	100	Yes	55	694.2	691.7	2.5	- -	- -	80	694.6	692.3	2.3	- -	- -	90	695.3	692.7	2.6	- -	- -
840	Private Bridge	2.31	1I	- -	- -	300	- -	- -	- -	- -	- -	500	- -	- -	- -	- -	- -	560	- -	- -	- -	- -	- -

[a] *Structure codes are as follows: 1—bridge or culvert; 2—dam, sill, or weir. 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] *Backwater is defined as the change in stage from the upstream side of the hydraulic structure to the downstream side.*

[d] *The flood stage indicated represents the water surface elevation approximately 100 feet from the bridge.*

Source: SEWRPC.

Table E-8

HYDROLOGIC-HYDRAULIC SUMMARY—AIRPORT BRANCH: YEAR 2000 PLANNED LAND USE AND EXISTING CHANNEL CONDITIONS

Structure Identification and Selected Characteristics						10-Year Recurrence Interval Flood						50-Year Recurrence Interval Flood						100-Year Recurrence Interval Flood					
Number	Name	River Mile	Structure Type and Hydraulic Significance[a]	Recommended Design Frequency (years)	Adequate Hydraulic Capacity[b]	Instantaneous Peak Discharge (cfs)	Upstream Stage[d] (feet above msl)	Downstream Stage[d] (feet above msl)	Backwater[c] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)	Instantaneous Peak Discharge (cfs)	Upstream Stage[d] (feet above msl)	Downstream Stage[d] (feet above msl)	Backwater[c] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)	Instantaneous Peak Discharge (cfs)	Upstream Stage[d] (feet above msl)	Downstream Stage[d] (feet above msl)	Backwater[c] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)
900	Private Bridge	0.18	1I	--	--	325	--	--	--	--	--	420	--	--	--	--	--	440	--	--	--	--	--
905	Private Bridge	0.39	1I	--	--	325	--	--	--	--	--	420	--	--	--	--	--	440	--	--	--	--	--
910	Chicago, Milwaukee, St. Paul & Pacific Railroad Company	0.41	1S	100	Yes	310	679.0	676.9	2.1	--	--	395	680.7	677.3	3.4	--	--	420	681.4	677.4	4.0	--	--

[a]*Structure codes are as follows: 1—bridge or culvert; 2—dam, sill, or weir. 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]*Backwater is defined as the change in stage from the upstream side of the hydraulic structure to the downstream side.*

[d]*The flood stage indicated represents the water surface elevation approximately 100 feet from the bridge.*

Source: SEWRPC.

Table E-9

HYDROLOGIC-HYDRAULIC SUMMARY—LAMPAREK DITCH: YEAR 2000 PLANNED LAND USE AND EXISTING CHANNEL CONDITIONS

Structure Identification and Selected Characteristics						10-Year Recurrence Interval Flood						50-Year Recurrence Interval Flood						100-Year Recurrence Interval Flood					
Number	Name	River Mile	Structure Type and Hydraulic Significance[a]	Recommended Design Frequency (years)	Adequate Hydraulic Capacity[b]	Instantaneous Peak Discharge (cfs)	Upstream Stage[d] (feet above msl)	Downstream Stage[d] (feet above msl)	Backwater[c] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)	Instantaneous Peak Discharge (cfs)	Upstream Stage[d] (feet above msl)	Downstream Stage[d] (feet above msl)	Backwater[c] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)	Instantaneous Peak Discharge (cfs)	Upstream Stage[d] (feet above msl)	Downstream Stage[d] (feet above msl)	Backwater[c] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)
700	Private Bridge	0.54	1S	--	--	25	664.7	662.5	2.2	--	--	140	668.0	664.2	3.8	--	--	205	669.6	664.9	4.7	--	--
705	Chicago & North Western Transportation Company	0.77	1S	100	Yes	25	669.6	667.5	2.1	--	--	140	673.5	669.0	4.5	--	--	205	673.8	670.2	3.6	--	--
710	90th Street	1.56	1S	50	Yes	20	680.8	680.4	0.4	--	--	120	682.4	682.1	0.3	--	--	170	683.0	682.6	0.4	--	--
715	Private Bridge	2.12	1I	--	--	20	--	--	--	--	--	110	--	--	--	--	--	155	--	--	--	--	--
720	Chicago, Milwaukee, St. Paul & Pacific Railroad Company	2.26	1S	100	Yes	20	699.0	697.2	1.8	--	--	100	702.5	698.8	3.7	--	--	140	703.2	699.4	3.8	--	--
725	Private Bridge	2.61	1I	--	--	20	--	--	--	--	--	90	--	--	--	--	--	130	--	--	--	--	--
730	Private Bridge	2.73	1S	--	--	15	709.6	709.0	0.6	--	--	80	711.3	710.5	0.8	--	--	115	712.0	711.1	0.9	--	--

[a]*Structure codes are as follows: 1—bridge or culvert; 2—dam, sill, or weir. 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]*Backwater is defined as the change in stage from the upstream side of the hydraulic structure to the downstream side.*

[d]*The flood stage indicated represents the water surface elevation approximately 100 feet from the bridge.*

Source: SEWRPC.

Table E-10

HYDROLOGIC-HYDRAULIC SUMMARY—CHICORY CREEK: YEAR 2000 PLANNED LAND USE AND EXISTING CHANNEL CONDITIONS

Structure Identification and Selected Characteristics						10-Year Recurrence Interval Flood						50-Year Recurrence Interval Flood						100-Year Recurrence Interval Flood					
Number	Name	River Mile	Structure Type and Hydraulic Significance[a]	Recommended Design Frequency (years)	Adequate Hydraulic Capacity[b]	Instantaneous Peak Discharge (cfs)	Upstream Stage[d] (feet above msl)	Downstream Stage[d] (feet above msl)	Backwater[c] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)	Instantaneous Peak Discharge (cfs)	Upstream Stage[d] (feet above msl)	Downstream Stage[d] (feet above msl)	Backwater[c] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)	Instantaneous Peak Discharge (cfs)	Upstream Stage[d] (feet above msl)	Downstream Stage[d] (feet above msl)	Backwater[c] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)
600	Private Bridge	0.20	1I	- -	- -	35	- -	- -	- -	- -	- -	95	- -	- -	- -	- -	- -	140	- -	- -	- -	- -	- -
605	Chicago & North Western Transportation Company	0.46	1S	100	Yes	35	673.3	671.5	1.8	- -	- -	95	674.2	672.3	1.9	- -	- -	140	674.7	672.6	2.1	- -	- -
610	Private Bridge	0.54	1S	- -	- -	35	675.9	673.3	2.6	- -	- -	85	677.6	674.2	3.4	0.8	0.8	125	677.8	674.7	3.1	1.0	1.0
615	Private Bridge	0.62	1S	- -	- -	35	677.2	675.9	1.3	- -	- -	85	679.7	677.6	2.1	1.7	0.1	125	679.8	677.8	2.0	1.8	0.2
620	90th Street	1.13	1S	50	Yes	35	684.7	683.8	0.9	- -	- -	80	685.5	684.0	1.5	- -	- -	115	686.0	684.2	1.8	- -	- -

[a] *Structure codes are as follows: 1—bridge or culvert; 2—dam, sill, or weir. 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] *Backwater is defined as the change in stage from the upstream side of the hydraulic structure to the downstream side.*

[d] *The flood stage indicated represents the water surface elevation approximately 100 feet from the bridge.*

Source: SEWRPC.

Table E-11

HYDROLOGIC-HYDRAULIC SUMMARY—WAXDALE CREEK AND THE TRIBUTARY TO WAXDALE CREEK: YEAR 2000 PLANNED LAND USE AND EXISTING CHANNEL CONDITIONS

Structure Identification and Selected Characteristics						10-Year Recurrence Interval Flood						50-Year Recurrence Interval Flood						100-Year Recurrence Interval Flood					
Number	Name	River Mile	Structure Type and Hydraulic Significance[a]	Recommended Design Frequency (years)	Adequate Hydraulic Capacity[b]	Instantaneous Peak Discharge (cfs)	Upstream Stage[d] (feet above msl)	Downstream Stage[d] (feet above msl)	Backwater[c] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)	Instantaneous Peak Discharge (cfs)	Upstream Stage[d] (feet above msl)	Downstream Stage[d] (feet above msl)	Backwater[c] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)	Instantaneous Peak Discharge (cfs)	Upstream Stage[d] (feet above msl)	Downstream Stage[d] (feet above msl)	Backwater[c] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)
400	Chicago & North Western Transportation Company	0.27	1S	100	Yes	170	668.7[e]	668.7[e]	0.0	- -	- -	250	670.4[e]	670.4[e]	0.0	- -	- -	280	670.7[e]	670.7[e]	0.0	- -	- -
405	Willow Road	0.29	1S	50	Yes	170	668.7[e]	668.7[e]	0.0	- -	- -	250	670.4[e]	670.4[e]	0.0	- -	- -	280	670.7[e]	670.7[e]	0.0	- -	- -
410	Chicago, Milwaukee, St. Paul & Pacific Railroad Company	0.47	1S	100	Yes	150	668.7[e]	668.7[e]	0.0	- -	- -	230	670.4[e]	670.4[e]	0.0	- -	- -	255	670.9	670.7[e]	0.2	- -	- -
415	Buried Conduit	0.51	1S	- -	- -	400	677.1	668.7[e]	8.4	0.6	0.6	650	677.6	670.4[e]	7.2	1.1	1.1	720	677.7	670.9	6.8	1.2	1.2
420	Private Bridge	1.11	1I	- -	- -	340	- -	- -	- -	- -	- -	610	- -	- -	- -	- -	- -	710	- -	- -	- -	- -	- -
425	90th Street	1.23	1S	50	No	295	690.1	684.9	5.2	- -	- -	565	691.4	686.1	5.3	1.4	1.4	655	691.5	686.4	5.1	1.5	1.5
430	CTH H/Wisconsin Street	1.89	1S	50	No	180	710.3	704.5	5.8	0.7	- -	415	711.2	705.0	6.2	1.6	0.4	495	711.4	705.2	6.2	1.8	0.6

[a] *Structure codes are as follows: 1—bridge or culvert; 2—dam, sill, or weir. 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] *Backwater is defined as the change in stage from the upstream side of the hydraulic structure to the downstream side.*

[d] *The flood stage indicated represents the water surface elevation approximately 100 feet from the bridge.*

[e] *The flood stage indicated represents the water surface elevation of the Pike River at the confluence with Waxdale Creek.*

Source: SEWRPC.

Table E-12

HYDROLOGIC-HYDRAULIC SUMMARY—BARTLETT BRANCH: YEAR 2000 PLANNED LAND USE AND EXISTING CHANNEL CONDITIONS

Structure Identification and Selected Characteristics						10-Year Recurrence Interval Flood						50-Year Recurrence Interval Flood						100-Year Recurrence Interval Flood					
Number	Name	River Mile	Structure Type and Hydraulic Significance[a]	Recommended Design Frequency (years)	Adequate Hydraulic Capacity[b]	Instantaneous Peak Discharge (cfs)	Upstream Stage[d] (feet above msl)	Downstream Stage[d] (feet above msl)	Backwater[c] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)	Instantaneous Peak Discharge (cfs)	Upstream Stage[d] (feet above msl)	Downstream Stage[d] (feet above msl)	Backwater[c] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)	Instantaneous Peak Discharge (cfs)	Upstream Stage[d] (feet above msl)	Downstream Stage[d] (feet above msl)	Backwater[c] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)
325	Private Bridge	0.12	1S	--	--	300	684.2	683.7	0.5	0.2	0.2	520	685.6	685.5	0.1	1.6	1.6	590	685.7	685.6	0.1	1.7	1.7
330	Private Bridge	0.32	1S	--	--	300	684.2	684.2	0.0	2.2	1.8	520	685.6	685.6	0.0	5.0	3.2	590	685.7	685.7	0.0	5.1	3.3
335	Chicago & North Western Transportation Company	0.34	1S	100	Yes	300	684.7	684.2	0.5	--	--	520	687.0	685.6	1.4	--	--	590	687.7	685.8	1.9	--	--
340	Stuart Road	0.53	1S	50	No	365	685.7	684.8	0.9	--	--	705	688.9	687.1	1.8	0.7	0.7	800	689.1	687.7	1.4	0.9	0.9
345	Footbridge	0.67	1I	--	--	325	--	--	--	--	--	660	--	--	--	--	--	750	--	--	--	--	--
350	Clinton Lane Extended	0.79	1S	10	No	225	686.0	685.9	0.1	1.2	--	380	689.1	689.1	0.0	4.3	2.3	415	689.3	689.3	0.0	4.5	2.5
355	Private Bridge	1.07	1I	--	--	210	--	--	--	--	--	340	--	--	--	--	--	370	--	--	--	--	--
360	Footbridge	1.16	1I	--	--	210	--	--	--	--	--	340	--	--	--	--	--	370	--	--	--	--	--
365	Spring Street	1.21	1S	10	Yes	190	687.5	686.1	1.4	--	--	290	692.4	689.1	3.3	--	--	315	692.7	689.4	3.3	--	--

[a] *Structure codes are as follows: 1—bridge or culvert; 2—dam, sill, or weir. 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] *Backwater is defined as the change in stage from the upstream side of the hydraulic structure to the downstream side.*

[d] *The flood stage indicated represents the water surface elevation approximately 100 feet from the bridge.*

Source: SEWRPC.

Appendix F

HYDROLOGIC-HYDRAULIC SUMMARY FOR STRUCTURES ON THE PIKE RIVER AND SELECTED MAJOR TRIBUTARIES: YEAR 2000 PLANNED LAND USE AND PLANNED CHANNEL CONDITIONS

Table F-1

HYDROLOGIC-HYDRAULIC SUMMARY—LOWER PIKE RIVER: YEAR 2000 PLANNED LAND USE AND PLANNED CHANNEL CONDITIONS

Structure Identification and Selected Characteristics						10-Year Recurrence Interval Flood						50-Year Recurrence Interval Flood						100-Year Recurrence Interval Flood					
Number	Name	River Mile	Structure Type and Hydraulic Significance[a]	Recommended Design Frequency (years)	Adequate Hydraulic Capacity[b]	Instantaneous Peak Discharge (cfs)	Upstream Stage[d] (feet above msl)	Downstream Stage[d] (feet above msl)	Backwater[c] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)	Instantaneous Peak Discharge (cfs)	Upstream Stage[d] (feet above msl)	Downstream Stage[d] (feet above msl)	Backwater[c] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)	Instantaneous Peak Discharge (cfs)	Upstream Stage[d] (feet above msl)	Downstream Stage[d] (feet above msl)	Backwater[c] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)
100	STH 32/Alford Park Drive	0.21	1S	50	Yes	2,360	582.0	581.1	0.9	--	--	3,540	583.3	581.1	2.2	--	--	4,120	584.3	581.1	3.2	--	--
105	STH 32/Sheridan Road	1.35	1S	50	Yes	2,360	585.3	584.6	0.7	--	--	3,540	586.4	586.0	0.4	--	--	4,120	586.9	586.7	0.2	--	--
110	Footbridge	1.52	1I	--	--	2,360	--	--	--	--	--	3,540	--	--	--	--	--	4,120	--	--	--	--	--
115	Drive to Carthage College	1.70	1S	10	Yes	2,360	586.3	585.9	0.4	--	--	3,540	587.8	587.1	0.7	--	--	4,215	588.6	587.6	1.0	--	--
120	STH 32/S. 32nd Street	1.79	1S	50	Yes	2,360	587.3	586.3	1.0	--	--	3,540	589.2	587.8	1.4	--	--	4,215	590.2	588.6	1.6	--	--
125	Footbridge	2.46	1I	--	--	2,340	--	--	--	--	--	3,600	--	--	--	--	--	4,350	--	--	--	--	--
125A	Footbridge	2.69	1I	--	--	2,340	--	--	--	--	--	3,600	--	--	--	--	--	4,500	--	--	--	--	--
130	Chicago & North Western Transportation Company	3.04	1S	100	Yes	2,340	591.3	591.1	0.2	--	--	3,600	592.6	592.2	0.4	--	--	4,500	593.3	592.9	0.4	--	--
135	CTH E/12th Street	3.27	1S	50	Yes	2,340	593.5	592.9	0.6	--	--	3,600	595.3	594.0	1.3	--	--	4,500	596.5	594.7	1.8	--	--
140	CTH A/7th Street	4.61	1S	50	Yes	2,450	598.8	598.3	0.5	--	--	3,700	600.5	599.6	0.9	--	--	4,500	601.4	600.2	1.2	1.2	--
145	Lathrop Avenue	4.79	1S	50	No	2,450	599.5	598.9	0.6	1.7	--	3,810	601.0	600.7	0.3	3.2	--	4,500	601.9	601.6	0.3	4.1	--
150	Chicago, North Shore & Milwaukee Railroad (abandoned)	4.88	1S	--	--	2,450	600.1	599.5	1.5	--	--	3,810	602.0	601.0	1.0	--	--	4,500	603.3	601.9	1.4	--	--
155	Private Bridge	4.92	1I	--	--	2,450	--	--	--	--	--	3,810	--	--	--	--	--	4,500	--	--	--	--	--
160	Private Bridge	5.00	1I	--	--	2,450	--	--	--	--	--	3,570	--	--	--	--	--	4,400	--	--	--	--	--
165	Private Bridge	5.09	1I	--	--	2,450	--	--	--	--	--	3,570	--	--	--	--	--	4,400	--	--	--	--	--
170	Private Bridge	5.12	1I	--	--	2,450	--	--	--	--	--	3,570	--	--	--	--	--	4,400	--	--	--	--	--
175	Private Bridge	5.31	1I	--	--	2,450	--	--	--	--	--	3,570	--	--	--	--	--	4,400	--	--	--	--	--
177	Kenosha Country Club Dam	5.31	2S	--	--	2,450	--	--	--	--	--	3,570	--	--	--	--	--	4,400	--	--	--	--	--
180	Private Bridge	5.37	1I	--	--	2,210	--	--	--	--	--	3,570	--	--	--	--	--	4,400	--	--	--	--	--
185	Private Bridge	5.40	1I	--	--	2,210	--	--	--	--	--	3,570	--	--	--	--	--	4,400	--	--	--	--	--
190	Private Bridge	5.44	1I	--	--	2,210	--	--	--	--	--	3,570	--	--	--	--	--	4,400	--	--	--	--	--
195	Private Bridge	5.52	1I	--	--	2,210	--	--	--	--	--	3,570	--	--	--	--	--	4,400	--	--	--	--	--
200	Private Bridge	5.59	1I	--	--	2,210	--	--	--	--	--	3,570	--	--	--	--	--	4,400	--	--	--	--	--
205	CTH Y/22nd Avenue	5.63	1S	50	Yes	2,210	603.8	602.8	1.0	--	--	3,570	606.7	603.6	3.1	--	--	4,400	607.5	604.3	3.2	0.8	0.8
210	CTH G/Wood Road	6.60	1S	50	No	2,300	615.6	614.8	0.8	--	--	3,330	617.3	615.9	1.4	0.8	--	4,500	618.2	617.1	1.1	1.7	--
215	CTH A/7th Street	6.96	1S	50	Yes	2,300	617.7	616.8	0.9	--	--	3,740	619.7	618.3	1.4	--	--	4,500	623.2	618.8	4.4	--	--
220	Petrifying Springs Park Road	8.26	1S	10	Yes	2,300	629.8	629.4	0.4	--	--	3,740	631.9	630.4	1.5	--	--	4,500	632.5	630.8	1.7	--	--
225	Footbridge	8.34	1I	--	--	2,300	--	--	--	--	--	3,740	--	--	--	--	--	4,500	--	--	--	--	--
230	Footbridge	8.48	1I	--	--	2,300	--	--	--	--	--	3,740	--	--	--	--	--	4,500	--	--	--	--	--
235	Footbridge	8.61	1I	--	--	2,300	--	--	--	--	--	3,740	--	--	--	--	--	4,500	--	--	--	--	--
245	Footbridge	8.80	1I	--	--	2,300	--	--	--	--	--	3,740	--	--	--	--	--	4,500	--	--	--	--	--
245A	Footbridge	8.93	1I	--	--	2,300	--	--	--	--	--	3,740	--	--	--	--	--	4,500	--	--	--	--	--
250	Park Drive, Footbridge, and Control Structure	9.07	2S	10	Yes	2,300	--	--	--	--	--	3,740	--	--	--	--	--	4,310	--	--	--	--	--
255	Petrifying Springs Park Drive	9.39	1S	10	Yes	2,300	640.3	639.8	0.5	--	--	3,740	642.8	641.1	1.7	1.4	--	4,310	643.5	641.7	1.8	2.1	--
260	CTH A/7th Street	9.55	1S	50	Yes	2,300	642.3	641.9	0.4	--	--	3,740	644.9	644.0	0.9	1.3	--	4,310	645.4	644.6	0.8	1.8	--

[a]*Structure codes are as follows: 1—bridge or culvert; 2—dam, sill, or weir. 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]*Backwater is defined as the change in stage from the upstream side of the hydraulic structure to the downstream side.*

[d]*The flood stage indicated represents the water surface elevation approximately 100 feet from the bridge.*

Source: SEWRPC.

Table F-2

HYDROLOGIC-HYDRAULIC SUMMARY—UPPER PIKE RIVER: YEAR 2000 PLANNED LAND USE AND PLANNED CHANNEL CONDITIONS

Structure Identification and Selected Characteristics						10-Year Recurrence Interval Flood						50-Year Recurrence Interval Flood						100-Year Recurrence Interval Flood					
Number	Name	River Mile	Structure Type and Hydraulic Significance[a]	Recommended Design Frequency (years)	Adequate Hydraulic Capacity[b]	Instantaneous Peak Discharge (cfs)	Upstream Stage[d] (feet above msl)	Downstream Stage[d] (feet above msl)	Backwater[c] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)	Instantaneous Peak Discharge (cfs)	Upstream Stage[d] (feet above msl)	Downstream Stage[d] (feet above msl)	Backwater[c] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)	Instantaneous Peak Discharge (cfs)	Upstream Stage[d] (feet above msl)	Downstream Stage[d] (feet above msl)	Backwater[c] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)
265	STH 31/ Green Bay Road	10.38	1S	50	Yes	1,430	644.5	644.4	0.1	--	--	2,690	647.1	647.0	0.1	--	--	3,410	648.0	647.8	0.2	--	--
270	CTH KR/ County Line Road	11.15	1S	50	Yes	1,310	648.2	647.9	0.3	--	--	2,560	651.0	650.7	0.3	--	--	3,210	652.1	651.8	0.3	--	--
272	Private Bridge	11.56	1I	--	--	1,310	--	--	--	--	--	2,560	--	--	--	--	--	3,210	--	--	--	--	--
275	Braun Road	12.23	1S	50	Yes	1,140	658.0	657.7	0.3	--	--	2,370	660.9	660.5	0.4	--	--	2,920	661.9	661.5	0.4	--	--
280	Private Bridge	12.99	1I	--	--	890	661.8	661.6	0.2	--	--	2,030	--	--	--	--	--	2,460	--	--	--	--	--
285	STH 11/Durand Road	13.29	1S	50	Yes	890	662.8	662.7	0.1	--	--	2,030	666.3	666.2	0.1	--	--	2,460	667.3	667.1	0.2	--	--
290	Chicago, Milwaukee, St. Paul & Pacific Railroad Company	13.72	1I	100	Yes	660	--	--	--	--	--	1,580	--	--	--	--	--	1,930	--	--	--	--	--
295	Oakes Road	14.51	1S	10	Yes	440	670.4	666.1	4.3	--	--	1,150	672.3	668.8	3.5	--	--	1,430	672.9	669.8	3.1	--	--
300	STH 20/S. 20th Street	14.94	1S	50	Yes	310	672.8	672.6	0.2	--	--	890	675.6	675.3	0.3	--	--	1,130	676.4	676.1	0.3	--	--
305	Private Bridge	15.00	1S	--	--	310	672.9	672.8	0.1	--	--	890	675.9	675.6	0.3	--	--	1,130	676.9	676.4	0.5	--	--
310	Footbridge	15.15	1I	--	--	270	--	--	--	--	--	800	--	--	--	--	--	1,010	--	--	--	--	--
315	Private Bridge	15.29	1S	--	--	230	674.7	674.2	0.5	--	--	670	677.5	677.0	0.5	--	--	840	678.4	677.9	0.5	--	--
320	Private Bridge	15.77	1I	--	--	220	--	--	--	--	--	630	--	--	--	--	--	790	--	--	--	--	--
370	Spring Street	16.24	1S	10	Yes	150	679.8	679.1	0.7	--	--	450	682.2	681.5	0.7	--	--	560	682.6	682.2	0.4	--	--

[a] Structure codes are as follows: 1—bridge or culvert; 2—dam, sill, or weir. 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] Backwater is defined as the change in stage from the upstream side of the hydraulic structure to the downstream side.

[d] The flood stage indicated represents the water surface elevation approximately 100 feet from the bridge.

Source: SEWRPC.

Table F-3

HYDROLOGIC-HYDRAULIC SUMMARY—KENOSHA BRANCH: YEAR 2000 PLANNED LAND USE AND PLANNED CHANNEL CONDITIONS

Structure Identification and Selected Characteristics						10-Year Recurrence Interval Flood						50-Year Recurrence Interval Flood						100-Year Recurrence Interval Flood					
Number	Name	River Mile	Structure Type and Hydraulic Significance[a]	Recommended Design Frequency (years)	Adequate Hydraulic Capacity[b]	Instantaneous Peak Discharge (cfs)	Upstream Stage[d] (feet above msl)	Downstream Stage[d] (feet above msl)	Backwater[c] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)	Instantaneous Peak Discharge (cfs)	Upstream Stage[d] (feet above msl)	Downstream Stage[d] (feet above msl)	Backwater[c] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)	Instantaneous Peak Discharge (cfs)	Upstream Stage[d] (feet above msl)	Downstream Stage[d] (feet above msl)	Backwater[c] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)
1200	20th Avenue	0.76	1S	50	No	485	610.3	602.9	7.4	0.5	0.5	785	611.6	603.5	8.1	1.8	1.8	865	611.8	603.6	8.2	2.0	2.0
1205	Private Bridge	0.82	1I	--	--	485	--	--	--	--	--	785	--	--	--	--	--	865	--	--	--	--	--
1210	Chicago, North Shore & Milwaukee Railroad (abandoned)	0.87	1S	--	--	355	612.2	610.4	1.8	--	--	650	619.0	611.7	7.3	0.6	0.3	735	619.4	612.0	7.4	1.0	0.7
1215	CTH Y/22nd Avenue	0.90	1S	50	No	355	615.7	612.2	3.5	--	--	650	620.9	619.0	1.9	0.7	0.7	735	620.9	619.4	1.5	0.7	0.7
1220	25th Avenue	1.1	1I	--	--	355	--	--	--	--	--	650	--	--	--	--	--	735	--	--	--	--	--

[a] Structure codes are as follows: 1—bridge or culvert; 2—dam, sill, or weir. 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] Backwater is defined as the change in stage from the upstream side of the hydraulic structure to the downstream side.

[d] The flood stage indicated represents the water surface elevation approximately 100 feet from the bridge.

Source: SEWRPC.

Table F-4

HYDROLOGIC-HYDRAULIC SUMMARY—SORENSON CREEK: YEAR 2000 PLANNED LAND USE AND PLANNED CHANNEL CONDITIONS

Structure Identification and Selected Characteristics						10-Year Recurrence Interval Flood						50-Year Recurrence Interval Flood						100-Year Recurrence Interval Flood					
Number	Name	River Mile	Structure Type and Hydraulic Significance[a]	Recommended Design Frequency (years)	Adequate Hydraulic Capacity[b]	Instantaneous Peak Discharge (cfs)	Upstream Stage[d] (feet above msl)	Downstream Stage[d] (feet above msl)	Backwater[c] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)	Instantaneous Peak Discharge (cfs)	Upstream Stage[d] (feet above msl)	Downstream Stage[d] (feet above msl)	Backwater[c] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)	Instantaneous Peak Discharge (cfs)	Upstream Stage[d] (feet above msl)	Downstream Stage[d] (feet above msl)	Backwater[c] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)
1000	Private Bridge	0.03	1I	- -	- -	630	- -	- -	- -	- -	- -	1,010	- -	- -	- -	- -	- -	1,080	- -	- -	- -	- -	- -
1005	Private Bridge	0.92	1I	- -	- -	720	- -	- -	- -	- -	- -	1,150	- -	- -	- -	- -	- -	1,240	- -	- -	- -	- -	- -
1010	CTH KR/ County Line Road	1.56	1S	50	No	720	614.7	611.1	3.6	- -	- -	1,150	617.2	611.5	5.7	0.3	0.3	1,240	617.2	611.6	5.6	0.3	0.3
1015	Private Bridge	1.67	1S	- -	- -	720	615.1	614.8	0.3	1.6	1.6	1,150	617.4	617.2	0.2	3.9	3.9	1,240	617.4	617.3	0.1	3.9	3.9
1020	Chicago, North Shore & Milwaukee Railroad (abandoned)	1.96	1S	- -	- -	610	616.4	615.7	0.7	- -	- -	1,040	620.5	617.7	2.8	- -	- -	1,120	621.1	617.8	3.3	- -	- -
1025	Private Bridge	2.37	1S	- -	- -	530	622.3	620.2	2.1	- -	- -	905	623.9	622.2	1.7	1.5	1.5	980	624.0	622.6	1.4	1.6	1.6
1030	Lathrop Avenue	2.62	1S	50	Yes	530	626.9	624.1	2.8	- -	- -	905	629.4	625.6	3.8	- -	- -	980	629.8	625.8	4.0	- -	- -
1035	Chicory Road	2.93	1S	50	Yes	512	632.0	630.8	1.2	- -	- -	770	633.1	631.8	1.3	- -	- -	835	633.3	632.0	1.3	- -	- -
1040	Private Bridge	3.03	1S	- -	- -	450	636.7	633.7	3.0	1.1	1.1	660	637.5	634.6	2.9	1.9	1.9	715	637.6	634.8	2.8	2.0	2.0
1045	Pleasant Lane	3.15	1S	10	No	450	638.7	637.1	1.6	0.5	0.5	660	638.9	637.8	1.1	0.7	0.7	715	638.9	638.0	0.9	0.7	0.7
1050	Taylor Avenue	3.49	1S	50	No	445	651.2	645.8	5.4[e]	- -	- -	615	652.4	646.5	5.9[e]	0.2	0.2	650	652.7	646.6	6.1[e]	0.7	0.5

[a]*Structure codes are as follows: 1—bridge or culvert; 2—dam, sill, or weir. 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]*Backwater is defined as the change in stage from the upstream side of the hydraulic structure to the downstream side.*

[d]*The flood stage indicated represents the water surface elevation approximately 100 feet from the bridge.*

Source: SEWRPC.

Table F-5

HYDROLOGIC-HYDRAULIC SUMMARY—NELSON CREEK: YEAR 2000 PLANNED LAND USE AND PLANNED CHANNEL CONDITIONS

Structure Identification and Selected Characteristics						10-Year Recurrence Interval Flood						50-Year Recurrence Interval Flood						100-Year Recurrence Interval Flood					
Number	Name	River Mile	Structure Type and Hydraulic Significance[a]	Recommended Design Frequency (years)	Adequate Hydraulic Capacity[b]	Instantaneous Peak Discharge (cfs)	Upstream Stage[d] (feet above msl)	Downstream Stage[d] (feet above msl)	Backwater[c] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)	Instantaneous Peak Discharge (cfs)	Upstream Stage[d] (feet above msl)	Downstream Stage[d] (feet above msl)	Backwater[c] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)	Instantaneous Peak Discharge (cfs)	Upstream Stage[d] (feet above msl)	Downstream Stage[d] (feet above msl)	Backwater[c] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)
1100	Private Bridge	0.05	1S	- -	- -	119	603.2	598.9	3.6	0.6	0.4	208	603.2	599.9	3.3	0.6	0.4	236	603.3	600.0	3.3	0.7	0.5
1105	Chicago, North Shore & Milwaukee Railroad (abandoned)	0.12	1S	- -	- -	119	603.4	603.2	0.2	- -	- -	208	604.0	603.2	0.8	- -	- -	236	604.3	603.3	1.0	- -	- -
1110	Private Bridge	0.15	1I	- -	- -	119	- -	- -	- -	- -	- -	208	- -	- -	- -	- -	- -	236	- -	- -	- -	- -	- -
1115	Lathrop Avenue	0.44	1S	50	Yes	119	609.6	607.2	2.4	- -	- -	208	611.2	607.7	3.5	- -	- -	236	611.6	607.8	3.8	- -	- -
1120	Lathrop Avenue	0.55	1S	50	No	119	612.1	609.7	2.4	- -	- -	208	614.5	611.2	3.3	0.2	0.2	236	614.6	611.6	3.0	0.3	0.3
1125	Lathrop Avenue	0.62	1S	50	No	119	615.0	612.1	2.9	0.6	0.6	208	615.4	614.5	0.9	1.0	1.0	236	615.5	614.6	0.9	1.1	1.1
1130	CTH KR/ County Line Road	0.80	1S	50	Yes	140	617.8	615.4	2.4	- -	- -	225	618.9	616.0	2.9	- -	- -	255	619.3	616.1	3.2	- -	- -
1135	Private Bridge	1.27	1I	- -	- -	150	- -	- -	- -	- -	- -	255	- -	- -	- -	- -	- -	285	- -	- -	- -	- -	- -
1140	Private Bridge	1.63	1I	- -	- -	160	- -	- -	- -	- -	- -	265	- -	- -	- -	- -	- -	310	- -	- -	- -	- -	- -
1145	Private Bridge	1.67	1I	- -	- -	160	- -	- -	- -	- -	- -	265	- -	- -	- -	- -	- -	310	- -	- -	- -	- -	- -

[a]*Structure codes are as follows: 1—bridge or culvert; 2—dam, sill, or weir. 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]*Backwater is defined as the change in stage from the upstream side of the hydraulic structure to the downstream side.*

[d]*The flood stage indicated represents the water surface elevation approximately 100 feet from the bridge.*

[e]*There is a difference in streambed elevation of approximately 4.5 feet between the upstream side and the downstream side of the Taylor Avenue bridge.*

Source: SEWRPC.

Table F-6

HYDROLOGIC-HYDRAULIC SUMMARY—PIKE CREEK: YEAR 2000 PLANNED LAND USE AND PLANNED CHANNEL CONDITIONS

Structure Identification and Selected Characteristics						10-Year Recurrence Interval Flood						50-Year Recurrence Interval Flood						100-Year Recurrence Interval Flood					
Number	Name	River Mile	Structure Type and Hydraulic Significance[a]	Recommended Design Frequency (years)	Adequate Hydraulic Capacity[b]	Instantaneous Peak Discharge (cfs)	Upstream Stage[d] (feet above msl)	Downstream Stage[d] (feet above msl)	Backwater[c] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)	Instantaneous Peak Discharge (cfs)	Upstream Stage[d] (feet above msl)	Downstream Stage[d] (feet above msl)	Backwater[c] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)	Instantaneous Peak Discharge (cfs)	Upstream Stage[d] (feet above msl)	Downstream Stage[d] (feet above msl)	Backwater[c] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)
500	STH 31/Green Bay Road	0.05	1S	50	No	1,450	643.1	642.4	0.7	- -	- -	2,310	645.2	645.0	0.2	1.7	1.2	2,750	645.7	645.5	0.2	2.2	1.7
505	Private Bridge	0.89	1I	- -	- -	1,450	- -	- -	- -	- -	- -	2,310	- -	- -	- -	- -	- -	2,750	- -	- -	- -	- -	- -
510	Private Bridge	1.42	1I	- -	- -	1,450	- -	- -	- -	- -	- -	2,310	- -	- -	- -	- -	- -	2,750	- -	- -	- -	- -	- -
515	CTH E/12th Street	2.13	1S	50	Yes	1,450	659.9	659.8	0.1	- -	- -	2,310	661.5	661.3	0.2	- -	- -	2,750	662.1	661.9	0.2	- -	- -
520	Town of Somers Transfer Station	3.17	1S	10	Yes	1,330	664.7	664.4	0.3	- -	- -	2,170	666.8	666.4	0.4	- -	- -	2,650	668.0	667.4	0.6	- -	- -
525	Chicago & North Western Transportation Company	3.29	1S	100	Yes	1,330	665.7	664.9	0.8	- -	- -	2,170	668.2	667.0	1.2	- -	- -	2,650	669.4	667.9	1.5	- -	- -
530	CTH L/Lichter Road	3.34	1S	50	Yes	1,330	666.4	665.7	0.7	- -	- -	2,170	669.1	668.2	0.9	- -	- -	2,650	670.3	669.4	0.9	- -	- -
535	Private Bridge	3.98	1I	- -	- -	1,330	- -	- -	- -	- -	- -	2,170	- -	- -	- -	- -	- -	2,650	- -	- -	- -	- -	- -
540	Private Bridge	4.12	1I	- -	- -	1,330	- -	- -	- -	- -	- -	2,170	- -	- -	- -	- -	- -	2,650	- -	- -	- -	- -	- -
545	Private Bridge	4.24	1S	- -	- -	1,330	- -	- -	- -	- -	- -	2,170	- -	- -	- -	- -	- -	2,650	- -	- -	- -	- -	- -
550	STH 142/S. 43rd Street	4.86	1S	50	Yes	1,330	669.1	669.0	0.1	- -	- -	2,170	671.7	671.6	0.1	- -	- -	2,650	672.8	672.7	0.1	- -	- -
555	Footbridge	4.90	1I	- -	- -	1,310	- -	- -	- -	- -	- -	2,170	- -	- -	- -	- -	- -	2,650	- -	- -	- -	- -	- -
560	STH 158/52nd Street	5.90	1S	50	Yes	1,060	671.4	671.2	0.2	- -	- -	1,710	673.8	673.6	0.2	- -	- -	2,050	674.9	674.7	0.2	- -	- -
565	CTH K/60th Street	6.45	1S	50	Yes	930	673.2	673.0	0.2	- -	- -	1,530	675.4	675.2	0.2	- -	- -	1,850	676.4	676.2	0.2	- -	- -
570	Chicago, Milwaukee, St. Paul & Pacific Railroad Company	6.85	1S	100	Yes	590	673.9	673.8	0.1	- -	- -	980	676.1	676.0	0.1	- -	- -	1,200	677.1	677.0	0.1	- -	- -

[a]Structure codes are as follows: 1—bridge or culvert; 2—dam, sill, or weir. 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]Backwater is defined as the change in stage from the upstream side of the hydraulic structure to the downstream side.

[d]The flood stage indicated represents the water surface elevation approximately 100 feet from the bridge.

Source: SEWRPC.

Table F-7

HYDROLOGIC-HYDRAULIC SUMMARY—SOMERS BRANCH: YEAR 2000 PLANNED LAND USE AND PLANNED CHANNEL CONDITIONS

Structure Identification and Selected Characteristics						10-Year Recurrence Interval Flood						50-Year Recurrence Interval Flood						100-Year Recurrence Interval Flood					
Number	Name	River Mile	Structure Type and Hydraulic Significance[a]	Recommended Design Frequency (years)	Adequate Hydraulic Capacity[b]	Instantaneous Peak Discharge (cfs)	Upstream Stage[d] (feet above msl)	Downstream Stage[d] (feet above msl)	Backwater[c] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)	Instantaneous Peak Discharge (cfs)	Upstream Stage[d] (feet above msl)	Downstream Stage[d] (feet above msl)	Backwater[c] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)	Instantaneous Peak Discharge (cfs)	Upstream Stage[d] (feet above msl)	Downstream Stage[d] (feet above msl)	Backwater[c] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)
800	Private Bridge	0.06	1I	- -	- -	110	- -	- -	- -	- -	- -	255	- -	- -	- -	- -	- -	320	- -	- -	- -	- -	- -
805	Private Bridge	0.53	1I	- -	- -	110	- -	- -	- -	- -	- -	255	- -	- -	- -	- -	- -	320	- -	- -	- -	- -	- -
810	Chicago & North Western Transportation Company	0.69	1S	100	Yes	110	669.4	669.1	0.3	- -	- -	255	671.5	670.1	1.4	- -	- -	320	672.6	670.3	2.3	- -	- -
815	CTH EA/90th Street	1.11	1S	50	Yes	115	673.9	673.8	0.1	- -	- -	270	675.5	675.3	0.2	- -	- -	320	675.8	675.5	0.3	- -	- -
820	Private Bridge	1.43	1I	- -	- -	70	- -	- -	- -	- -	- -	110	- -	- -	- -	- -	- -	120	- -	- -	- -	- -	- -
825	Private Bridge	1.77	1S	- -	- -	60	690.7	689.8	0.9	- -	- -	95	691.6	690.3	1.3	- -	- -	110	692.3	690.5	1.8	- -	- -
830	Private Bridge	1.94	1I	- -	- -	55	- -	- -	- -	- -	- -	80	- -	- -	- -	- -	- -	90	- -	- -	- -	- -	- -
835	Chicago, Milwaukee, St. Paul & Pacific Railroad Company	1.95	1S	100	Yes	55	694.2	691.7	2.5	- -	- -	80	694.6	692.3	2.3	- -	- -	90	695.3	692.7	2.6	- -	- -
840	Private Bridge	2.31	1I	- -	- -	300	- -	- -	- -	- -	- -	500	- -	- -	- -	- -	- -	560	- -	- -	- -	- -	- -

[a]Structure codes are as follows: 1—bridge or culvert; 2—dam, sill, or weir. 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]Backwater is defined as the change in stage from the upstream side of the hydraulic structure to the downstream side.

[d]The flood stage indicated represents the water surface elevation approximately 100 feet from the bridge.

Source: SEWRPC.

Table F-8

HYDROLOGIC-HYDRAULIC SUMMARY—AIRPORT BRANCH: YEAR 2000 PLANNED LAND USE AND PLANNED CHANNEL CONDITIONS

Structure Identification and Selected Characteristics						10-Year Recurrence Interval Flood						50-Year Recurrence Interval Flood						100-Year Recurrence Interval Flood					
Number	Name	River Mile	Structure Type and Hydraulic Significance[a]	Recommended Design Frequency (years)	Adequate Hydraulic Capacity[b]	Instantaneous Peak Discharge (cfs)	Upstream Stage[d] (feet above msl)	Downstream Stage[d] (feet above msl)	Backwater[c] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)	Instantaneous Peak Discharge (cfs)	Upstream Stage[d] (feet above msl)	Downstream Stage[d] (feet above msl)	Backwater[c] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)	Instantaneous Peak Discharge (cfs)	Upstream Stage[d] (feet above msl)	Downstream Stage[d] (feet above msl)	Backwater[c] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)
900	Private Bridge	0.18	1I	- -	- -	930	- -	- -	- -	- -	- -	1,420	- -	- -	- -	- -	- -	1,570	- -	- -	- -	- -	- -
905	Private Bridge	0.39	1I	- -	- -	930	- -	- -	- -	- -	- -	1,420	- -	- -	- -	- -	- -	1,570	- -	- -	- -	- -	- -
910	Chicago, Milwaukee, St. Paul & Pacific Railroad Company	0.41	1S	100	Yes	930	673.7	673.1	0.6	- -	- -	1,420	675.1	674.4	0.7	- -	- -	1,570	674.9	674.3	0.6	- -	- -

[a]*Structure codes are as follows: 1—bridge or culvert; 2—dam, sill, or weir. 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]*Backwater is defined as the change in stage from the upstream side of the hydraulic structure to the downstream side.*

[d]*The flood stage indicated represents the water surface elevation approximately 100 feet from the bridge.*

Source: SEWRPC.

Table F-9

HYDROLOGIC-HYDRAULIC SUMMARY—LAMPAREK DITCH: YEAR 2000 PLANNED LAND USE AND PLANNED CHANNEL CONDITIONS

Structure Identification and Selected Characteristics						10-Year Recurrence Interval Flood						50-Year Recurrence Interval Flood						100-Year Recurrence Interval Flood					
Number	Name	River Mile	Structure Type and Hydraulic Significance[a]	Recommended Design Frequency (years)	Adequate Hydraulic Capacity[b]	Instantaneous Peak Discharge (cfs)	Upstream Stage[d] (feet above msl)	Downstream Stage[d] (feet above msl)	Backwater[c] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)	Instantaneous Peak Discharge (cfs)	Upstream Stage[d] (feet above msl)	Downstream Stage[d] (feet above msl)	Backwater[c] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)	Instantaneous Peak Discharge (cfs)	Upstream Stage[d] (feet above msl)	Downstream Stage[d] (feet above msl)	Backwater[c] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)
700	Private Bridge	0.54	1S	- -	- -	25	664.7	662.5	2.2	- -	- -	140	668.0	664.2	3.8	- -	- -	205	669.6	664.9	4.7	- -	- -
705	Chicago & North Western Transportation Company	0.77	1S	100	Yes	25	669.6	667.5	2.1	- -	- -	140	673.5	669.0	4.5	- -	- -	205	673.8	670.2	3.6	- -	- -
710	90th Street	1.56	1S	50	Yes	20	680.8	680.4	0.4	- -	- -	120	682.4	682.1	0.3	- -	- -	170	683.0	682.6	0.4	- -	- -
715	Private Bridge	2.12	1I	- -	- -	20	- -	- -	- -	- -	- -	110	- -	- -	- -	- -	- -	155	- -	- -	- -	- -	- -
720	Chicago, Milwaukee, St. Paul & Pacific Railroad Company	2.26	1S	100	Yes	20	699.0	697.2	1.8	- -	- -	100	702.5	698.8	3.7	- -	- -	140	703.2	699.4	3.8	- -	- -
725	Private Bridge	2.61	1I	- -	- -	20	- -	- -	- -	- -	- -	90	- -	- -	- -	- -	- -	130	- -	- -	- -	- -	- -
730	Private Bridge	2.73	1S	- -	- -	15	709.6	709.0	0.6	- -	- -	80	711.3	710.5	0.8	- -	- -	115	712.0	711.1	0.9	- -	- -

[a]*Structure codes are as follows: 1—bridge or culvert; 2—dam, sill, or weir. 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]*Backwater is defined as the change in stage from the upstream side of the hydraulic structure to the downstream side.*

[d]*The flood stage indicated represents the water surface elevation approximately 100 feet from the bridge.*

Source: SEWRPC.

Table F-10

HYDROLOGIC-HYDRAULIC SUMMARY—CHICORY CREEK: YEAR 2000 PLANNED LAND USE AND PLANNED CHANNEL CONDITIONS

Structure Identification and Selected Characteristics						10-Year Recurrence Interval Flood						50-Year Recurrence Interval Flood						100-Year Recurrence Interval Flood					
Number	Name	River Mile	Structure Type and Hydraulic Significance[a]	Recommended Design Frequency (years)	Adequate Hydraulic Capacity[b]	Instantaneous Peak Discharge (cfs)	Upstream Stage[d] (feet above msl)	Downstream Stage[d] (feet above msl)	Backwater[c] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)	Instantaneous Peak Discharge (cfs)	Upstream Stage[d] (feet above msl)	Downstream Stage[d] (feet above msl)	Backwater[c] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)	Instantaneous Peak Discharge (cfs)	Upstream Stage[d] (feet above msl)	Downstream Stage[d] (feet above msl)	Backwater[c] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)
600	Private Bridge	0.20	1I	- -	- -	35	- -	- -	- -	- -	- -	95	- -	- -	- -	- -	- -	140	- -	- -	- -	- -	- -
605	Chicago & North Western Transportation Company	0.46	1S	100	Yes	35	673.3	671.5	1.8	- -	- -	95	674.2	672.3	1.9	- -	- -	140	674.7	672.6	2.1	- -	- -
610	Private Bridge	0.54	1S	- -	- -	35	675.9	673.3	2.6	- -	- -	85	677.6	674.2	3.4	0.8	0.8	125	677.8	674.7	3.1	1.0	1.0
615	Private Bridge	0.62	1S	- -	- -	35	677.2	675.9	1.3	- -	- -	85	679.7	677.6	2.1	1.7	0.1	125	679.8	677.8	2.0	1.8	0.2
620	90th Street	1.13	1S	50	Yes	35	684.7	683.8	0.9	- -	- -	80	685.5	684.0	1.5	- -	- -	115	686.0	684.2	1.8	- -	- -

[a]*Structure codes are as follows: 1—bridge or culvert; 2—dam, sill, or weir. 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]*Backwater is defined as the change in stage from the upstream side of the hydraulic structure to the downstream side.*

[d]*The flood stage indicated represents the water surface elevation approximately 100 feet from the bridge.*

Source: SEWRPC.

Table F-11

HYDROLOGIC-HYDRAULIC SUMMARY—WAXDALE CREEK AND THE TRIBUTARY TO WAXDALE CREEK: YEAR 2000 PLANNED LAND USE AND PLANNED CHANNEL CONDITIONS

Structure Identification and Selected Characteristics							10-Year Recurrence Interval Flood					50-Year Recurrence Interval Flood						100-Year Recurrence Interval Flood					
Number	Name	River Mile	Structure Type and Hydraulic Significance[a]	Recommended Design Frequency (years)	Adequate Hydraulic Capacity[b]	Instantaneous Peak Discharge (cfs)	Upstream Stage[d] (feet above msl)	Downstream Stage[d] (feet above msl)	Backwater[c] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)	Instantaneous Peak Discharge (cfs)	Upstream Stage[d] (feet above msl)	Downstream Stage[d] (feet above msl)	Backwater[c] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)	Instantaneous Peak Discharge (cfs)	Upstream Stage[d] (feet above msl)	Downstream Stage[d] (feet above msl)	Backwater[c] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)
400	Chicago & North Western Transportation Company	0.27	1S	100	Yes	170	666.9	663.6[e]	3.3	- -	- -	250	668.0	667.1[e]	0.9	- -	- -	280	668.2	667.8[e]	0.4	- -	- -
405	Willow Road	0.29	1S	50	Yes	170	667.0	666.9	0.1	- -	- -	250	668.2	668.0	0.2	- -	- -	280	668.6	668.2	0.4	- -	- -
410	Chicago, Milwaukee, St. Paul & Pacific Railroad Company	0.47	1S	100	Yes	150	668.0	667.3	0.7	- -	- -	230	670.2	668.6	1.6	- -	- -	255	670.9	668.9	2.0	- -	- -
415	Buried Conduit	0.51	1S	- -	- -	400	677.1	668.0	9.1	0.6	0.6	650	677.6	670.2	7.4	1.1	1.1	720	677.7	670.9	6.8	1.2	1.2
420	Private Bridge	1.11	1I	- -	- -	340	- -	- -	- -	- -	- -	610	- -	- -	- -	- -	- -	710	- -	- -	- -	- -	- -
425	90th Street	1.23	1S	50	No	295	690.1	684.9	5.2	- -	- -	565	691.4	686.1	5.3	1.4	1.4	655	691.5	686.4	5.1	1.5	1.5
430	CTH H/Wisconsin Street	1.89	1S	50	No	180	710.3	704.5	5.8	0.7	- -	415	711.2	705.0	6.2	1.6	0.4	495	711.4	705.2	6.2	1.8	0.6

[a]*Structure codes are as follows: 1—bridge or culvert; 2—dam, sill, or weir. 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]*Backwater is defined as the change in stage from the upstream side of the hydraulic structure to the downstream side.*

[d]*The flood stage indicated represents the water surface elevation approximately 100 feet from the bridge.*

[e]*The flood stage indicated represents the water surface elevation of the Pike River at the confluence with Waxdale Creek.*

Source: SEWRPC.

Table F-12

HYDROLOGIC-HYDRAULIC SUMMARY—BARTLETT BRANCH: YEAR 2000 PLANNED LAND USE AND PLANNED CHANNEL CONDITIONS

Structure Identification and Selected Characteristics						10-Year Recurrence Interval Flood						50-Year Recurrence Interval Flood						100-Year Recurrence Interval Flood					
Number	Name	River Mile	Structure Type and Hydraulic Significance[a]	Recommended Design Frequency (years)	Adequate Hydraulic Capacity[b]	Instantaneous Peak Discharge (cfs)	Upstream Stage[d] (feet above msl)	Downstream Stage[d] (feet above msl)	Backwater[c] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)	Instantaneous Peak Discharge (cfs)	Upstream Stage[d] (feet above msl)	Downstream Stage[d] (feet above msl)	Backwater[c] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)	Instantaneous Peak Discharge (cfs)	Upstream Stage[d] (feet above msl)	Downstream Stage[d] (feet above msl)	Backwater[c] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)
325	Private Bridge	0.12	1S	- -	- -	300	680.1	678.6	1.5	- -	- -	520	681.9	680.4	1.5	- -	- -	590	683.0	681.0	2.0	- -	- -
330	Private Bridge	0.32	1S	- -	- -	300	681.0	680.4	0.6	- -	- -	520	682.4	682.2	0.2	0.4	- -	590	683.4	683.2	0.2	1.4	1.0
335	Chicago & North Western Transportation Company	0.34	1S	100	Yes	300	681.6	681.0	0.6	- -	- -	520	683.5	682.4	1.1	- -	- -	590	685.2	683.4	1.8	- -	- -
340	Stuart Road	0.53	1S	50	Yes	365	683.1	682.1	1.0	- -	- -	705	687.5	684.0	3.5	- -	- -	800	688.8	685.4	3.4	0.6	0.6
345	Footbridge	0.67	1I	- -	- -	325	- -	- -	- -	- -	- -	660	- -	- -	- -	- -	- -	750	- -	- -	- -	- -	- -
350	Clinton Lane Extended	0.79	1S	10	Yes	225	684.2	684.0	0.2	- -	- -	380	687.9	687.8	0.1	3.1	1.1	415	689.0	689.0	0.0	4.2	2.2
355	Private Bridge	1.07	1I	- -	- -	210	- -	- -	- -	- -	- -	340	- -	- -	- -	- -	- -	370	- -	- -	- -	- -	- -
360	Footbridge	1.16	1I	- -	- -	210	- -	- -	- -	- -	- -	340	- -	- -	- -	- -	- -	370	- -	- -	- -	- -	- -
365	Spring Street	1.21	1S	10	Yes	190	686.1	684.7	1.4	- -	- -	290	691.1	687.9	3.2	- -	- -	315	692.7	689.1	3.6	- -	- -

[a]*Structure codes are as follows: 1—bridge or culvert; 2—dam, sill, or weir. 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]*Backwater is defined as the change in stage from the upstream side of the hydraulic structure to the downstream side.*

[d]*The flood stage indicated represents the water surface elevation approximately 100 feet from the bridge.*

Source: SEWRPC.

Appendix G

FLOOD STAGE AND STREAMBED PROFILES AND AERIAL PHOTOGRAPHS SHOWING AREAS SUBJECT TO FLOODING

Map G-1

AERIAL PHOTOGRAPH SHOWING AREAS SUBJECT TO FLOODING ALONG THE PIKE RIVER (RIVER MILE 0.00 TO 4.50)

LEGEND

APPROXIMATE EXISTING CHANNEL CENTERLINE AND RIVER MILE STATIONING

100-YEAR RECURRENCE INTERVAL FLOODLANDS--PLANNED LAND USE AND PLANNED CHANNEL CONDITIONS

NOTE: DUE TO MAP SCALE LIMITATIONS, THE DIFFERENCE BETWEEN THE 100-YEAR RECURRENCE INTERVAL FLOODLANDS UNDER PLANNED LAND USE AND EXISTING CHANNEL CONDITIONS, AND THE 100-YEAR RECURRENCE INTERVAL FLOODLANDS UNDER PLANNED LAND USE AND PLANNED CHANNEL CONDITIONS, MAY NOT APPEAR ON THIS MAP. WHERE NO DIFFERENCE APPEARS REFERENCE SHOULD BE MADE TO THE FLOOD STAGE PROFILE SHOWN BELOW.

GRAPHIC SCALE

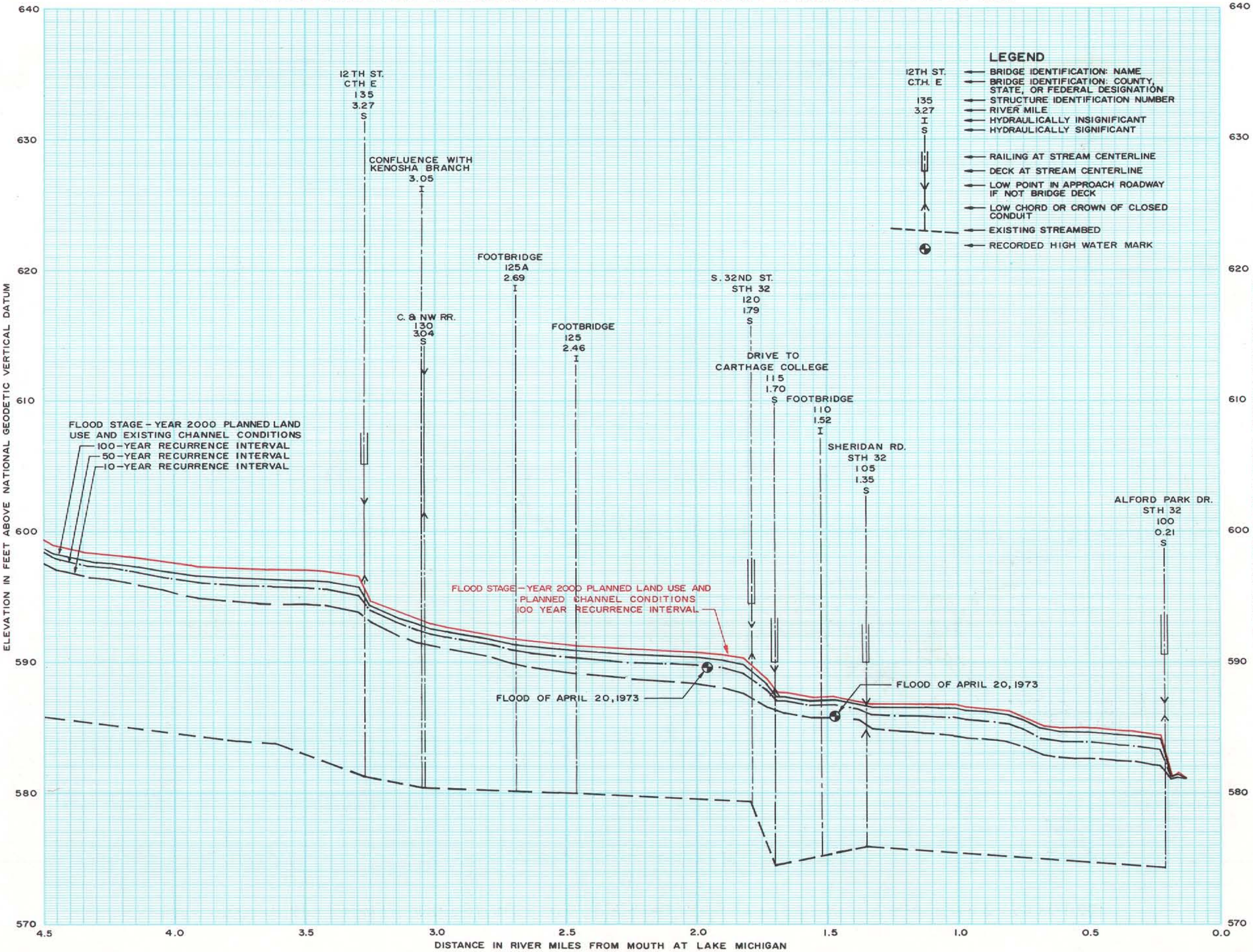
0 1/2 1 MILE

DATE OF PHOTOGRAPHY: APRIL 1980

Source: SEWRPC.

Figure G-1

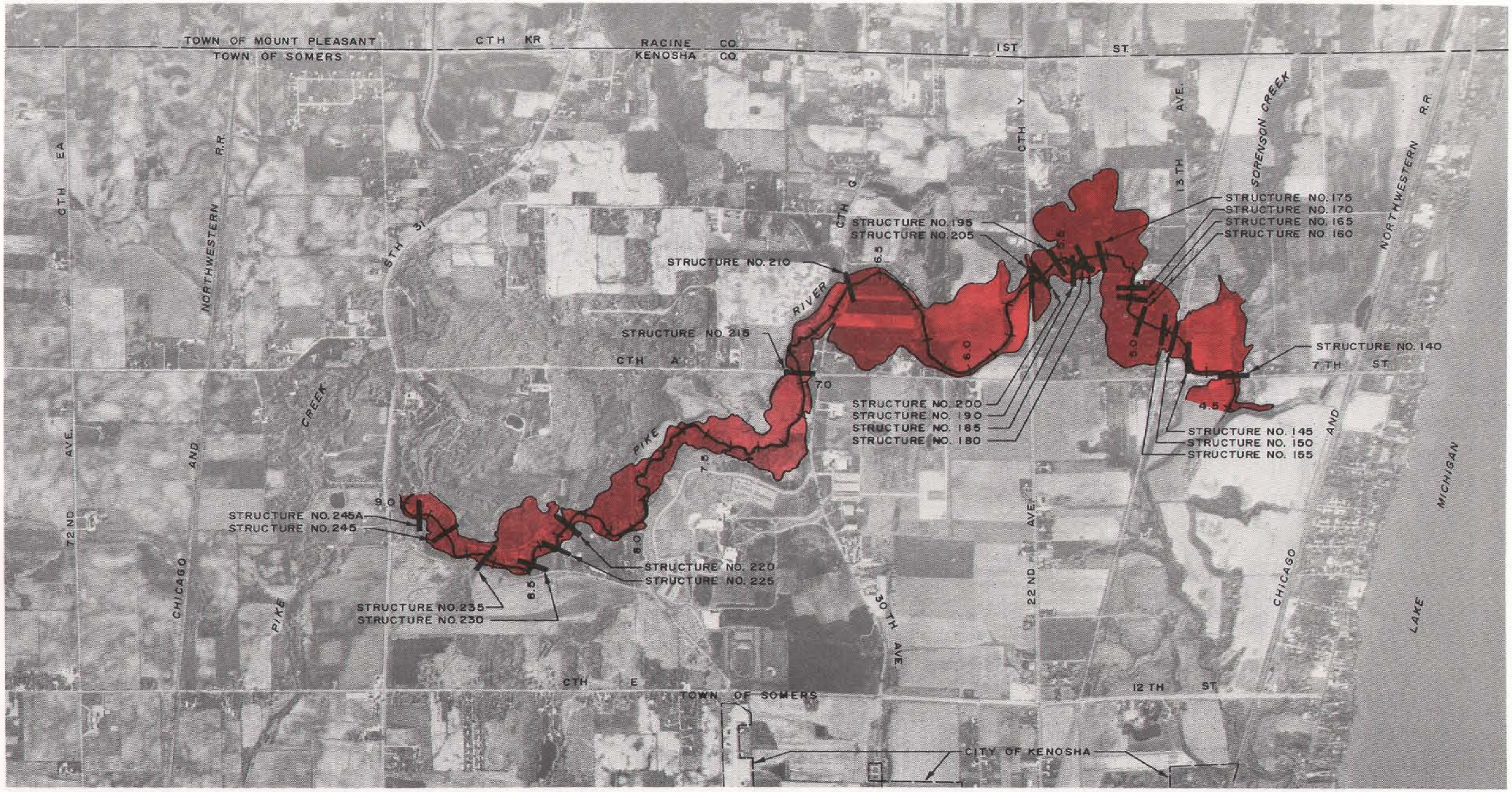
FLOOD STAGE AND STREAMBED PROFILE FOR THE PIKE RIVER (RIVER MILE 0.00 TO 4.50)



Source: SEWRPC.

Map G-2

AERIAL PHOTOGRAPH SHOWING AREAS SUBJECT TO FLOODING ALONG THE PIKE RIVER (RIVER MILE 4.50 TO 9.00)



LEGEND

APPROXIMATE EXISTING CHANNEL CENTERLINE AND RIVER MILE STATIONING

100-YEAR RECURRENCE INTERVAL FLOODLANDS-- PLANNED LAND USE AND PLANNED CHANNEL CONDITIONS

NOTE: DUE TO MAP SCALE LIMITATIONS, THE DIFFERENCE BETWEEN THE 100-YEAR RECURRENCE INTERVAL FLOODLANDS UNDER PLANNED LAND USE AND EXISTING CHANNEL CONDITIONS, AND THE 100-YEAR RECURRENCE INTERVAL FLOODLANDS UNDER PLANNED LAND USE AND PLANNED CHANNEL CONDITIONS, MAY NOT APPEAR ON THIS MAP. WHERE NO DIFFERENCE APPEARS REFERENCE SHOULD BE MADE TO THE FLOOD STAGE PROFILE SHOWN BELOW.

GRAPHIC SCALE

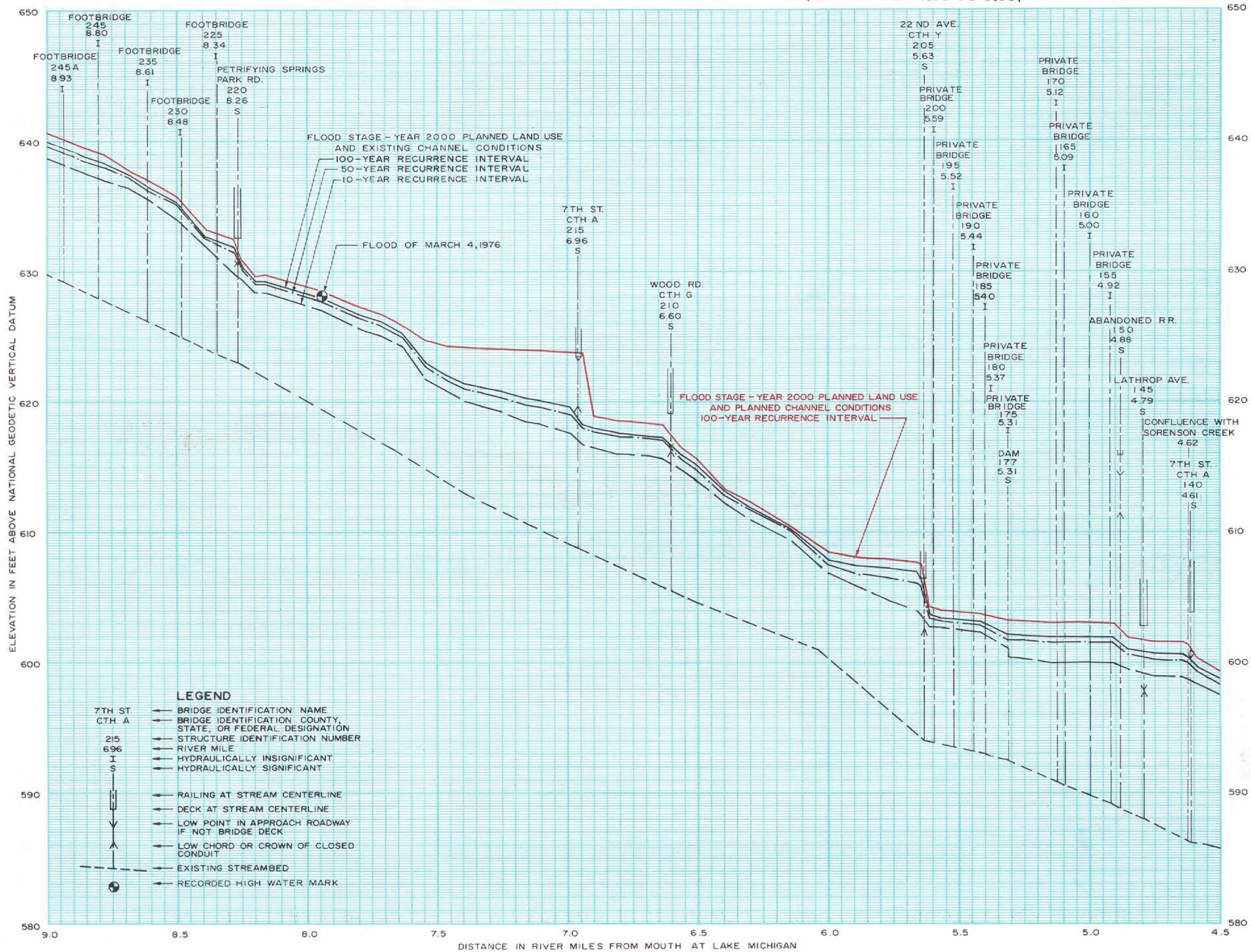
0 1/2 1 MILE

DATE OF PHOTOGRAPHY: APRIL 1980

Source: SEWRPC.

Figure G-2

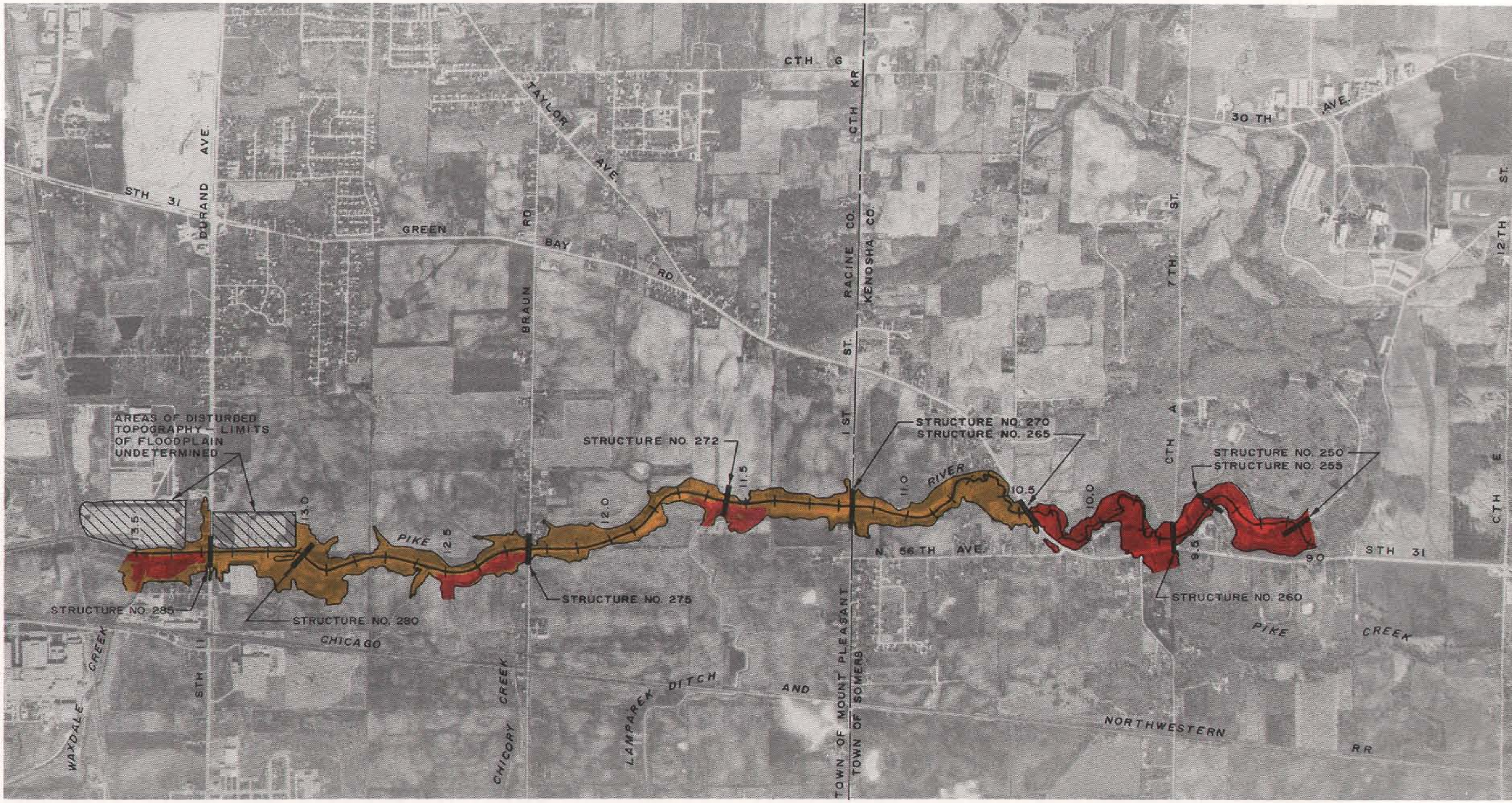
FLOOD STAGE AND STREAMBED PROFILE FOR THE PIKE RIVER (RIVER MILE 4.50 TO 9.00)



Source: SEWRPC.

Map G-3

AERIAL PHOTOGRAPH SHOWING AREAS SUBJECT TO FLOODING ALONG THE PIKE RIVER (RIVER MILE 9.00 TO 13.50)



LEGEND

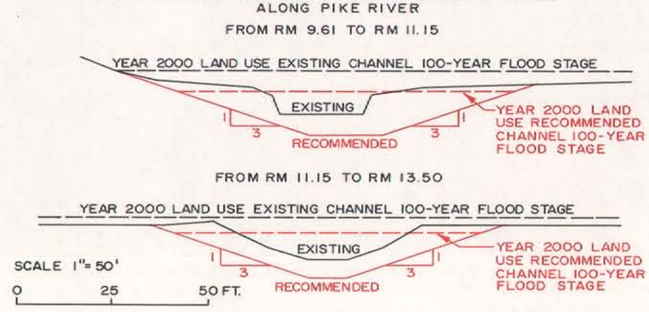
APPROXIMATE EXISTING CHANNEL CENTERLINE AND RIVER MILE STATIONING

100-YEAR RECURRENCE INTERVAL FLOODLANDS-- PLANNED LAND USE AND PLANNED CHANNEL CONDITIONS

100-YEAR RECURRENCE INTERVAL FLOODLANDS UNDER PLANNED LAND USE AND EXISTING CHANNEL CONDITIONS THAT WOULD BE ELIMINATED UNDER PLANNED CHANNEL CONDITIONS

NOTE: DUE TO MAP SCALE LIMITATIONS, THE DIFFERENCE BETWEEN THE 100-YEAR RECURRENCE INTERVAL FLOODLANDS UNDER PLANNED LAND USE AND EXISTING CHANNEL CONDITIONS, AND THE 100-YEAR RECURRENCE INTERVAL FLOODLANDS UNDER PLANNED LAND USE AND PLANNED CHANNEL CONDITIONS, MAY NOT APPEAR ON THIS MAP. WHERE NO DIFFERENCE APPEARS REFERENCE SHOULD BE MADE TO THE FLOOD STAGE PROFILE SHOWN BELOW.

TYPICAL CROSS-SECTIONS OF RECOMMENDED CHANNEL ALONG PIKE RIVER



GRAPHIC SCALE

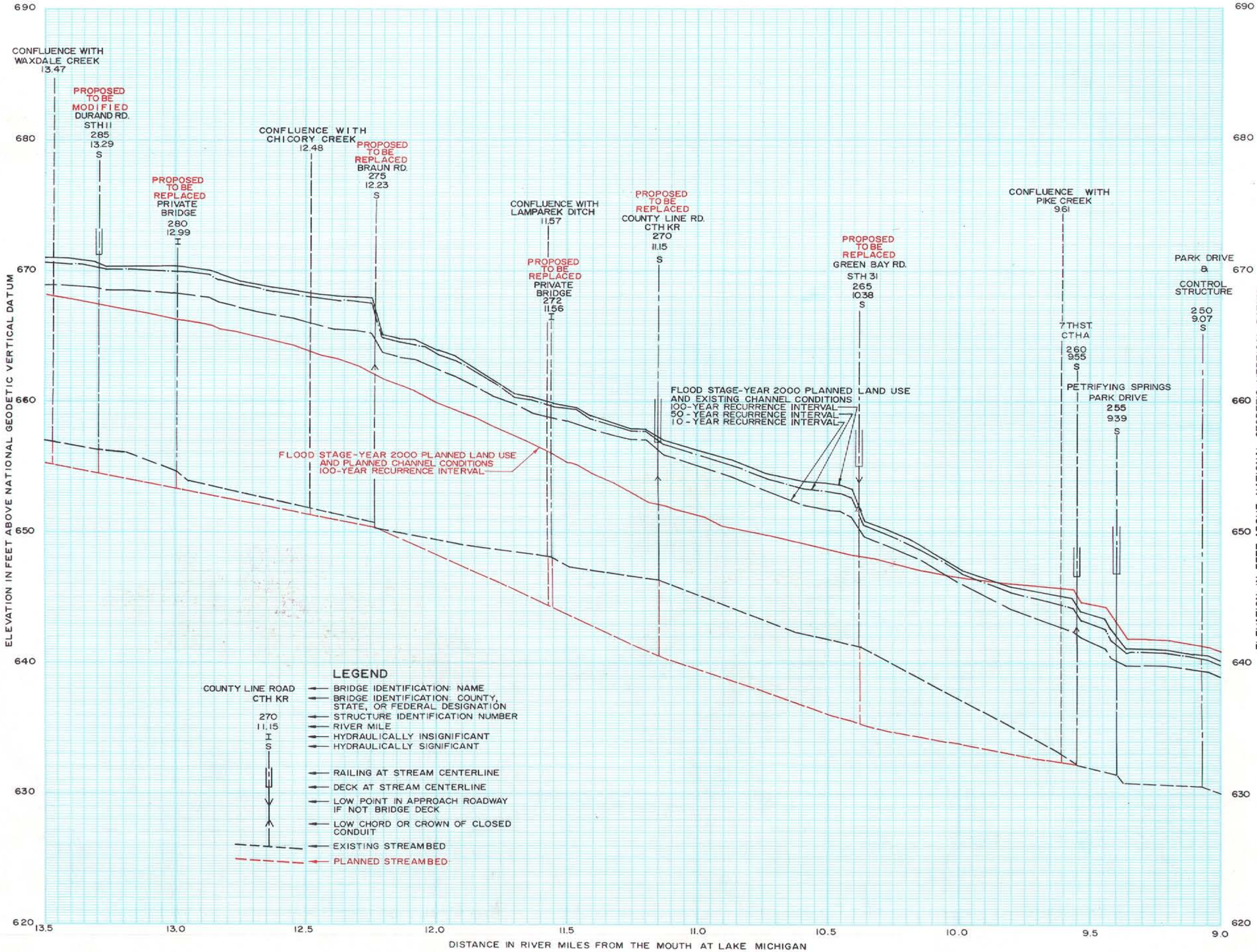
0 1/2 1 MILE

DATE OF PHOTOGRAPHY: APRIL 1980

Source: *SEWRPC.*

Figure G-3

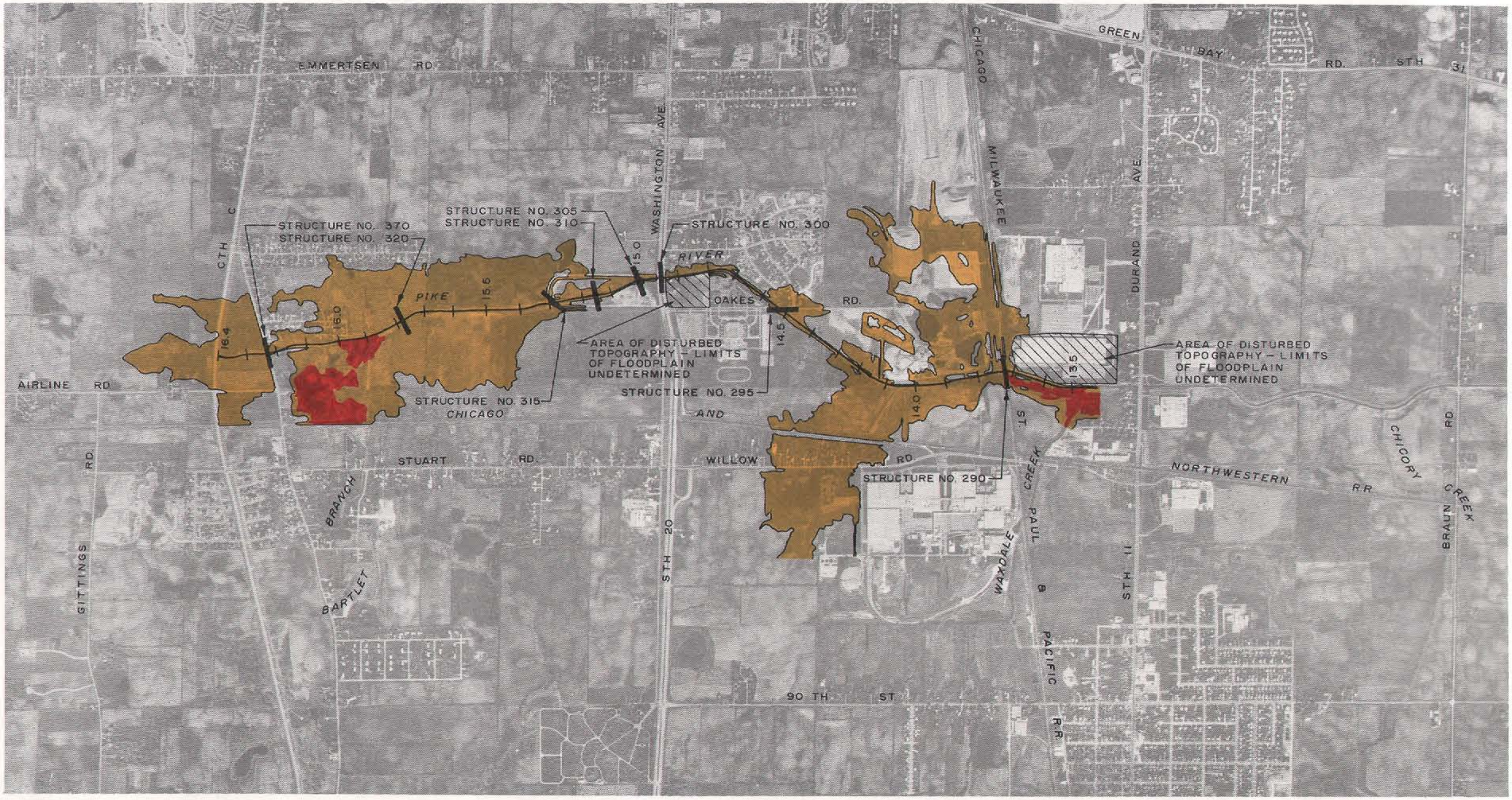
FLOOD STAGE AND STREAMBED PROFILE FOR THE PIKE RIVER (RIVER MILE 9.00-13.50)



Source: SEWRPC.

Map G-4

AERIAL PHOTOGRAPH SHOWING AREAS SUBJECT TO FLOODING ALONG THE PIKE RIVER (RIVER MILE 13.50 TO 16.40)



LEGEND

APPROXIMATE EXISTING CHANNEL CENTERLINE AND RIVER MILE STATIONING

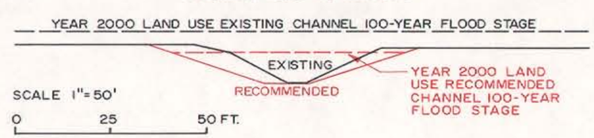
100-YEAR RECURRENCE INTERVAL FLOODLANDS-- PLANNED LAND USE AND PLANNED CHANNEL CONDITIONS

100-YEAR RECURRENCE INTERVAL FLOODLANDS UNDER PLANNED LAND USE AND EXISTING CHANNEL CONDITIONS THAT WOULD BE ELIMINATED UNDER PLANNED CHANNEL CONDITIONS

NOTE: DUE TO MAP SCALE LIMITATIONS, THE DIFFERENCE BETWEEN THE 100-YEAR RECURRENCE INTERVAL FLOODLANDS UNDER PLANNED LAND USE AND EXISTING CHANNEL CONDITIONS, AND THE 100-YEAR RECURRENCE INTERVAL FLOODLANDS UNDER PLANNED LAND USE AND PLANNED CHANNEL CONDITIONS, MAY NOT APPEAR ON THIS MAP. WHERE NO DIFFERENCE APPEARS REFERENCE SHOULD BE MADE TO THE FLOOD STAGE PROFILE SHOWN BELOW.

TYPICAL CROSS-SECTION OF RECOMMENDED CHANNEL ALONG PIKE RIVER

FROM RM 13.50 TO RM 16.40



GRAPHIC SCALE

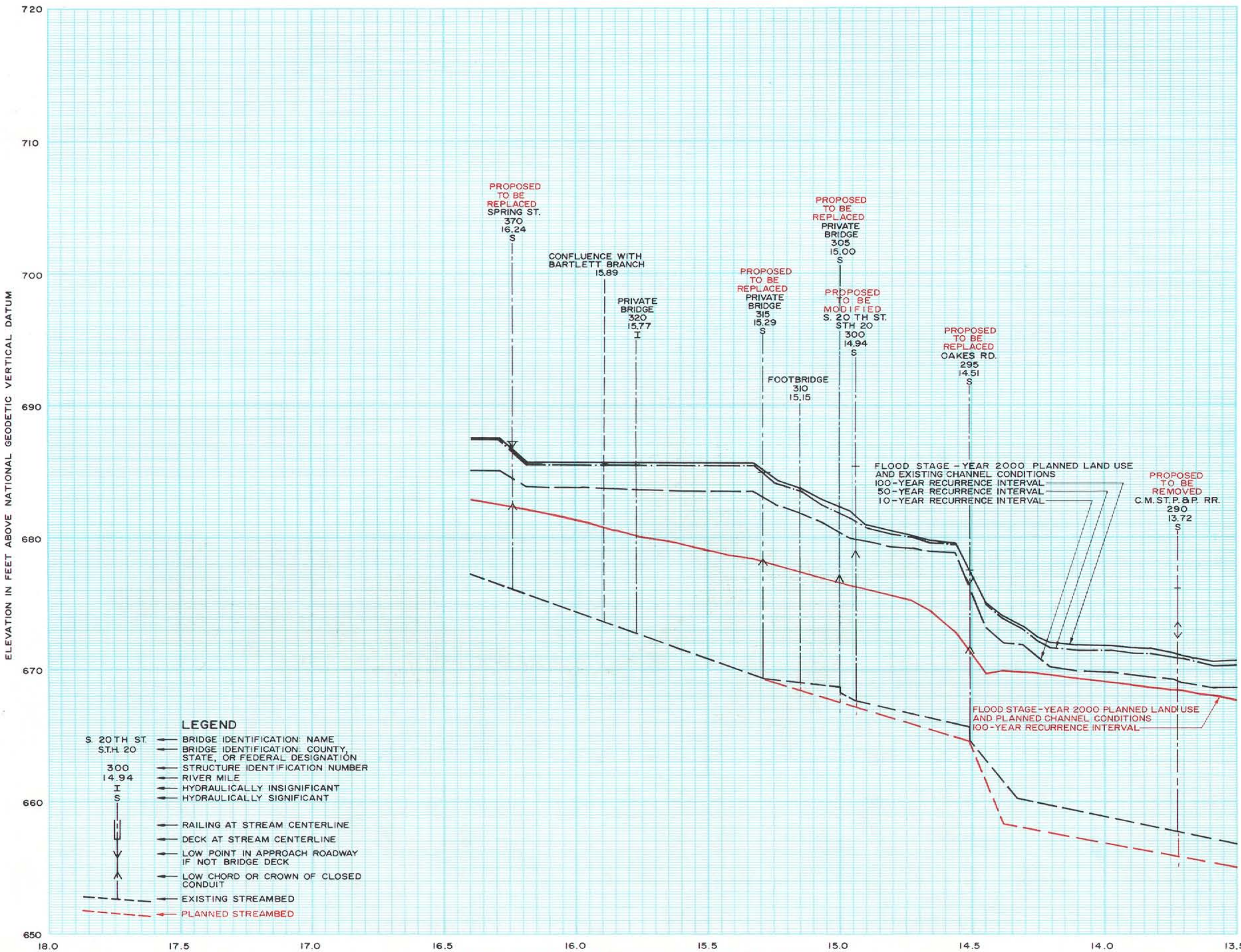
0 1/2 1 MILE

DATE OF PHOTOGRAPHY: APRIL 1980

Source: SEWRPC.

Figure G-4

FLOOD STAGE AND STREAMBED PROFILE FOR THE PIKE RIVER **(RIVER MILE 13.50 TO 16.40)**



Source: SEWRPC.

Map G-5

AERIAL PHOTOGRAPH SHOWING AREAS SUBJECT TO FLOODING ALONG KENOSHA BRANCH

LEGEND

APPROXIMATE EXISTING CHANNEL CENTERLINE AND RIVER MILE STATIONING

100-YEAR RECURRENCE INTERVAL FLOODLANDS--PLANNED LAND USE AND PLANNED CHANNEL CONDITIONS

NOTE: DUE TO MAP SCALE LIMITATIONS, THE DIFFERENCE BETWEEN THE 100-YEAR RECURRENCE INTERVAL FLOODLANDS UNDER PLANNED LAND USE AND EXISTING CHANNEL CONDITIONS, AND THE 100-YEAR RECURRENCE INTERVAL FLOODLANDS UNDER PLANNED LAND USE AND PLANNED CHANNEL CONDITIONS, MAY NOT APPEAR ON THIS MAP. WHERE NO DIFFERENCE APPEARS REFERENCE SHOULD BE MADE TO THE FLOOD STAGE PROFILE SHOWN BELOW.

GRAPHIC SCALE

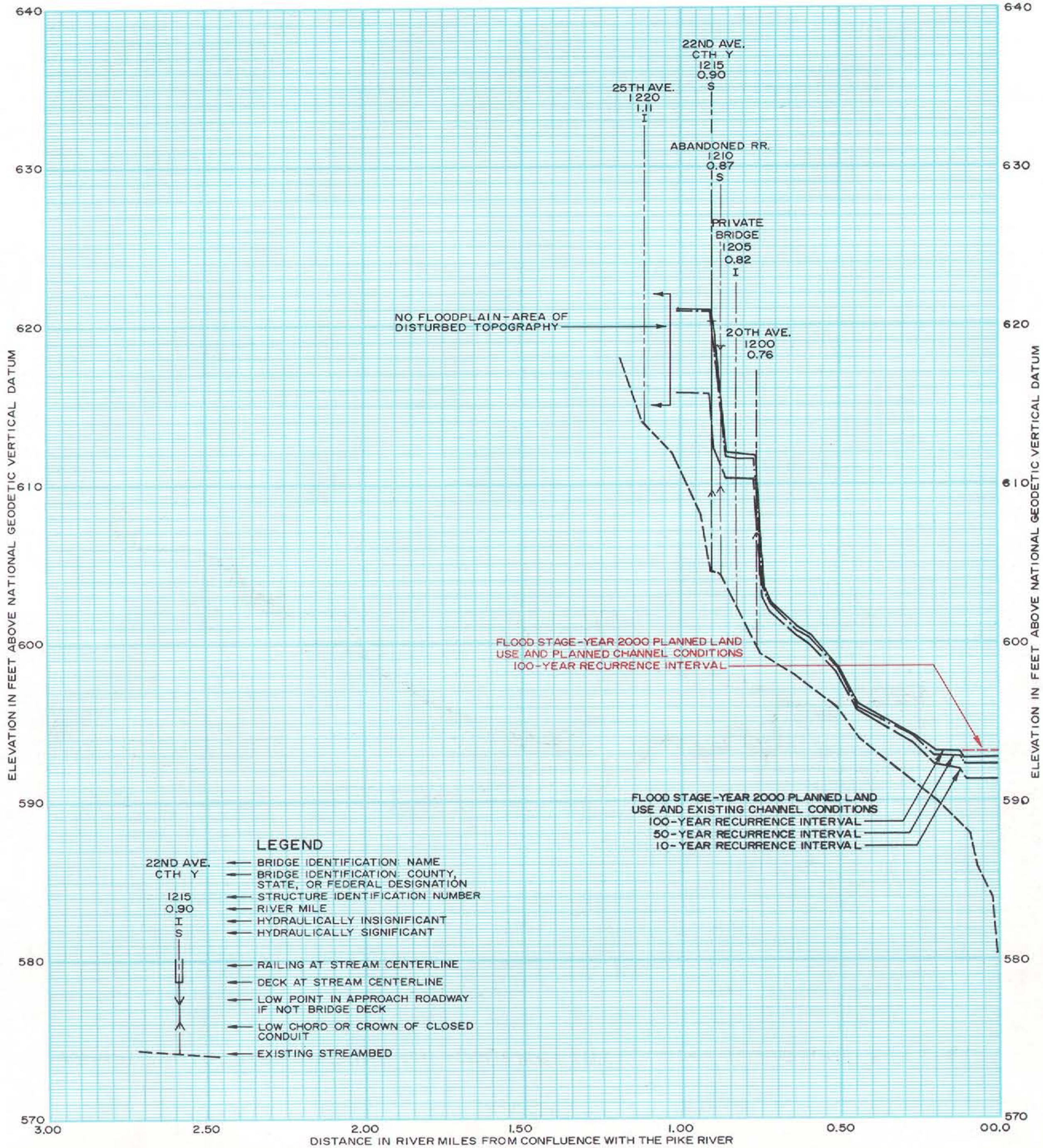
0 1/2 1 MILE

DATE OF PHOTOGRAPHY: APRIL 1980

Source: SEWRPC.

Figure G-5

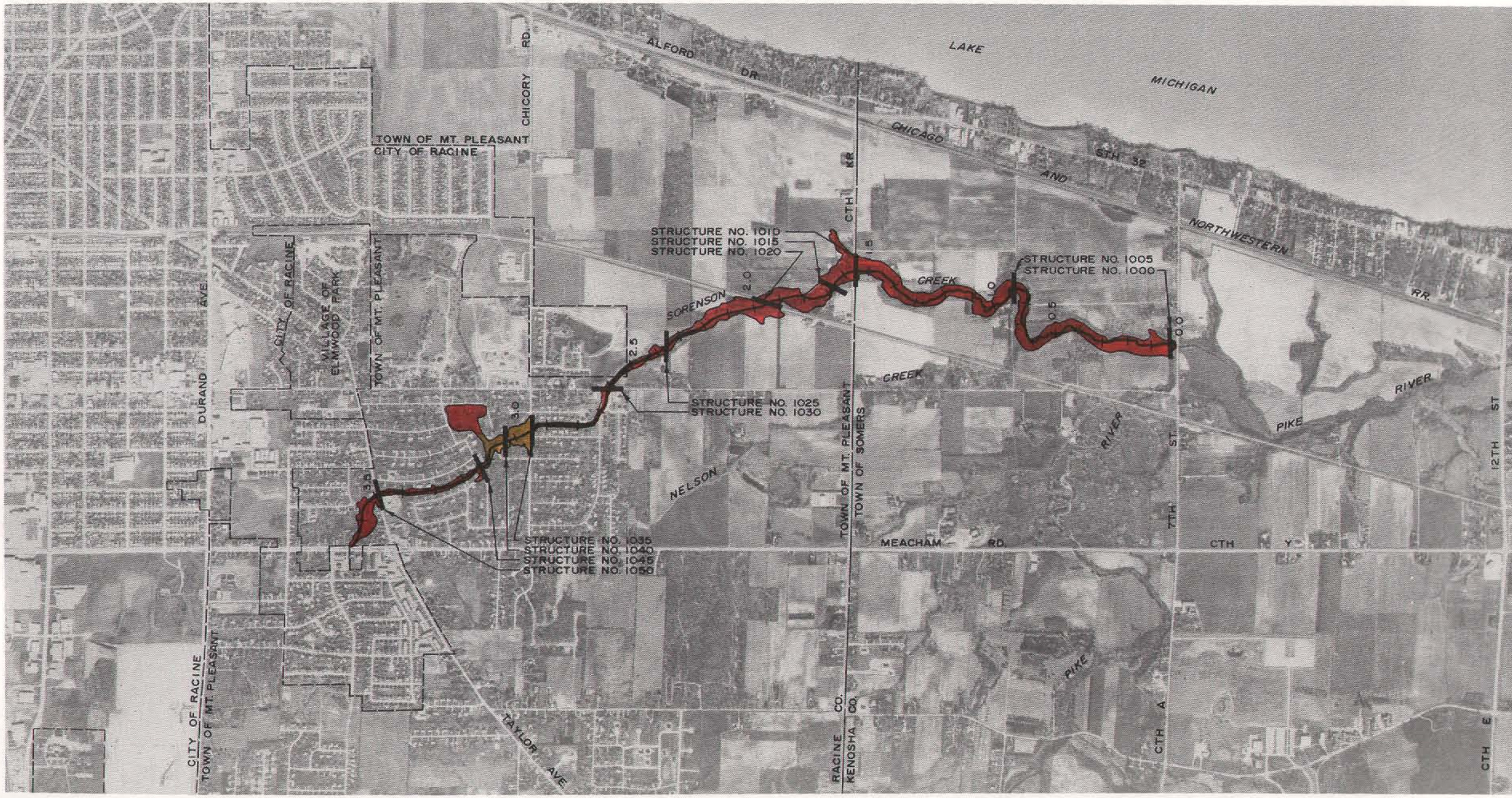
FLOOD STAGE AND STREAMBED PROFILE FOR KENOSHA BRANCH



Source: SEWRPC.

Map G-6

AERIAL PHOTOGRAPH SHOWING AREAS SUBJECT TO FLOODING ALONG SORENSON CREEK



LEGEND

APPROXIMATE EXISTING CHANNEL CENTERLINE AND RIVER MILE STATIONING

100-YEAR RECURRENCE INTERVAL FLOODLANDS--PLANNED LAND USE AND PLANNED CHANNEL CONDITIONS

100-YEAR RECURRENCE INTERVAL FLOODLANDS UNDER PLANNED LAND USE AND EXISTING CHANNEL CONDITIONS THAT WOULD BE ELIMINATED UNDER PLANNED CHANNEL CONDITIONS

NOTE: DUE TO MAP SCALE LIMITATIONS, THE DIFFERENCE BETWEEN THE 100-YEAR RECURRENCE INTERVAL FLOODLANDS UNDER PLANNED LAND USE AND EXISTING CHANNEL CONDITIONS, AND THE 100-YEAR RECURRENCE INTERVAL FLOODLANDS UNDER PLANNED LAND USE AND PLANNED CHANNEL CONDITIONS, MAY NOT APPEAR ON THIS MAP. WHERE NO DIFFERENCE APPEARS REFERENCE SHOULD BE MADE TO THE FLOOD STAGE PROFILE SHOWN BELOW.

GRAPHIC SCALE

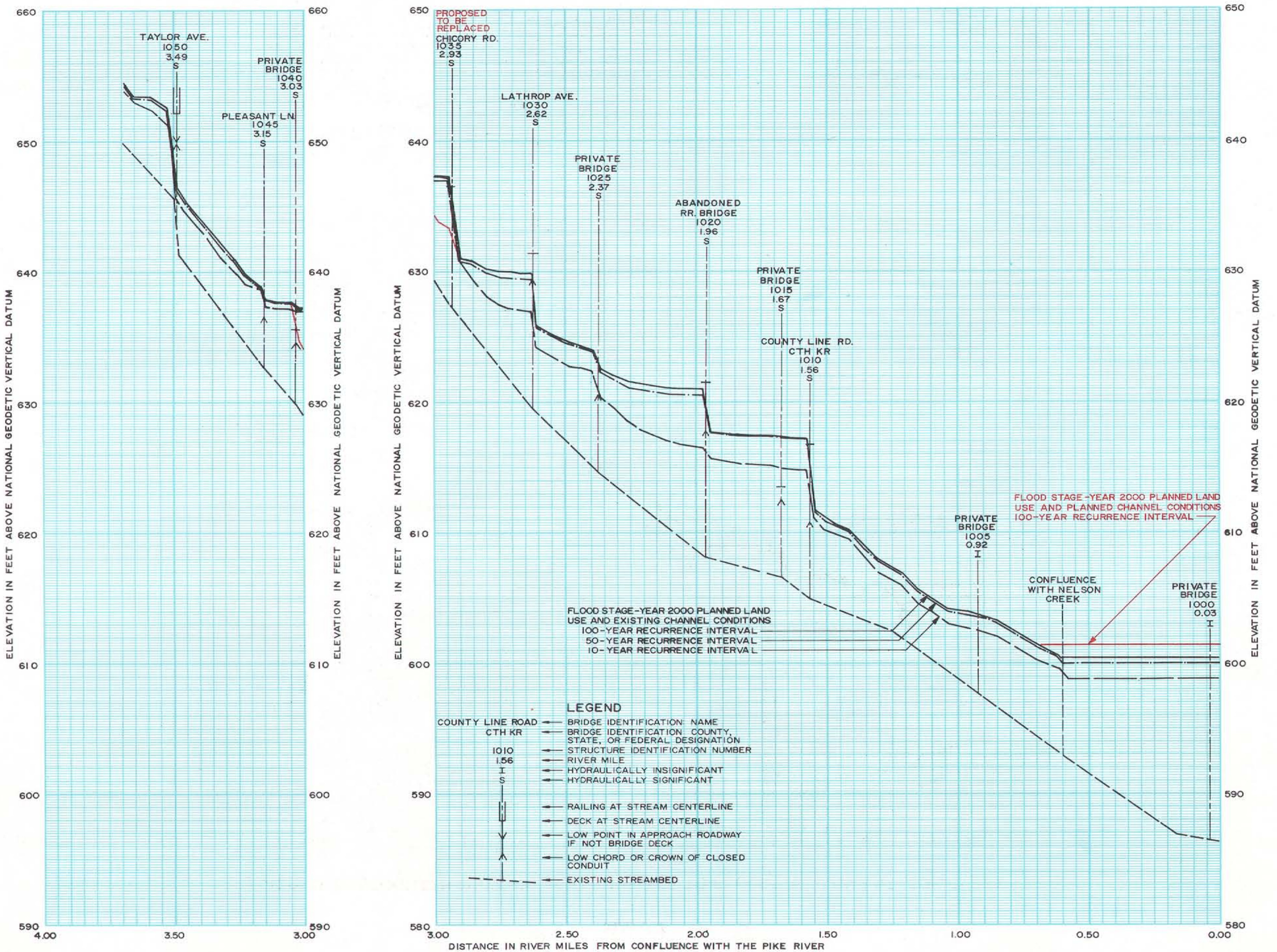
0 1/2 1 MILE

DATE OF PHOTOGRAPHY: APRIL 1980

Source: SEWRPC.

Figure G-6

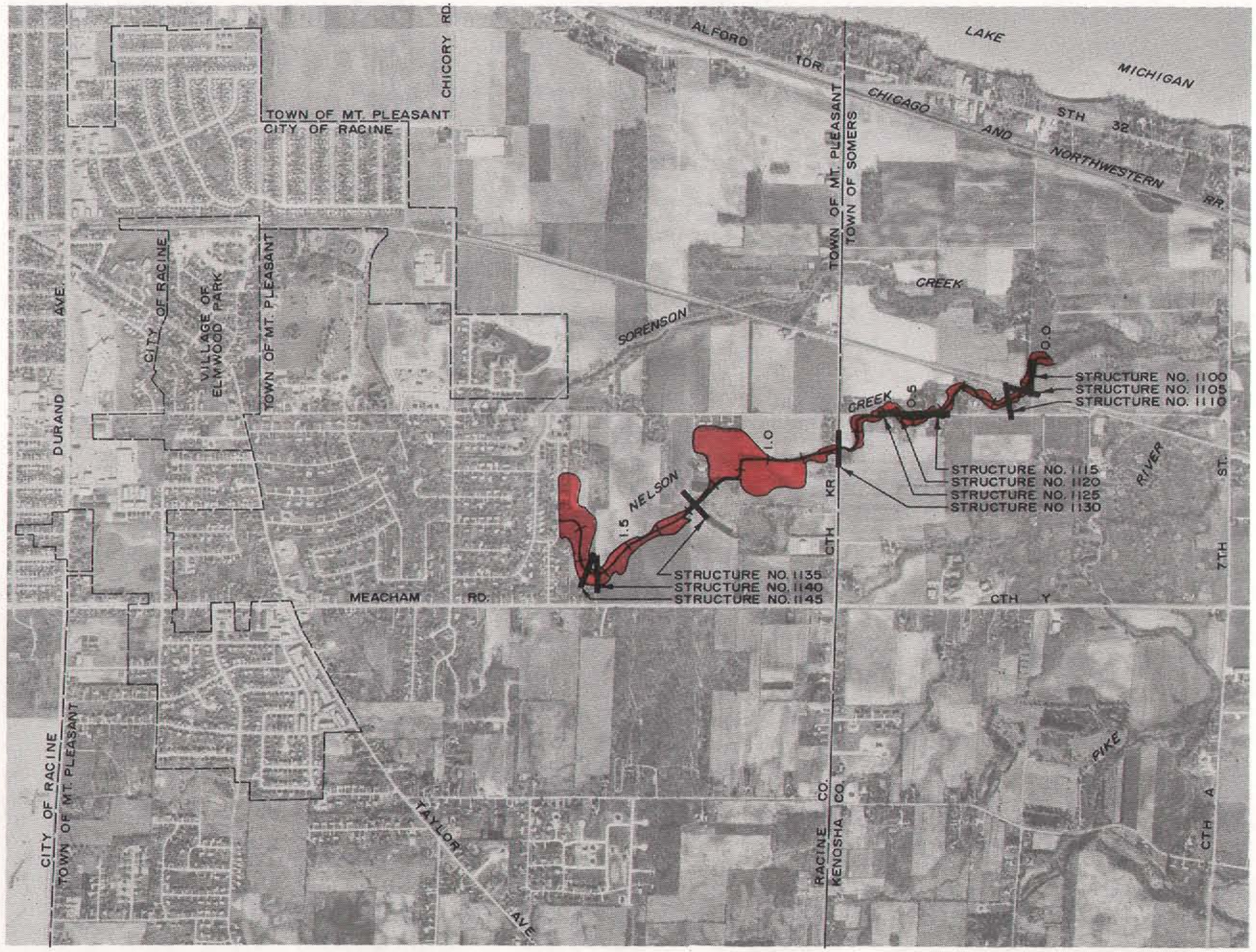
FLOOD STAGE AND STREAMBED PROFILE FOR SORENSON CREEK



Source: SEWRPC.

Map G-7

AERIAL PHOTOGRAPH SHOWING AREAS SUBJECT TO FLOODING ALONG NELSON CREEK



LEGEND

1.0 APPROXIMATE EXISTING CHANNEL CENTERLINE AND RIVER MILE STATIONING

100-YEAR RECURRENCE INTERVAL FLOODLANDS-- PLANNED LAND USE AND PLANNED CHANNEL CONDITION

NOTE: DUE TO MAP SCALE LIMITATIONS, THE DIFFERENCE BETWEEN THE 100-YEAR RECURRENCE INTERVAL FLOODLANDS UNDER PLANNED LAND USE AND EXISTING CHANNEL CONDITIONS, AND THE 100-YEAR RECURRENCE INTERVAL FLOODLANDS UNDER PLANNED LAND USE AND PLANNED CHANNEL CONDITIONS, MAY NOT APPEAR ON THIS MAP. WHERE NO DIFFERENCE APPEARS REFERENCE SHOULD BE MADE TO THE FLOOD STAGE PROFILE SHOWN BELOW.

GRAPHIC SCALE

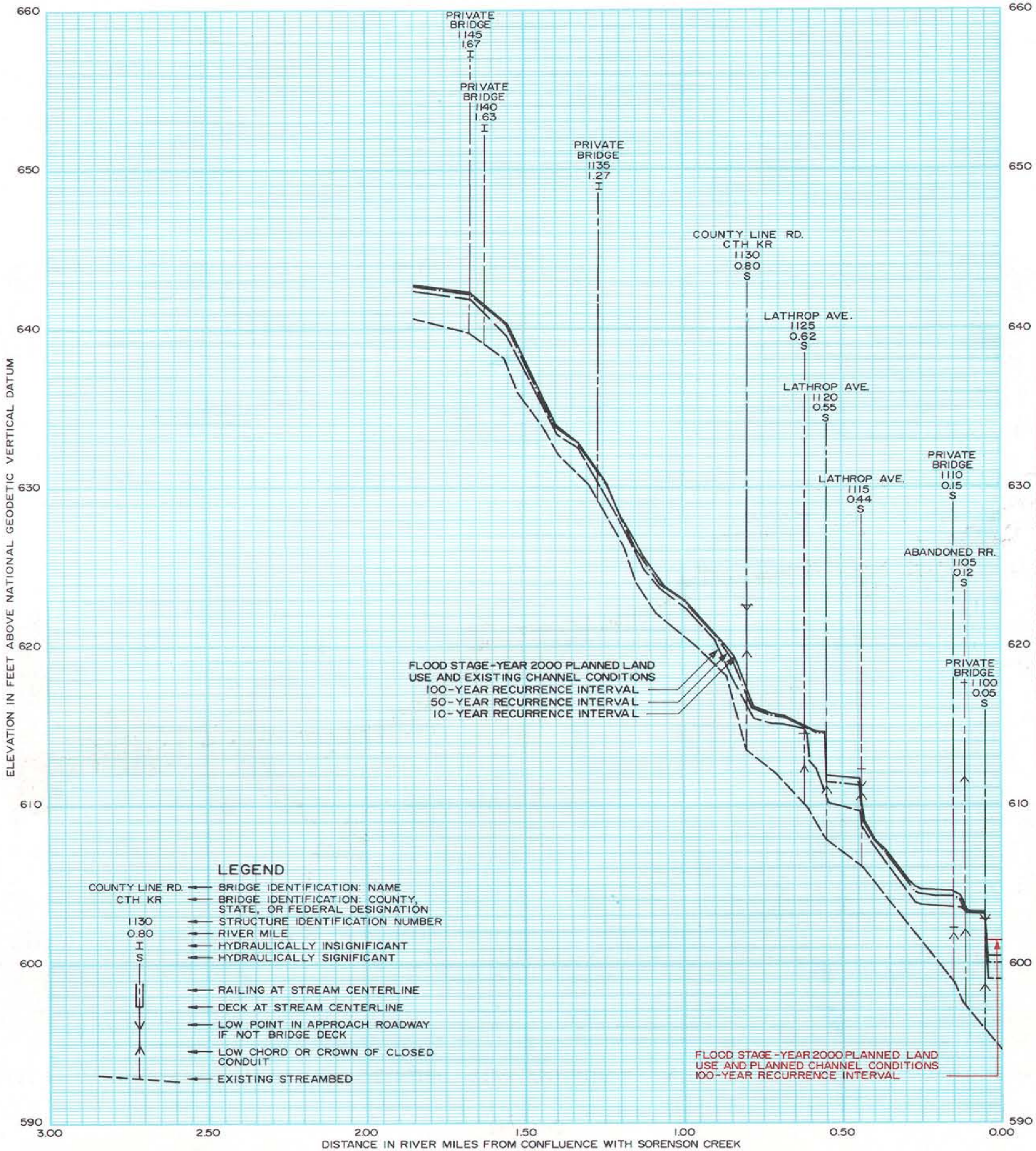
0 1/2 1 MILE

DATE OF PHOTOGRAPHY: APRIL 1980

Source: SEWRPC.

Figure G-7

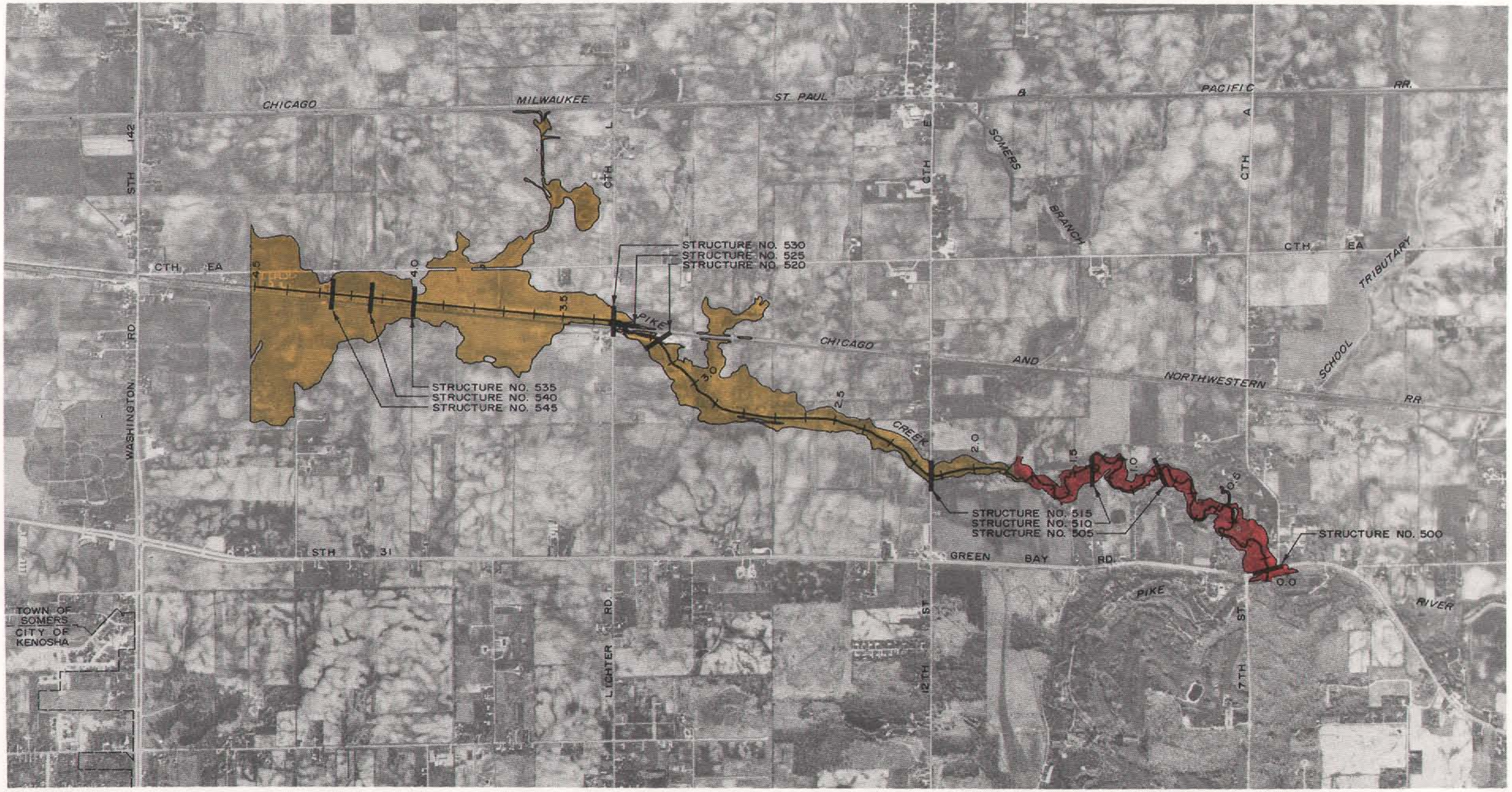
FLOOD STAGE AND STREAMBED PROFILE FOR NELSON CREEK



Source: SEWRPC.

Map G-8

AERIAL PHOTOGRAPH SHOWING AREAS SUBJECT TO FLOODING ALONG PIKE CREEK (RIVER MILE 0.00 TO 4.50)



LEGEND

1.0 — APPROXIMATE EXISTING CHANNEL CENTERLINE AND RIVER MILE STATIONING

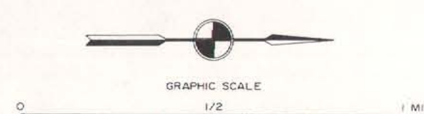
100-YEAR RECURRENCE INTERVAL FLOODLANDS-- PLANNED LAND USE AND PLANNED CHANNEL CONDITIONS

100-YEAR RECURRENCE INTERVAL FLOODLANDS UNDER PLANNED LAND USE AND EXISTING CHANNEL CONDITIONS THAT WOULD BE ELIMINATED UNDER PLANNED CHANNEL CONDITIONS

NOTE: DUE TO MAP SCALE LIMITATIONS, THE DIFFERENCE BETWEEN THE 100-YEAR RECURRENCE INTERVAL FLOODLANDS UNDER PLANNED LAND USE AND EXISTING CHANNEL CONDITIONS, AND THE 100-YEAR RECURRENCE INTERVAL FLOODLANDS UNDER PLANNED LAND USE AND PLANNED CHANNEL CONDITIONS, MAY NOT APPEAR ON THIS MAP. WHERE NO DIFFERENCE APPEARS REFERENCE SHOULD BE MADE TO THE FLOOD STAGE PROFILE SHOWN BELOW.

TYPICAL CROSS-SECTION OF RECOMMENDED CHANNEL ALONG PIKE CREEK

FROM RM 1.80 TO RM 4.50

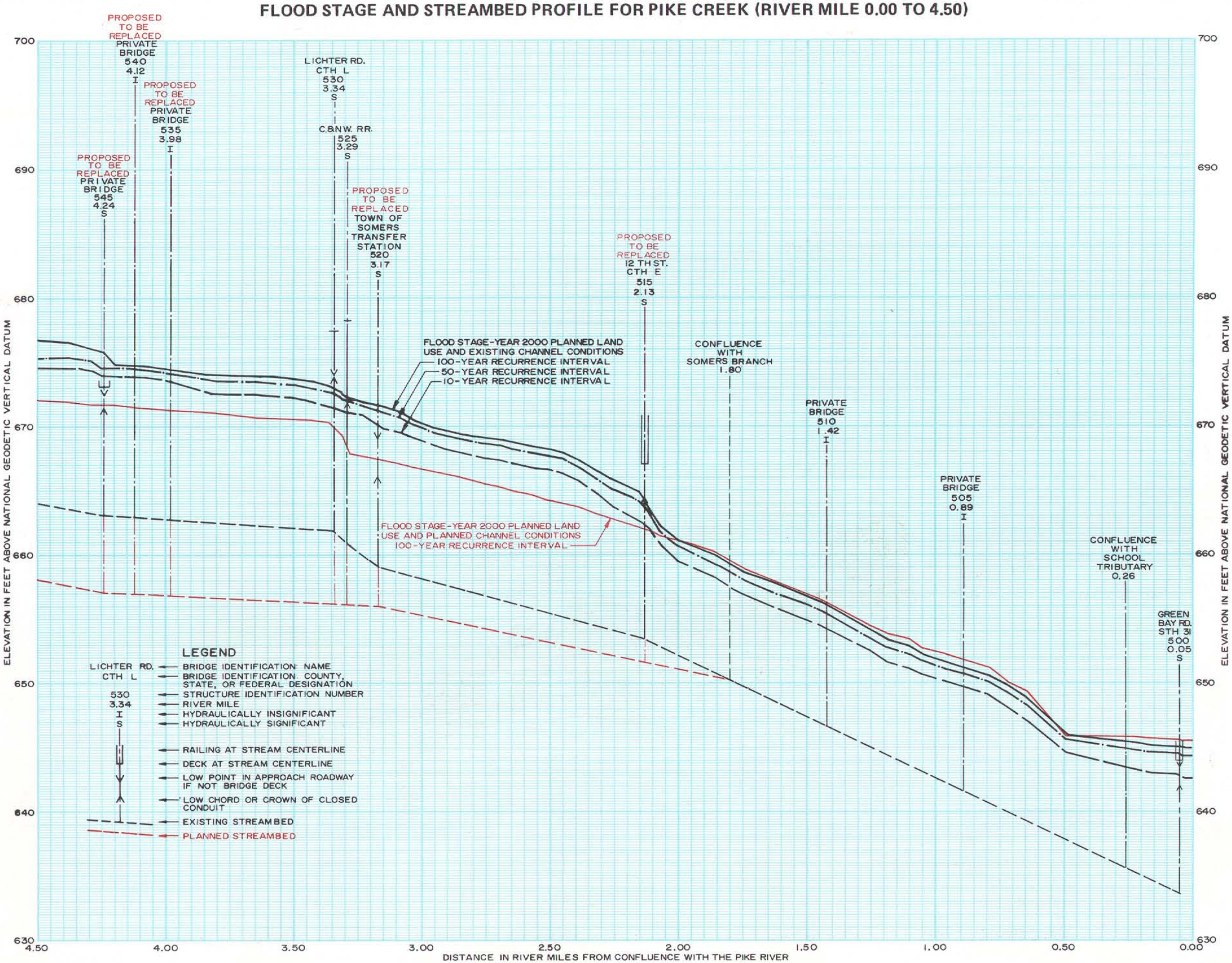


DATE OF PHOTOGRAPHY: APRIL 1980

Source: SEWRPC.

Figure G-8

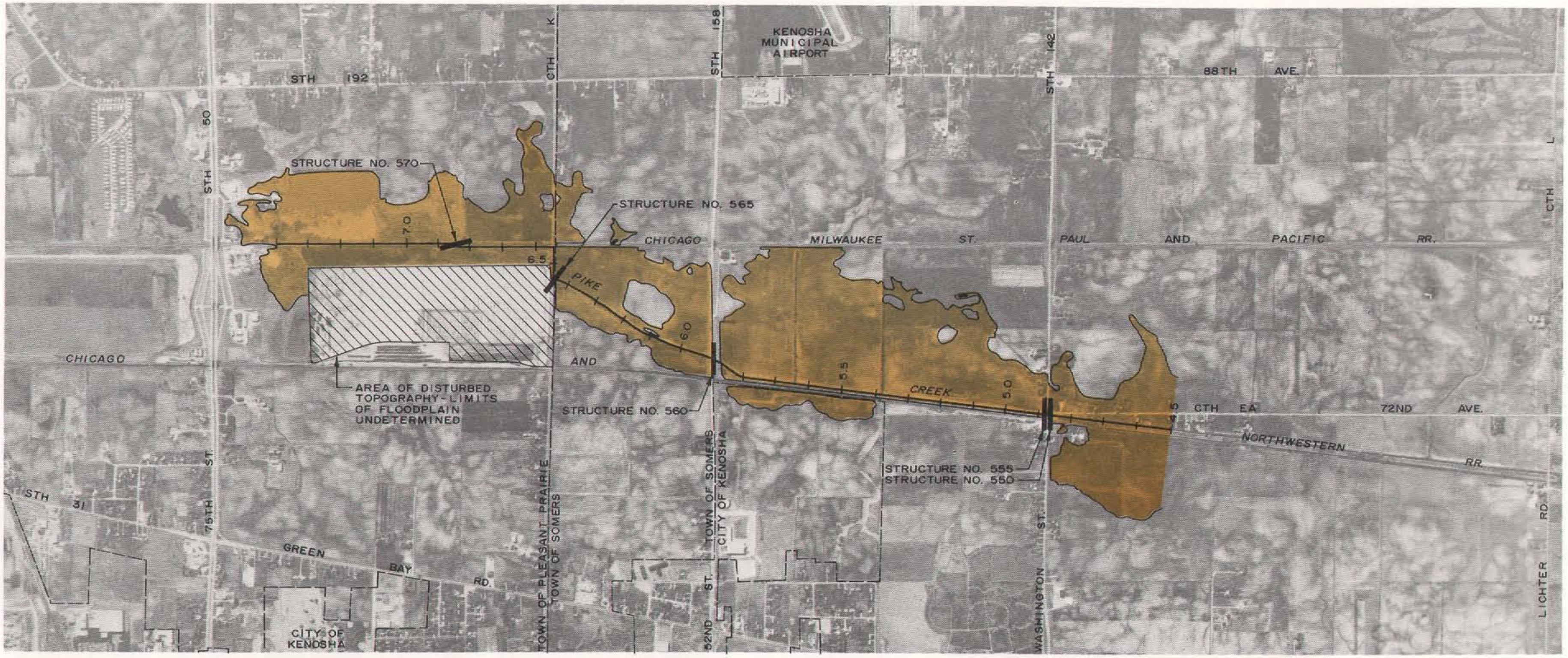
FLOOD STAGE AND STREAMBED PROFILE FOR PIKE CREEK (RIVER MILE 0.00 TO 4.50)



Source: SEWRPC.

Map G-9

AERIAL PHOTOGRAPH SHOWING AREAS SUBJECT TO FLOODING ALONG PIKE CREEK (RIVER MILE 4.50 TO 7.50)

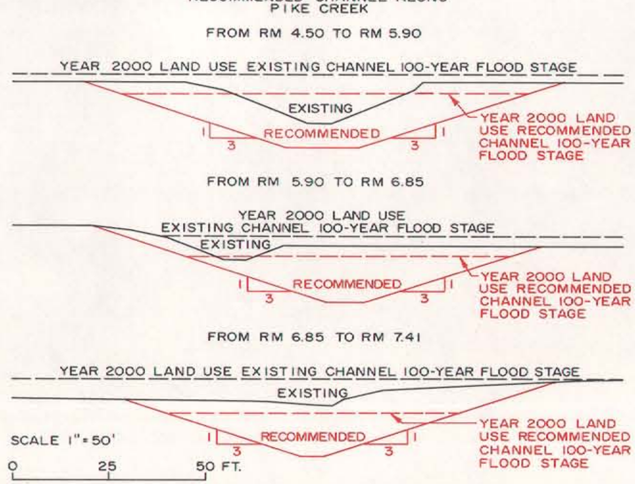


LEGEND

APPROXIMATE EXISTING CHANNEL CENTERLINE AND RIVER MILE STATIONING

100-YEAR RECURRENCE INTERVAL FLOODLANDS UNDER PLANNED LAND USE AND EXISTING CHANNEL CONDITIONS THAT WOULD BE ELIMINATED UNDER PLANNED CHANNEL CONDITIONS

TYPICAL CROSS-SECTIONS OF RECOMMENDED CHANNEL ALONG PIKE CREEK

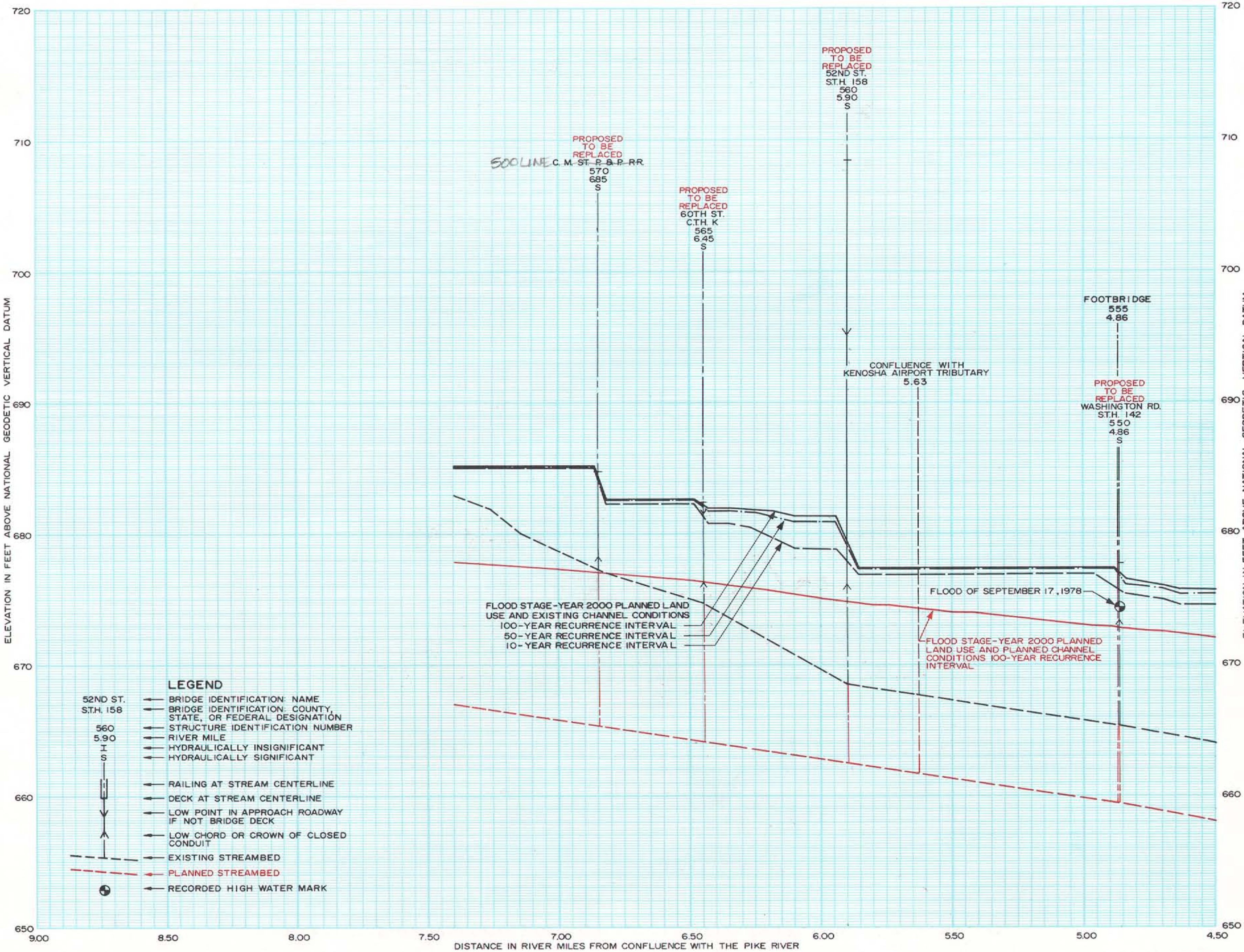


DATE OF PHOTOGRAPHY APRIL 1980

Source: SEWRPC.

Figure G-9

FLOOD STAGE AND STREAMBED PROFILE FOR PIKE CREEK (RIVER MILE 4.50 TO 7.50)



Source: SEWRPC.

Map G-10

AERIAL PHOTOGRAPH SHOWING AREAS SUBJECT TO FLOODING ALONG SOMERS BRANCH

LEGEND

APPROXIMATE EXISTING CHANNEL CENTERLINE AND RIVER MILE STATIONING

100-YEAR RECURRENCE INTERVAL FLOODLANDS-- PLANNED LAND USE AND PLANNED CHANNEL CONDITIONS

NOTE: DUE TO MAP SCALE LIMITATIONS, THE DIFFERENCE BETWEEN THE 100-YEAR RECURRENCE INTERVAL FLOODLANDS UNDER PLANNED LAND USE AND EXISTING CHANNEL CONDITIONS, AND THE 100-YEAR RECURRENCE INTERVAL FLOODLANDS UNDER PLANNED LAND USE AND PLANNED CHANNEL CONDITIONS, MAY NOT APPEAR ON THIS MAP. WHERE NO DIFFERENCE APPEARS REFERENCE SHOULD BE MADE TO THE FLOOD STAGE PROFILE SHOWN BELOW.

GRAPHIC SCALE

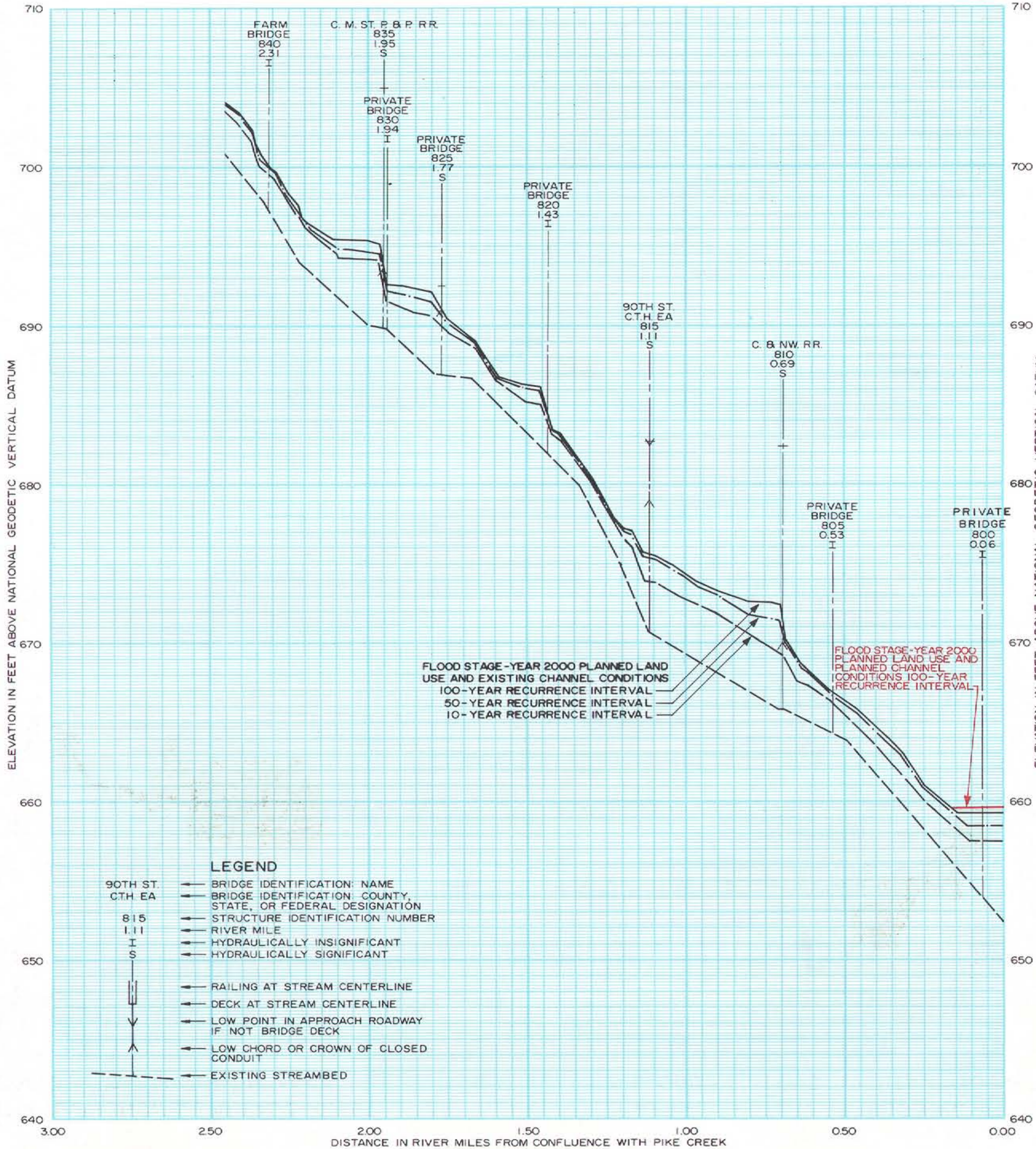
0 1/2 1 MILE

DATE OF PHOTOGRAPHY: APRIL 1980

Source: SEWRPC.

Figure G-10

FLOOD STAGE AND STREAMBED PROFILE FOR SOMERS BRANCH



Source: SEWRPC.

Map G-11

AERIAL PHOTOGRAPH SHOWING AREAS SUBJECT TO FLOODING ALONG AIRPORT BRANCH

LEGEND

0.5 — APPROXIMATE EXISTING CHANNEL CENTERLINE AND RIVER MILE STATIONING

100-YEAR RECURRENCE INTERVAL FLOODLANDS UNDER PLANNED LAND USE AND EXISTING CHANNEL CONDITIONS THAT WOULD BE ELIMINATED UNDER PLANNED CHANNEL CONDITIONS

GRAPHIC SCALE

0 — 1/2 — 1 MILE

DATE OF PHOTOGRAPHY: APRIL 1980

TYPICAL CROSS-SECTIONS OF RECOMMENDED CHANNEL ALONG AIRPORT BRANCH

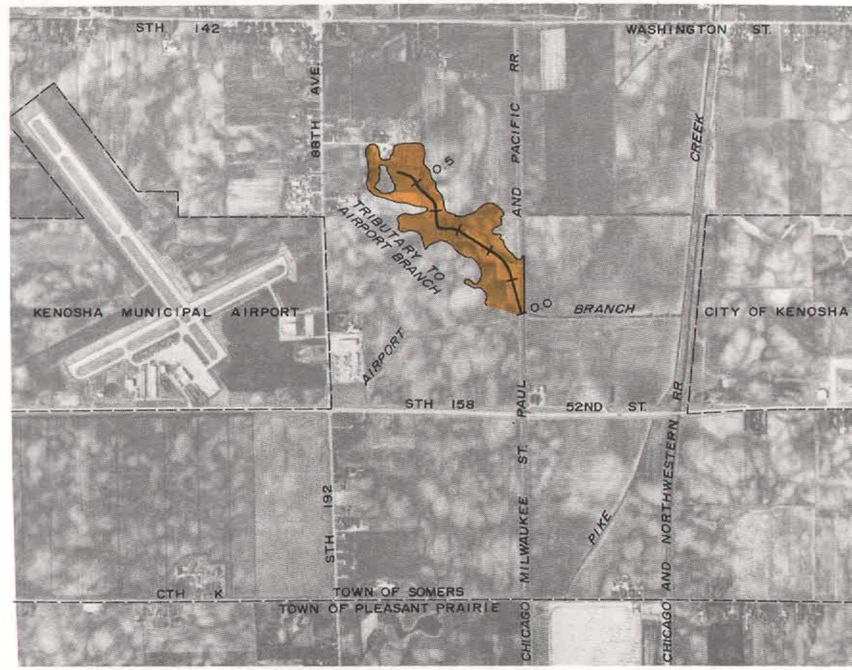
FROM RM 0.00 TO RM 0.41

FROM RM 0.41 TO RM 0.92

Source: SEWRPC.

Map G-12

AERIAL PHOTOGRAPH SHOWING AREAS SUBJECT TO FLOODING ALONG TRIBUTARY TO AIRPORT BRANCH



LEGEND

0.5 — APPROXIMATE EXISTING CHANNEL CENTERLINE AND RIVER MILE STATIONING

100-YEAR RECURRENCE INTERVAL FLOODLANDS UNDER PLANNED LAND USE AND EXISTING CHANNEL CONDITIONS THAT WOULD BE ELIMINATED UNDER PLANNED CHANNEL CONDITIONS

GRAPHIC SCALE

0 — 1/2 — 1 MILE

DATE OF PHOTOGRAPHY: APRIL 1980

TYPICAL CROSS-SECTION OF RECOMMENDED CHANNEL ALONG TRIBUTARY TO AIRPORT BRANCH

FROM RM 0.00 TO RM 0.52

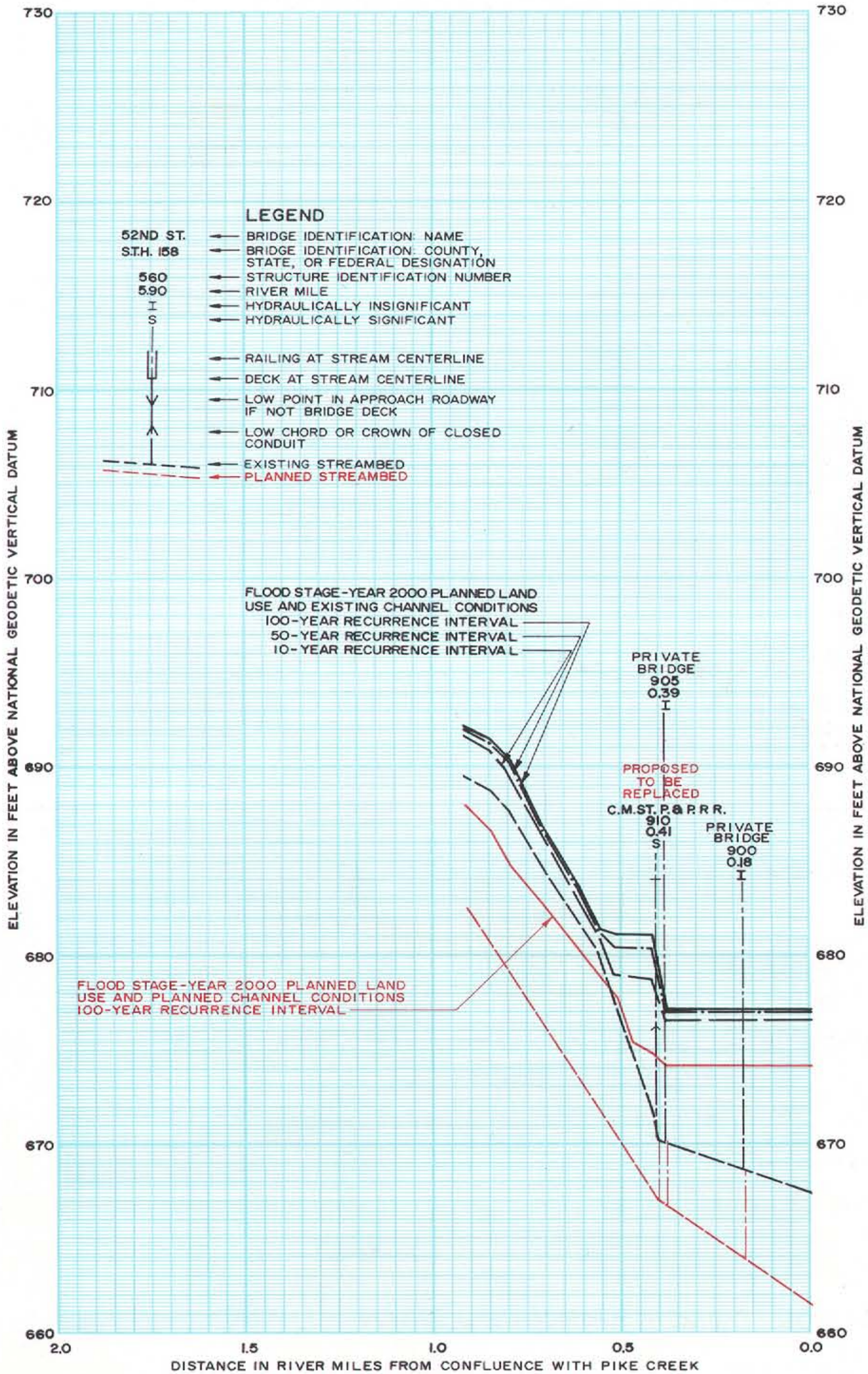
SCALE 1" = 50'

0 — 25 — 50 FT.

Source: SEWRPC.

Figure G-11

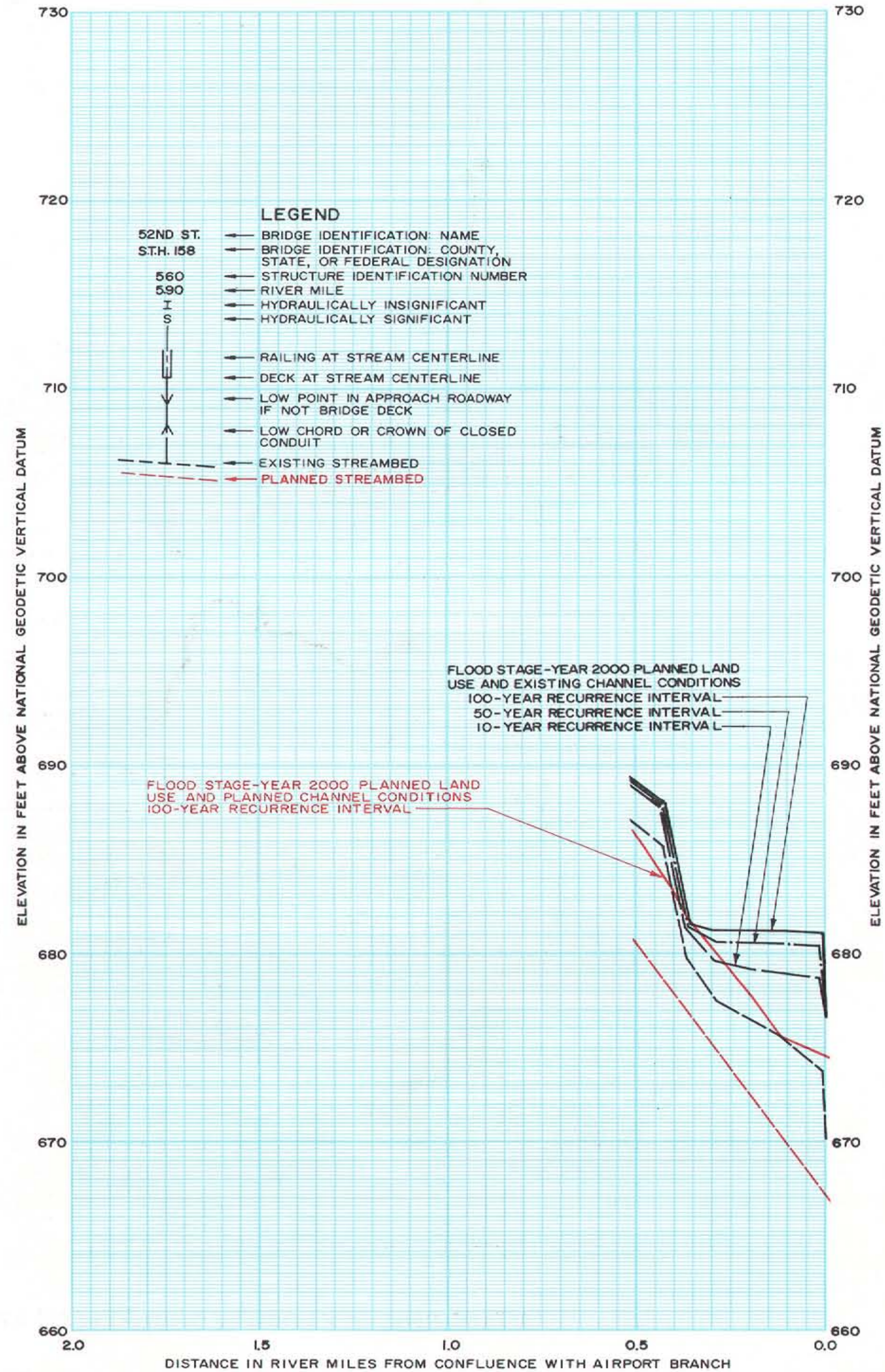
FLOOD STAGE AND STREAMBED PROFILE FOR AIRPORT BRANCH



Source: SEWRPC.

Figure G-12

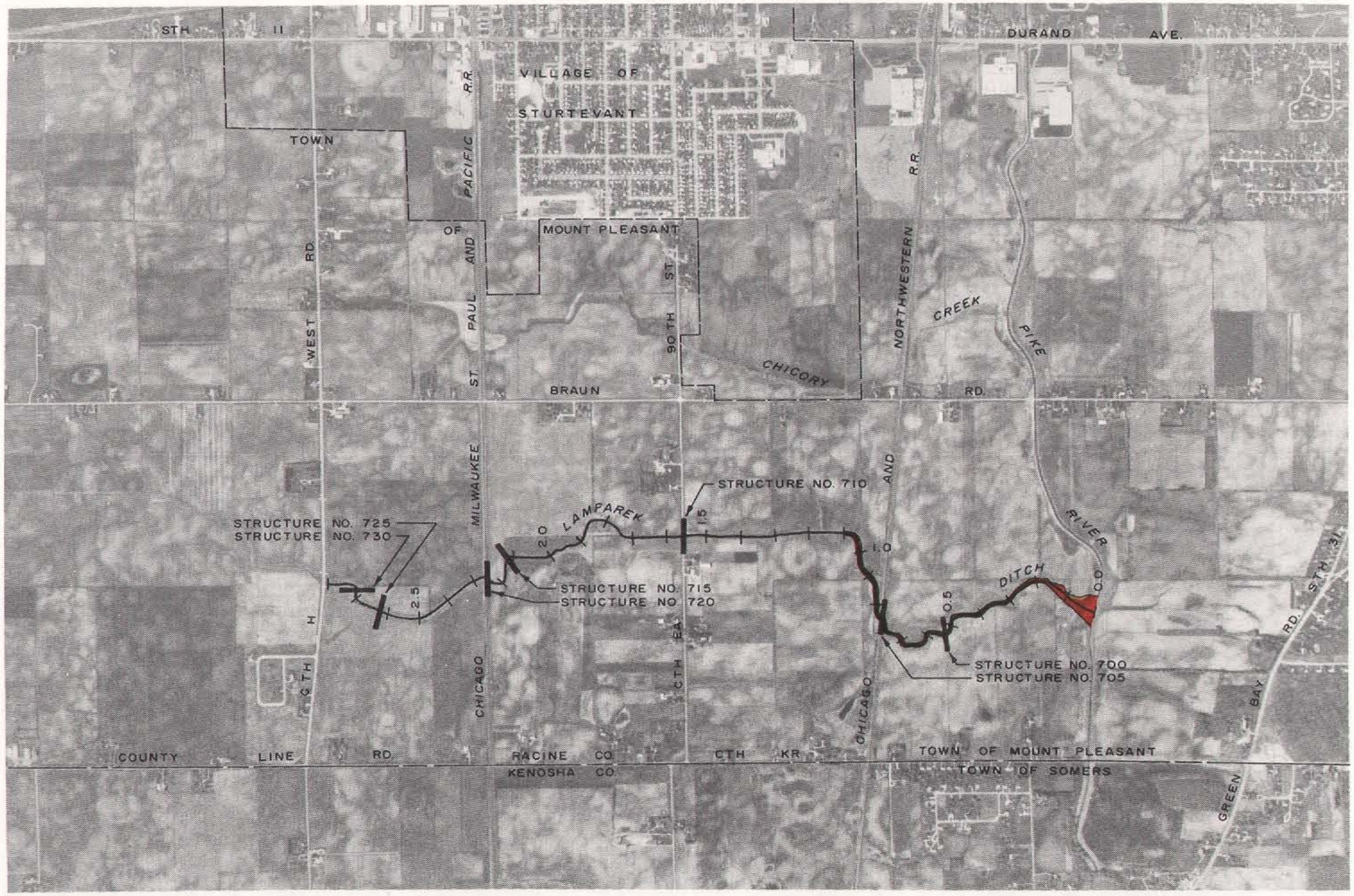
FLOOD STAGE AND STREAMBED PROFILE FOR TRIBUTARY TO AIRPORT BRANCH



Source: SEWRPC.

Map G-13

AERIAL PHOTOGRAPH SHOWING AREAS SUBJECT TO FLOODING ALONG LAMPAREK DITCH



LEGEND

APPROXIMATE EXISTING CHANNEL CENTERLINE AND RIVER MILE STATIONING

100-YEAR RECURRENCE INTERVAL FLOODLANDS-- PLANNED LAND USE AND PLANNED CHANNEL CONDITIONS

100-YEAR RECURRENCE INTERVAL FLOODLANDS UNDER PLANNED LAND USE AND EXISTING CHANNEL CONDITIONS THAT WOULD BE ELIMINATED UNDER PLANNED CHANNEL CONDITIONS

NOTE: DUE TO MAP SCALE LIMITATIONS, THE DIFFERENCE BETWEEN THE 100-YEAR RECURRENCE INTERVAL FLOODLANDS UNDER PLANNED LAND USE AND EXISTING CHANNEL CONDITIONS, AND THE 100-YEAR RECURRENCE INTERVAL FLOODLANDS UNDER PLANNED LAND USE AND PLANNED CHANNEL CONDITIONS, MAY NOT APPEAR ON THIS MAP. WHERE NO DIFFERENCE APPEARS REFERENCE SHOULD BE MADE TO THE FLOOD STAGE PROFILE SHOWN BELOW.

GRAPHIC SCALE

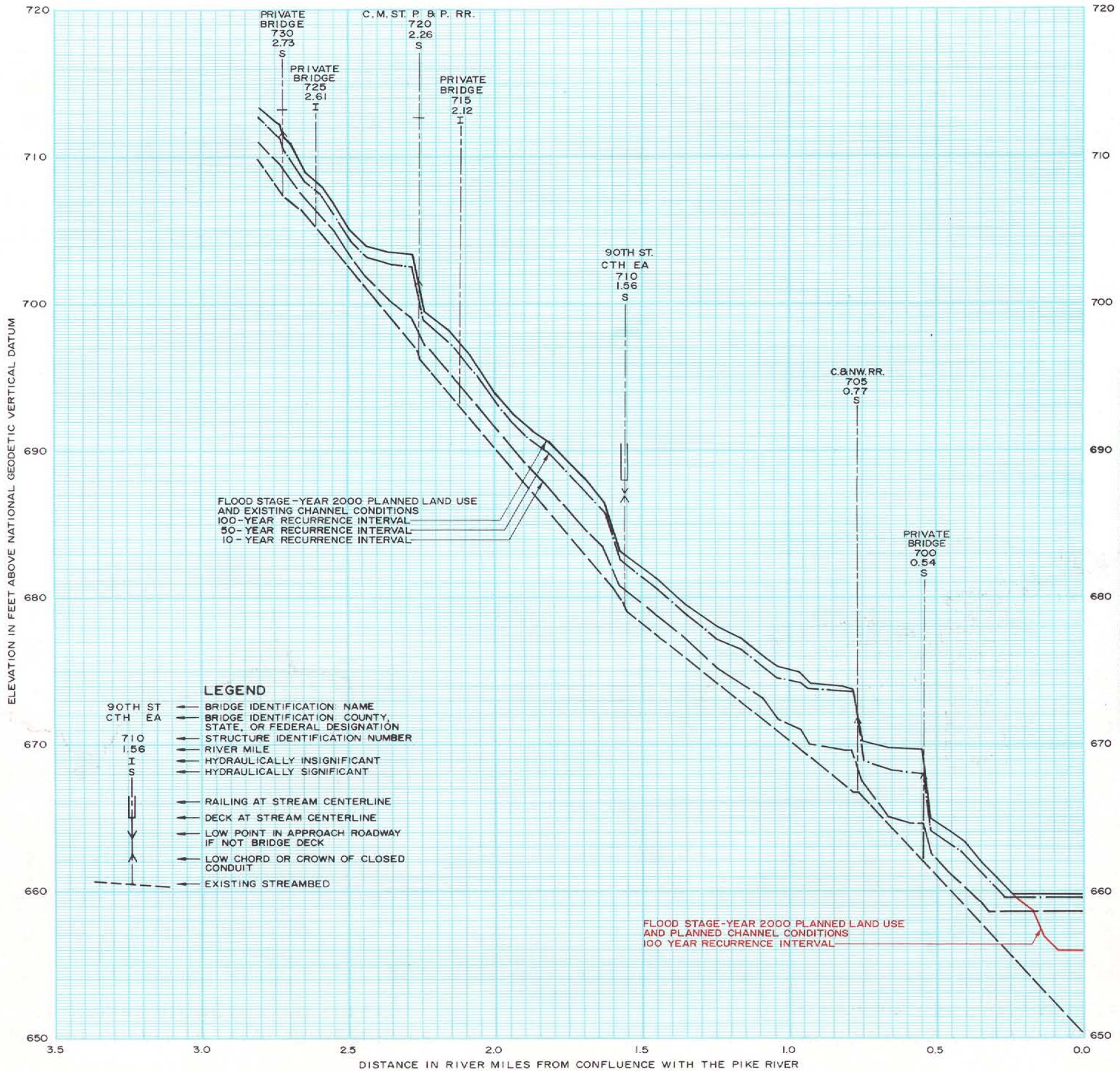
0 1/2 1 MILE

DATE OF PHOTOGRAPHY: APRIL 1980

Source: SEWRPC.

Figure G-13

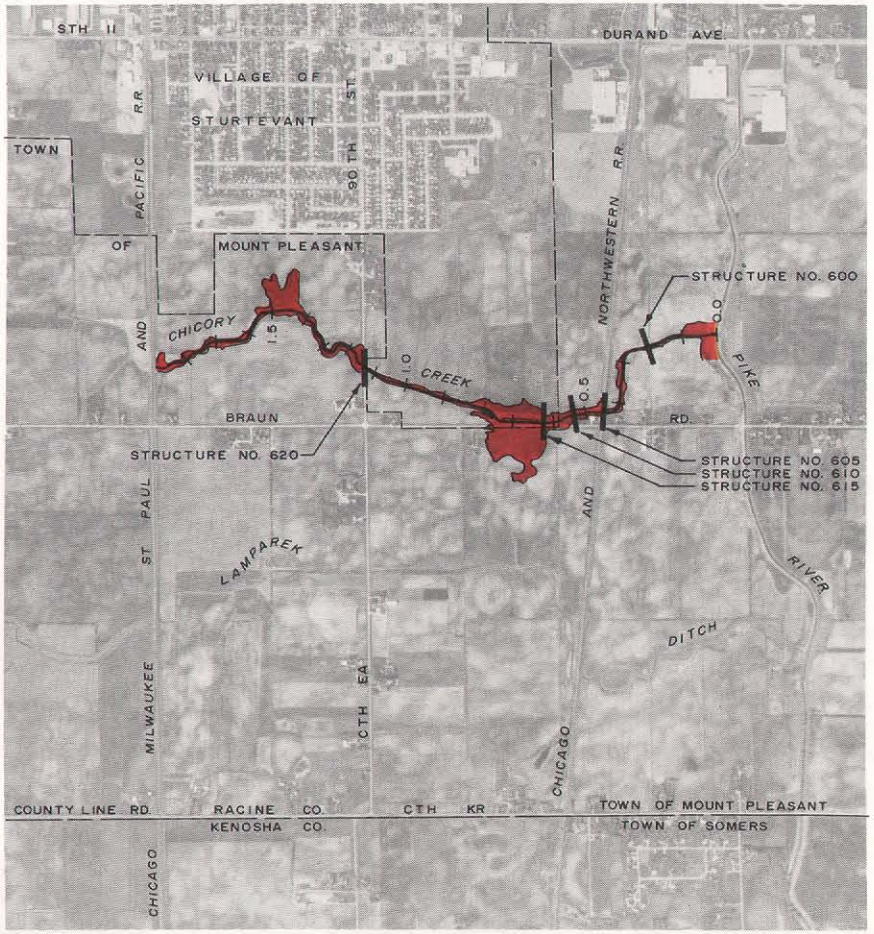
FLOOD STAGE AND STREAMBED PROFILE FOR LAMPAREK DITCH



Source: SEWRPC.

Map G-14

AERIAL PHOTOGRAPH SHOWING AREAS SUBJECT TO FLOODING ALONG CHICORY CREEK



LEGEND

APPROXIMATE EXISTING CHANNEL CENTERLINE AND RIVER MILE STATIONING

100-YEAR RECURRENCE INTERVAL FLOODLANDS--PLANNED LAND USE AND PLANNED CHANNEL CONDITIONS

100-YEAR RECURRENCE INTERVAL FLOODLANDS UNDER PLANNED LAND USE AND EXISTING CHANNEL CONDITIONS THAT WOULD BE ELIMINATED UNDER PLANNED CHANNEL CONDITIONS

NOTE: DUE TO MAP SCALE LIMITATIONS, THE DIFFERENCE BETWEEN THE 100-YEAR RECURRENCE INTERVAL FLOODLANDS UNDER PLANNED LAND USE AND EXISTING CHANNEL CONDITIONS, AND THE 100-YEAR RECURRENCE INTERVAL FLOODLANDS UNDER PLANNED LAND USE AND PLANNED CHANNEL CONDITIONS, MAY NOT APPEAR ON THIS MAP. WHERE NO DIFFERENCE APPEARS REFERENCE SHOULD BE MADE TO THE FLOOD STAGE PROFILE SHOWN BELOW.

GRAPHIC SCALE

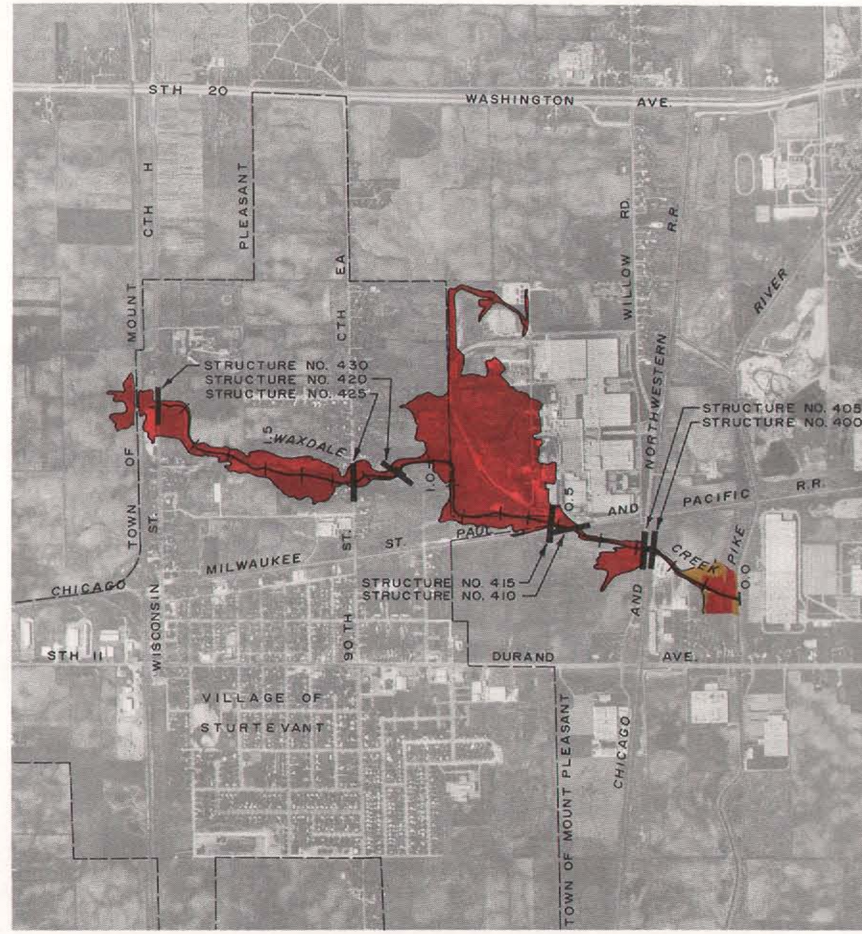
0 1/2 1 MILE

DATE OF PHOTOGRAPHY: APRIL 1980

Source: SEWRPC.

Map G-15

AERIAL PHOTOGRAPH SHOWING AREAS SUBJECT TO FLOODING ALONG WAXDALE CREEK



LEGEND

APPROXIMATE EXISTING CHANNEL CENTERLINE AND RIVER MILE STATIONING

100-YEAR RECURRENCE INTERVAL FLOODLANDS--PLANNED LAND USE AND PLANNED CHANNEL CONDITIONS

100-YEAR RECURRENCE INTERVAL FLOODLANDS UNDER PLANNED LAND USE AND EXISTING CHANNEL CONDITIONS THAT WOULD BE ELIMINATED UNDER PLANNED CHANNEL CONDITIONS

NOTE: DUE TO MAP SCALE LIMITATIONS, THE DIFFERENCE BETWEEN THE 100-YEAR RECURRENCE INTERVAL FLOODLANDS UNDER PLANNED LAND USE AND EXISTING CHANNEL CONDITIONS, AND THE 100-YEAR RECURRENCE INTERVAL FLOODLANDS UNDER PLANNED LAND USE AND PLANNED CHANNEL CONDITIONS, MAY NOT APPEAR ON THIS MAP. WHERE NO DIFFERENCE APPEARS REFERENCE SHOULD BE MADE TO THE FLOOD STAGE PROFILE SHOWN BELOW.

GRAPHIC SCALE

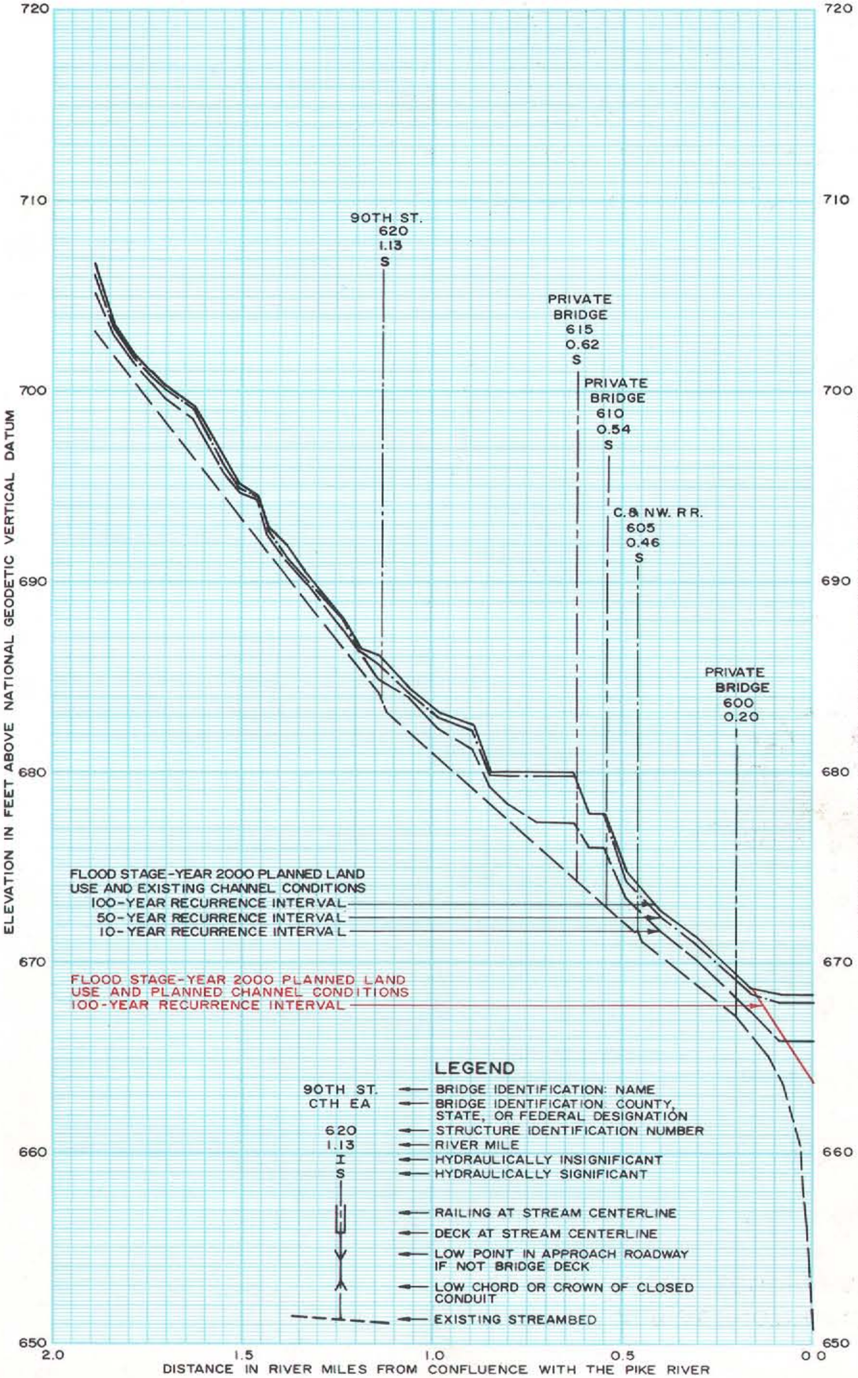
0 1/2 1 MILE

DATE OF PHOTOGRAPHY: APRIL 1980

Source: SEWRPC.

Figure G-14

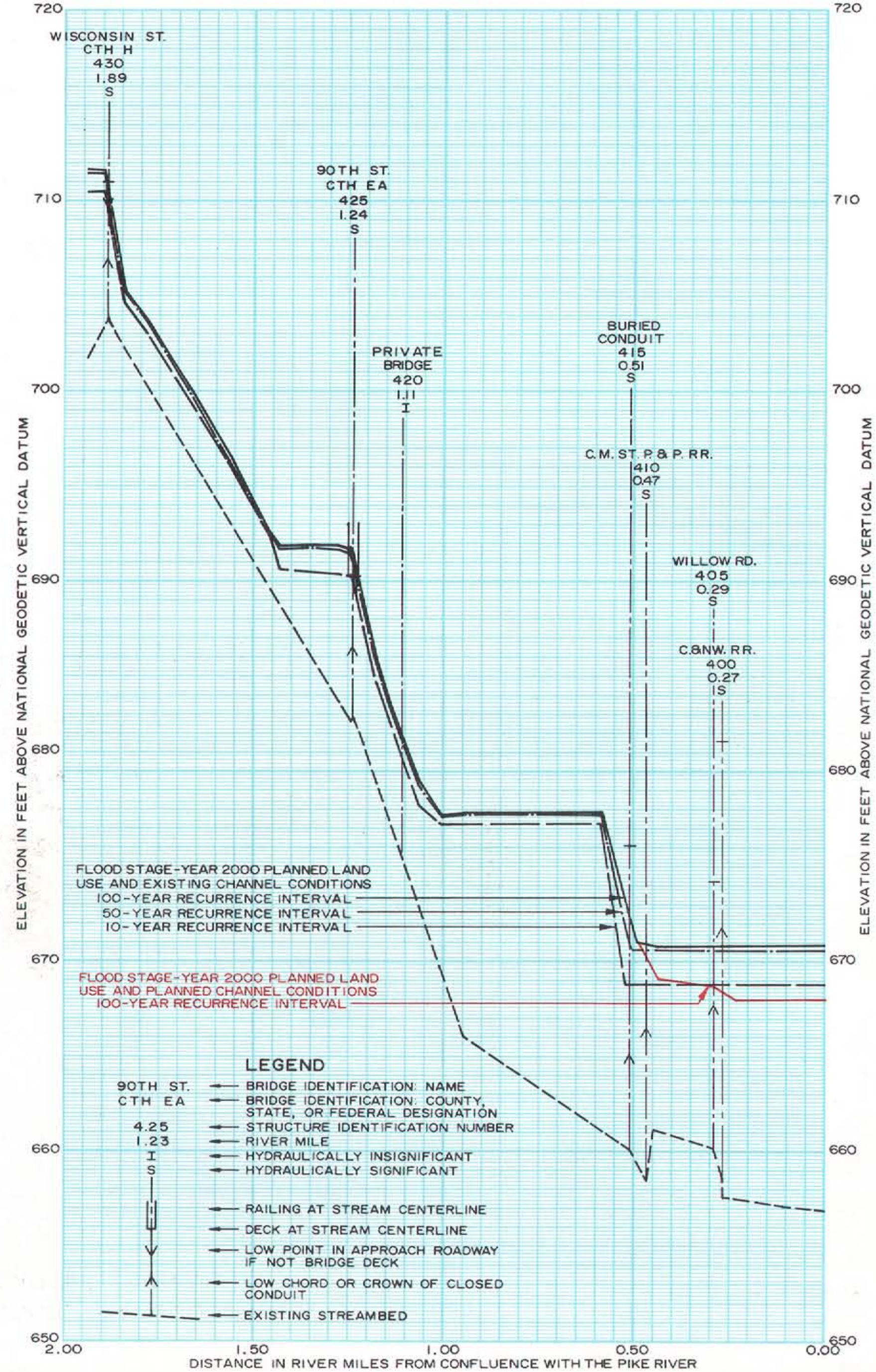
FLOOD STAGE AND STREAMBED PROFILE FOR CHICORY CREEK



Source: SEWRPC.

Figure G-15

FLOOD STAGE AND STREAMBED PROFILE FOR WAXDALE CREEK



Source: SEWRPC.

Map G-16

AERIAL PHOTOGRAPH SHOWING AREAS SUBJECT TO FLOODING ALONG BARTLETT BRANCH

LEGEND

0.1 — APPROXIMATE EXISTING CHANNEL CENTERLINE AND RIVER MILE STATIONING

100-YEAR RECURRENCE INTERVAL FLOODLANDS-- PLANNED LAND USE AND PLANNED CHANNEL CONDITIONS

100-YEAR RECURRENCE INTERVAL FLOODLANDS UNDER PLANNED LAND USE AND EXISTING CHANNEL CONDITIONS THAT WOULD BE ELIMINATED UNDER PLANNED CHANNEL CONDITIONS

NOTE: DUE TO MAP SCALE LIMITATIONS, THE DIFFERENCE BETWEEN THE 100-YEAR RECURRENCE INTERVAL FLOODLANDS UNDER PLANNED LAND USE AND EXISTING CHANNEL CONDITIONS, AND THE 100-YEAR RECURRENCE INTERVAL FLOODLANDS UNDER PLANNED LAND USE AND PLANNED CHANNEL CONDITIONS, MAY NOT APPEAR ON THIS MAP. WHERE NO DIFFERENCE APPEARS REFERENCE SHOULD BE MADE TO THE FLOOD STAGE PROFILE SHOWN BELOW.

GRAPHIC SCALE

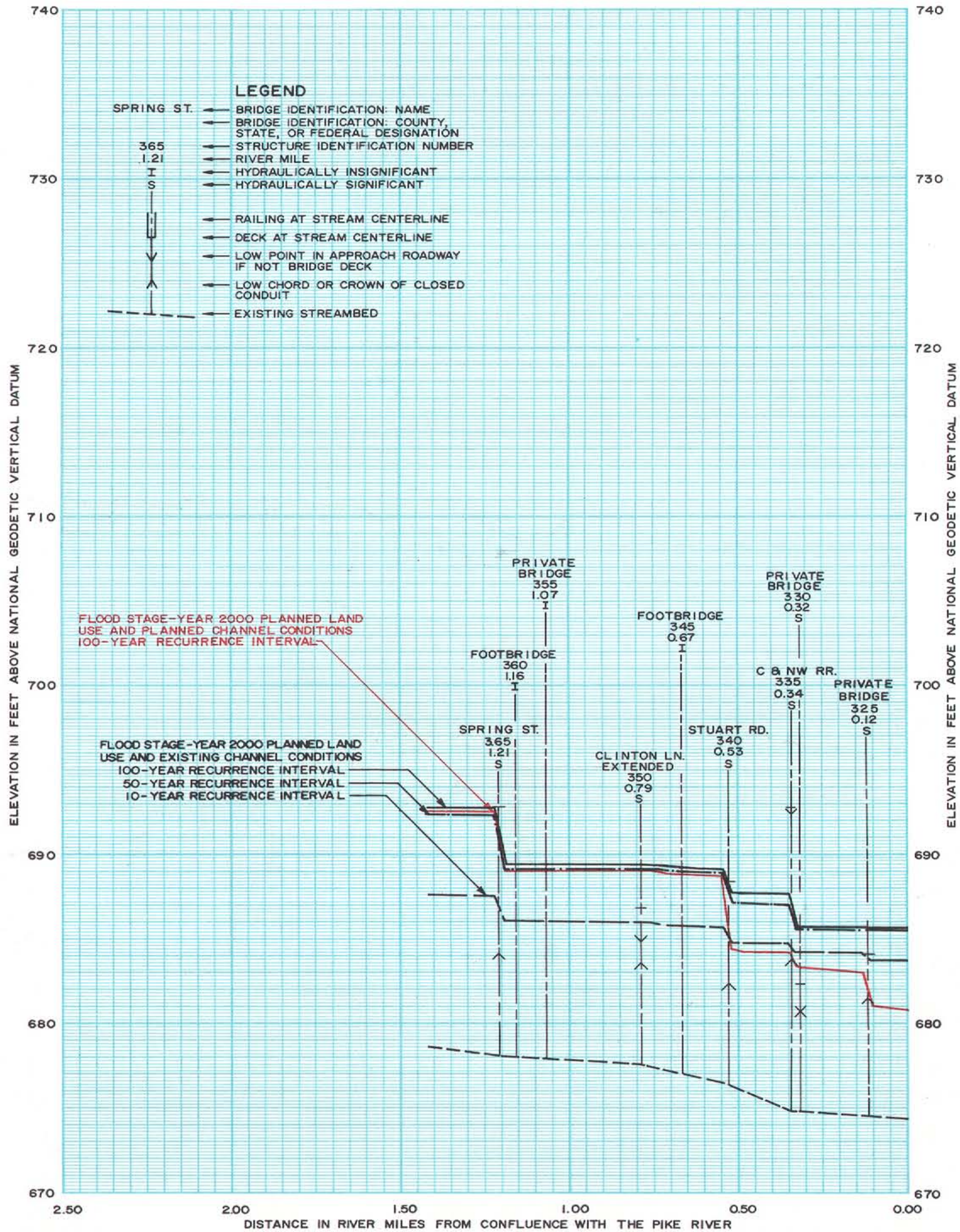
0 1/2 1 MILE

DATE OF PHOTOGRAPHY APRIL 1980

Source: SEWRPC.

Figure G-16

FLOOD STAGE AND STREAMBED PROFILE FOR BARTLETT BRANCH



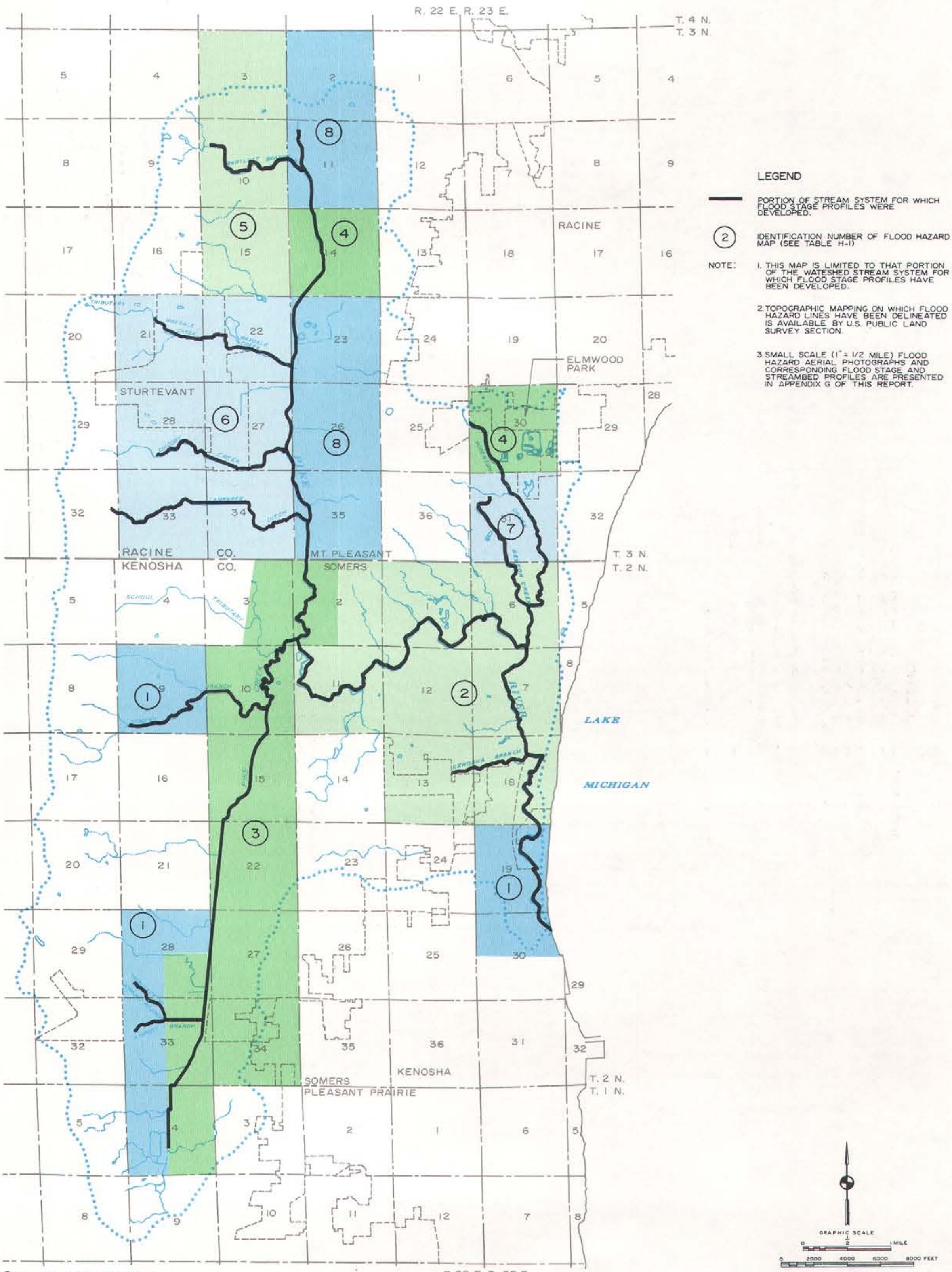
Source: SEWRPC.

Appendix H

LARGE-SCALE TOPOGRAPHIC FLOOD HAZARD MAPS FOR THE PIKE RIVER WATERSHED

Map H-1

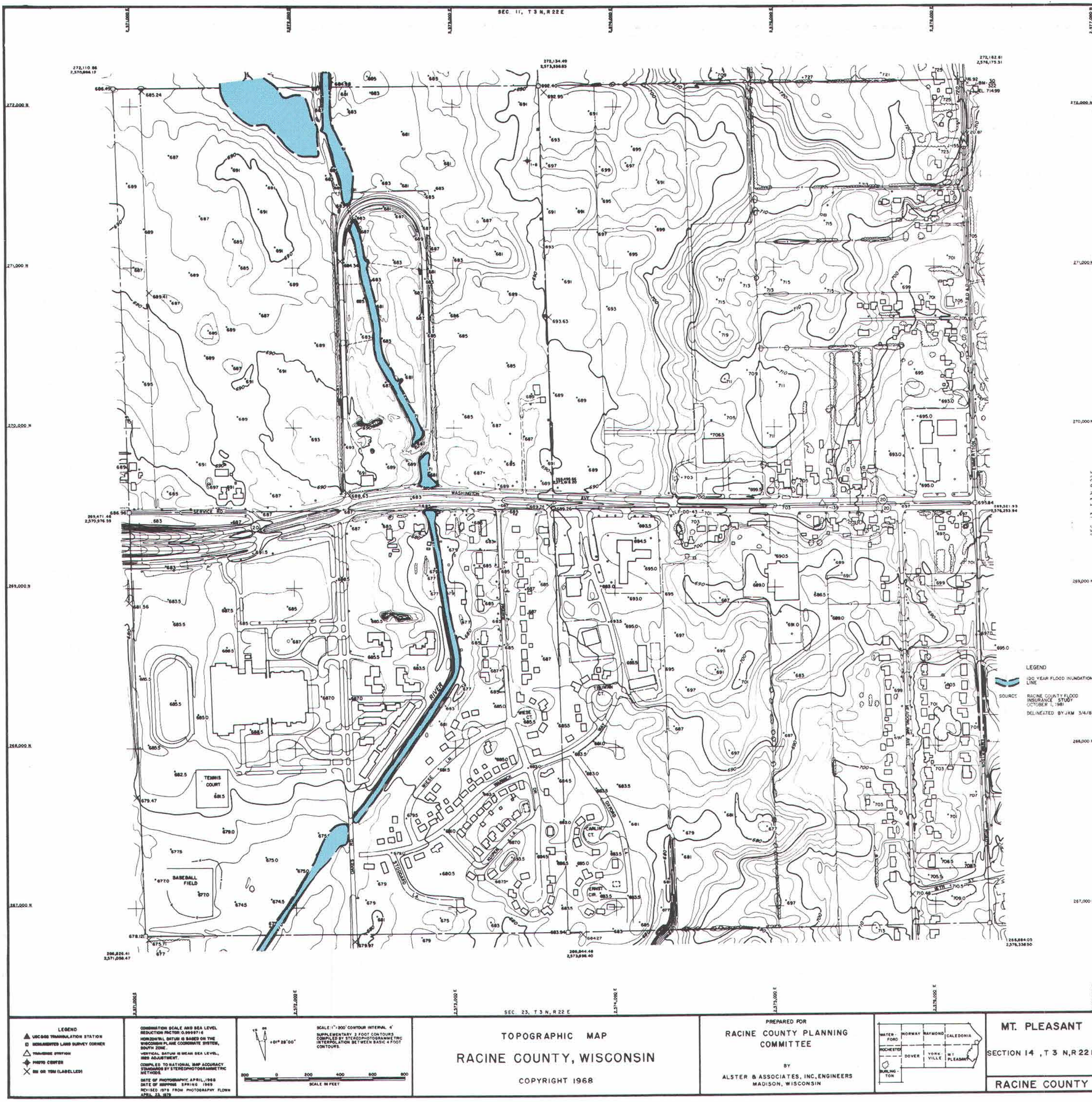
INDEX TO LARGE-SCALE TOPOGRAPHIC FLOOD HAZARD MAPPING IN THE PIKE RIVER WATERSHED: 1983



Source: SEWRPC.

Map H-2

TYPICAL FLOOD HAZARD MAP OF A PORTION OF THE PIKE RIVER WATERSHED



Source: Federal Emergency Management Agency, Racine County, and SEWRPC.

Table H-1

SELECTED INFORMATION PERTAINING TO LARGE-SCALE TOPOGRAPHIC FLOOD HAZARD MAPS IN THE PIKE RIVER WATERSHED[a]

County	Agency From Which Flood Hazard Mapping Can be Obtained	Identification Number on Map H-1	City, Village, or Town	Date of Photography Used for Map Preparation
Kenosha	Kenosha County Planning and Zoning Department	1	City of Kenosha Town of Somers	April 1979
		2	City of Kenosha Town of Somers	April 1970
		3	City of Kenosha Town of Somers	April 1966
Racine	Racine County Planning and Zoning Department	4	Town of Mt. Pleasant	April 1979
		5	Town of Mt. Pleasant	November 1974
		6	Village of Sturtevant	April 1973
		7	City of Racine Village of Elmwood Park Town of Mt. Pleasant	April 1969
		8	Town of Mt. Pleasant	April 1968

[a] *All topographic flood hazard maps are available at a scale of 1" = 200' with a contour interval of two feet.*

Source: SEWRPC.

Appendix I

STAFF-PROPOSED FISHERY RESOURCE DEVELOPMENT PLAN ELEMENT

The following discussion pertains to measures that may be taken within the Pike River watershed to enhance the fishery, given the framework of land use, park and open space, floodland management, and water quality recommendations set forth in this report. This discussion was originally presented by the study staff to the Pike River Watershed Committee, but was not endorsed by the Committee.

POTENTIAL FOR FISHERY DEVELOPMENT

Review of fishery data collected under the watershed study indicates that the Pike River watershed presently supports a dominance of fish that are generally tolerant of poor water quality conditions and degraded physical habitat provided by the stream channels. Certain reaches of the Pike River watershed stream system are nearly or entirely devoid of fish. Numerous adverse conditions have been created in the stream system by human activity in the watershed over the past 150 years, and particularly over the past 50 years, resulting in the destruction of a balanced fish population within the watershed. These adverse stream conditions are related to alterations both in water quality and in the physical habitat. The response of fish to such changes in their habitat over the short term may not always be as dramatically evident as a fish kill, although fish kills have occurred in the Pike River watershed, but in the long term the final result is the same. For example, adverse stream conditions may affect the natural reproduction of a fish species so that a few individuals are lost each year. Over time, the cumulative effects are such that the fish species within the watershed is extirpated.

The water pollution abatement measures recommended in the watershed plan constitute the most basic fishery enhancement measures possible. Improvement in water quality conditions may be expected to be accompanied by an improved fishery, at least in those stream reaches physically able to sustain a fishery. Certain additional measures may be taken in order to prevent the further decline of the Pike River watershed fishery and, to the extent practicable, rehabilitate the warmwater fishery, as well as enhance a limited sport fishery, within the Pike River watershed. These measures may be considered as accessory to the land use, park and open space, flood control, and water pollution abatement elements of the watershed plan.

In order to develop a set of management recommendations which will result in the maintenance and rehabilitation of a warmwater fishery within the Pike River watershed, it is necessary to identify the problems which have plagued the watershed in the past and continue to affect its fishery. Only by understanding these problems is it possible to consider the potential for changes in land and water resources management which could result in improvement in the fish habitat. The specific problems which have resulted in the degradation of the fishery include:

1. The draining and filling of wetlands adjacent to the stream system, which has resulted in a loss of fish spawning, nursery, and feeding areas.

2. The ditching and realignment of stream channels, which has resulted in a uniform aquatic environment where there was once a great heterogeneity in the form of alternating riffles, pools, and runs. This ditching and realignment of the stream channels has resulted in uniform bottom types and water velocities which limit the types of fish that can normally inhabit a stream system, and has thereby reduced the natural diversity.

3. Runoff from agricultural lands and construction sites which transports sediment into the stream system, filling pools, covering gravel beds and plants, clogging the gills of fish, increasing turbidity, interfering with the mating and feeding behavior of fish, and, through abrasive action, sometimes injuring fish.

4. Extreme fluctuations of water flow, which create alternating scouring and stagnant conditions within the stream system.

5. Runoff waters containing pesticides and fertilizers from urban and rural lands, sewage treatment plant effluent, industrial discharges, and chemical spills which have caused a decline in water quality conditions.

6. The lack of instream vegetation and cover, which has prevented fish from finding shelter from predators and sudden floods. Some fish species may not carry on normal reproductive activities without proper cover. In addition, the lack of vegetative cover for other aquatic organisms may reduce the food resources available to fish, thereby affecting their growth and reproductive capacity.

7. The Petrifying Springs County Park dam, the Kenosha Country Club spillway, and the fish gate at the Sheridan Road Bridge, as well as the occasional sandbars across the mouth of the Pike River, all inhibit the natural migration of fish up and down the stream system and into and out of Lake Michigan. These structures affect the reproductive habits and natural dispersal of fish species within the watershed. The recruitment of new fish species into depopulated areas is hampered or entirely prevented as a result of these obstructions.

8. As a result of the above-mentioned problems, the fish population of the Pike River watershed has reached a point where the natural source of "seed stock" necessary to restore the depopulated areas of the watershed is apparently lacking. Very tolerant fish, such as fathead minnow and carp, do well in the stream system; but intolerant species, such as darters, daces, and stonerollers, are lacking. Even such tolerant species as largemouth bass and bluegills would be more abundant in the Pike River watershed if a balanced fishery were present.

In an urbanizing watershed such as the Pike, it is not practicable to consider halting the historic trends in some of these factors. For example, the draining and filling of some wetlands along certain stream reaches and the ditching and realignment of stream channels may be expected to continue; indeed, the latter is recommended in the plan for flood control and damage purposes. Similarly, large fluctuations in streamflow cannot be totally avoided in an urbanizing watershed, where the stream system must serve urban storm water drainage purposes. On the other hand, remaining wetlands in some reaches can be protected, pollution and sediment loadings can be reduced, and certain measures, such as the revegetation of stream banks, can be undertaken.

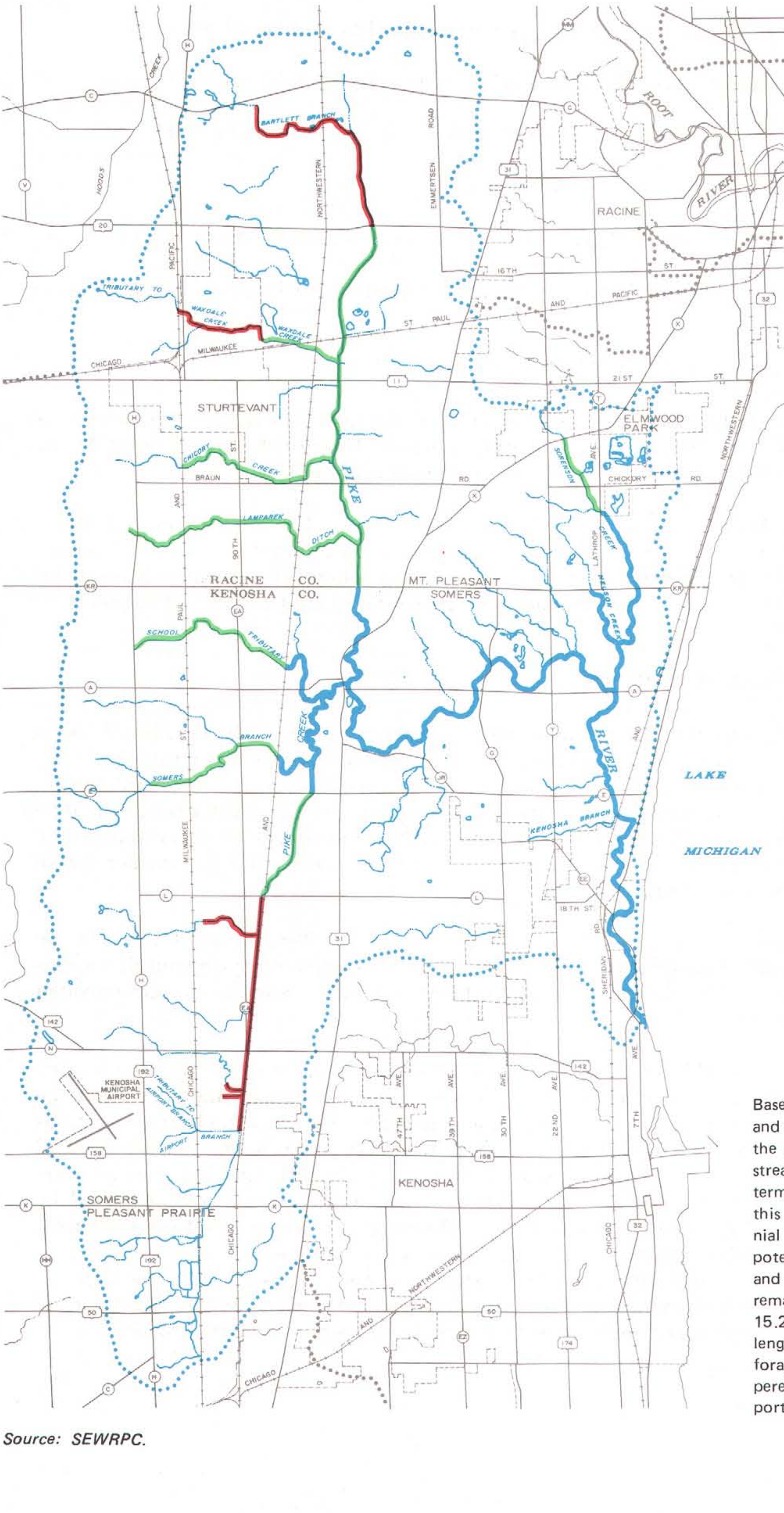
Based upon the Commission inventories of the fishery and related aquatic life, and of the physical features of the stream system, the Commission rated the various stream reaches of the Pike River and its tributaries in terms of their aquatic habitat potential. As shown on Map I-1, the following stream reaches, totaling 18.6 miles, or 46 percent of the total perennial stream length in the watershed, are considered potentially capable of supporting a balanced warmwater and anadromous, or seasonal, sport fishery:

- Pike River south of CTH KR in the Town of Somers and City of Kenosha.
- Sorenson Creek between Lathrop Avenue and its confluence with the Pike River in the Towns of Mt. Pleasant and Somers.
- Pike Creek between CTH E and its confluence with the Pike River in the Town of Somers.
- School Tributary east of the Chicago & North Western Railway to its confluence with the Pike Creek in the Town of Somers.
- Somers Branch Tributary east of the Chicago & North Western Railway to its confluence with the Pike Creek in the Town of Somers.

This rating assumes that physical barriers, such as dams, sills, weirs, and spillways, will be removed or altered to permit reestablishment of the fisheries in these stream reaches. Also shown on Map I-1 are the following stream reaches, totaling 15.2 miles, or 37 percent of the watershed, considered potentially capable of supporting a balanced forage fishery:

Map I-1

POTENTIAL FISHERY DEVELOPMENT BY STREAM REACH IN THE PIKE RIVER WATERSHED



Source: SEWRPC.

Based upon the Commission inventories of the fishery and related aquatic life, and of the physical features of the stream system, the Commission rated the various stream reaches of the Pike River and its tributaries in terms of their aquatic habitat potential. As shown on this map, 18.6 miles, or 46 percent of the total perennial stream length in the watershed, is considered potentially capable of supporting a balanced warmwater and anadromous, or seasonal, sport fishery. Of the remaining 22.0 miles of perennial stream length, 15.2 miles, or 37 percent of the total perennial stream length, is considered capable of supporting a balanced forage fishery, and 6.8 miles, or 17 percent of the total perennial stream length, is considered capable of supporting a limited forage fishery.

- The Pike River between STH 20 and CTH KR in the Town of Mt. Pleasant.
- Sorenson Creek between Pleasant Lane and Lathrop Avenue in the Town of Mt. Pleasant.
- Waxdale Creek east of the village limits of the Village of Sturtevant in the Town of Mt. Pleasant.
- Chicory Creek east of 90th Street in the Town of Mt. Pleasant.
- Lamparek Ditch east of CTH H in the Town of Mt. Pleasant.
- School Tributary between CTH H and the Chicago & North Western Railway in the Town of Somers.
- Somers Branch Tributary between CTH H and the Chicago & North Western Railway in the Town of Somers.
- Pike Creek between CTH L and CTH E in the Town of Somers.

Finally, as set forth on Map I-1, the remaining stream reaches, totaling 6.8 miles in length, or 17 percent of the watershed total, are considered capable of supporting only a limited forage fishery as a result of the major irreversible cultural modifications to the land surface and channel characteristics.

The two major factors of a good fishery are the presence of those species of fish necessary to provide recreational activity for people and a diversity of other fish species to provide a food base and overall stability to the stream community. To promote such a fishery, the following fish management measures should be considered as adjuncts to the land use, park and open space, flood control, and water pollution abatement plans for the watershed.

MEASURES TO MAINTAIN A MINIMUM FISHERY

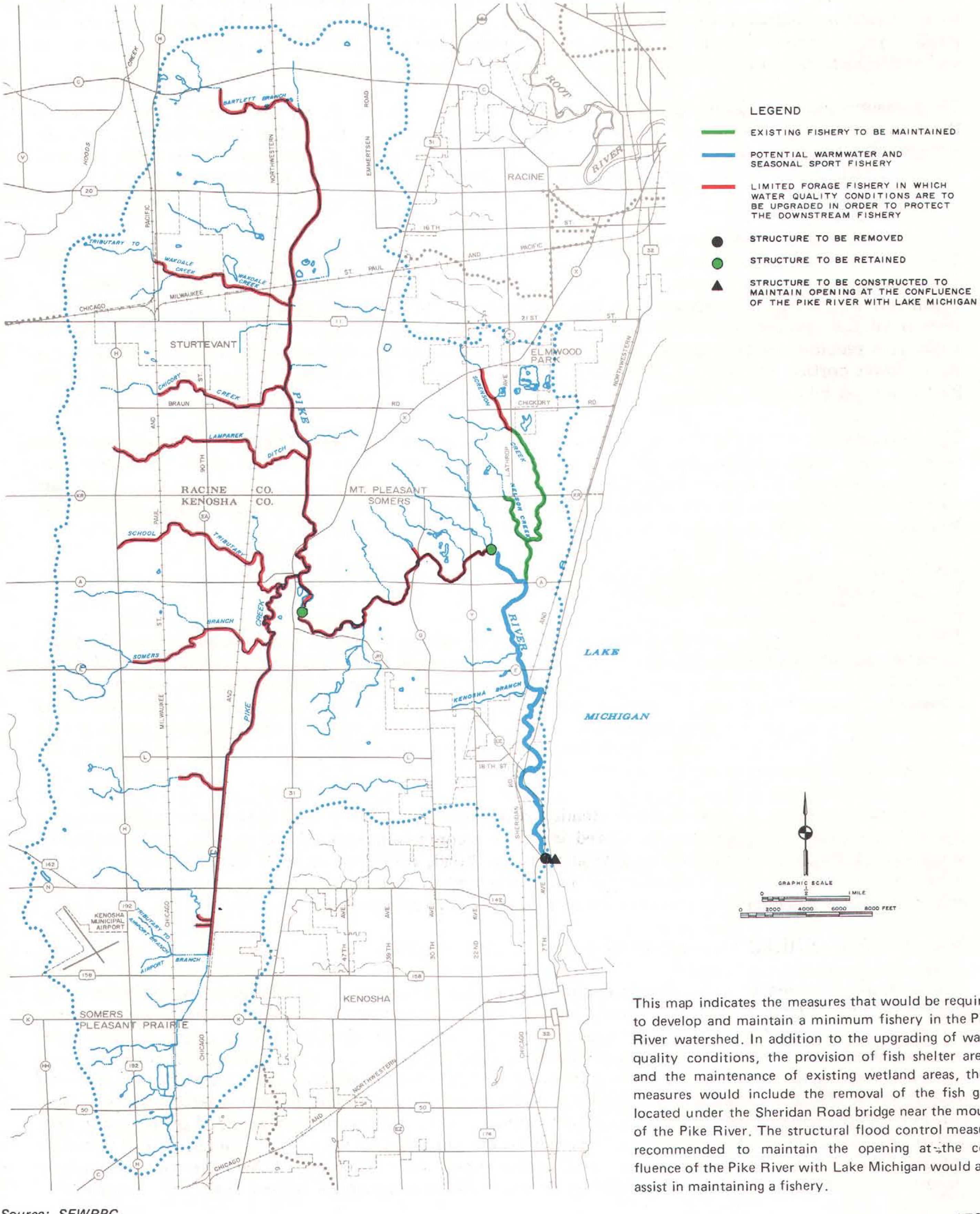
The measures that would be required to develop and maintain a minimum fishery in the Pike River watershed are indicated on Map I-2. These measures include the removal of the fish gate located under the Sheridan Road bridge near the mouth of the Pike River, which inhibits the migration of the larger salmonids. The structural flood control measure recommended to maintain the opening at the confluence of the Pike River with Lake Michigan would also assist in maintaining a fishery. These measures would accommodate the migration of both the larger fish species, such as salmonids and white suckers, and the smaller forage fish species, such as the daces, darters, and minnows.

The portion of Sorenson Creek between Lathrop Avenue in the Town of Mt. Pleasant and CTH A in the Town of Somers would be maintained in its present condition. This could be effected by the public acquisition of the primary environmental corridor along Sorenson Creek in the Town of Somers, as recommended in the park and open space plan element.

Water quality conditions in that reach of the Lower Pike River between the spillway of the dam located on the Kenosha Country Club grounds and the mouth of the Pike River should be upgraded to meet the adopted state warmwater fishery water quality objectives and standards. Sediment and concentrations of organic compounds which may be deposited in the lower reaches of the Pike River, causing stressful oxygen-demand conditions in the proposed fishery, should be limited. In addition, the discharge of toxic substances and leachates, including insecticides and herbicides, to the surface water system should be eliminated. This would be effected by implementation of the diffuse source water pollution abatement measures contained in the plan. Instream vegetation and bank cover which provide fish with shelter from predators, food, spawning areas, and protection from floods should be reestablished in this reach of the Pike River. In addition, the remaining wetland areas adjacent to the lower reaches of the Pike River should be maintained in order to provide spawning and feeding areas, as well as protective cover for fish fry.

Map I-2

MEASURES REQUIRED TO MAINTAIN A MINIMUM FISHERY IN THE PIKE RIVER WATERSHED



This map indicates the measures that would be required to develop and maintain a minimum fishery in the Pike River watershed. In addition to the upgrading of water quality conditions, the provision of fish shelter areas, and the maintenance of existing wetland areas, these measures would include the removal of the fish gate located under the Sheridan Road bridge near the mouth of the Pike River. The structural flood control measure recommended to maintain the opening at the confluence of the Pike River with Lake Michigan would also assist in maintaining a fishery.

Source: SEWRPC.

The dam located on the grounds of the Kenosha Country Club and the dam located in Petrifying Springs County Park and attendant impoundments would be maintained. These two dams, however, act as barriers to the upstream migration of fish species into the middle and upper reaches of the Pike River watershed stream system. Therefore, only a limited forage fishery may be expected to be supported in the middle and upper portions of the watershed under this fishery management proposal.

The measures required to maintain a minimum fishery in the Pike River watershed are all encompassed in the water resource management and related land use recommendations of the watershed plan with the exception of the removal of the fish gate at Sheridan Road. The cost of this removal is nominal, and such removal could be accomplished by existing Wisconsin Department of Natural Resources personnel.

MEASURES REQUIRED TO MAINTAIN AN EXTENDED MINIMUM FISHERY

The measures required to develop and maintain an extended minimum fishery are indicated on Map I-3. These measures include, in addition to the removal of the fish gate at Sheridan Road, the removal or modification of the dam located on the Kenosha Country Club grounds. This would allow the free migration of all fish species between the mouth of the Pike River and the impoundment in Petrifying Springs Park. This recommendation would provide for the maintenance of a warmwater fishery throughout the entire lower portion of the Pike River watershed and a limited forage fishery in the upper reaches of the Pike River and Pike Creek and their tributaries.

The measures required to maintain an extended minimum fishery in the Pike River watershed are all encompassed in the water resource management and related land use recommendations of the watershed plan, with the exception of the removal of the fish gate at Sheridan Road and the modification of the dam located on the Kenosha Country Club grounds. As noted above, the cost of the fish gate removal is nominal. Modification of the Kenosha Country Club dam would cost about $3,000.

MEASURES REQUIRED TO MAINTAIN AN EXTENDED MINIMUM AND SEASONAL SPORT FISHERY

The measures required to develop and maintain an extended minimum and seasonal sport fishery are indicated on Map I-4. A fish ladder would be installed adjacent to the dam in Petrifying Springs County Park similar to that shown in Figure I-1. Such a fish ladder would allow larger fish species, particularly the salmonids, to seasonally migrate into the upper portions of the Pike River and Pike Creek. Rehabilitation of the stream channels in the upper reaches of the Pike River, Pike Creek, and the tributaries to these two streams would not be necessary, as these fish would be transient and would not substantially add to the reproducing fish population of the Pike River watershed.

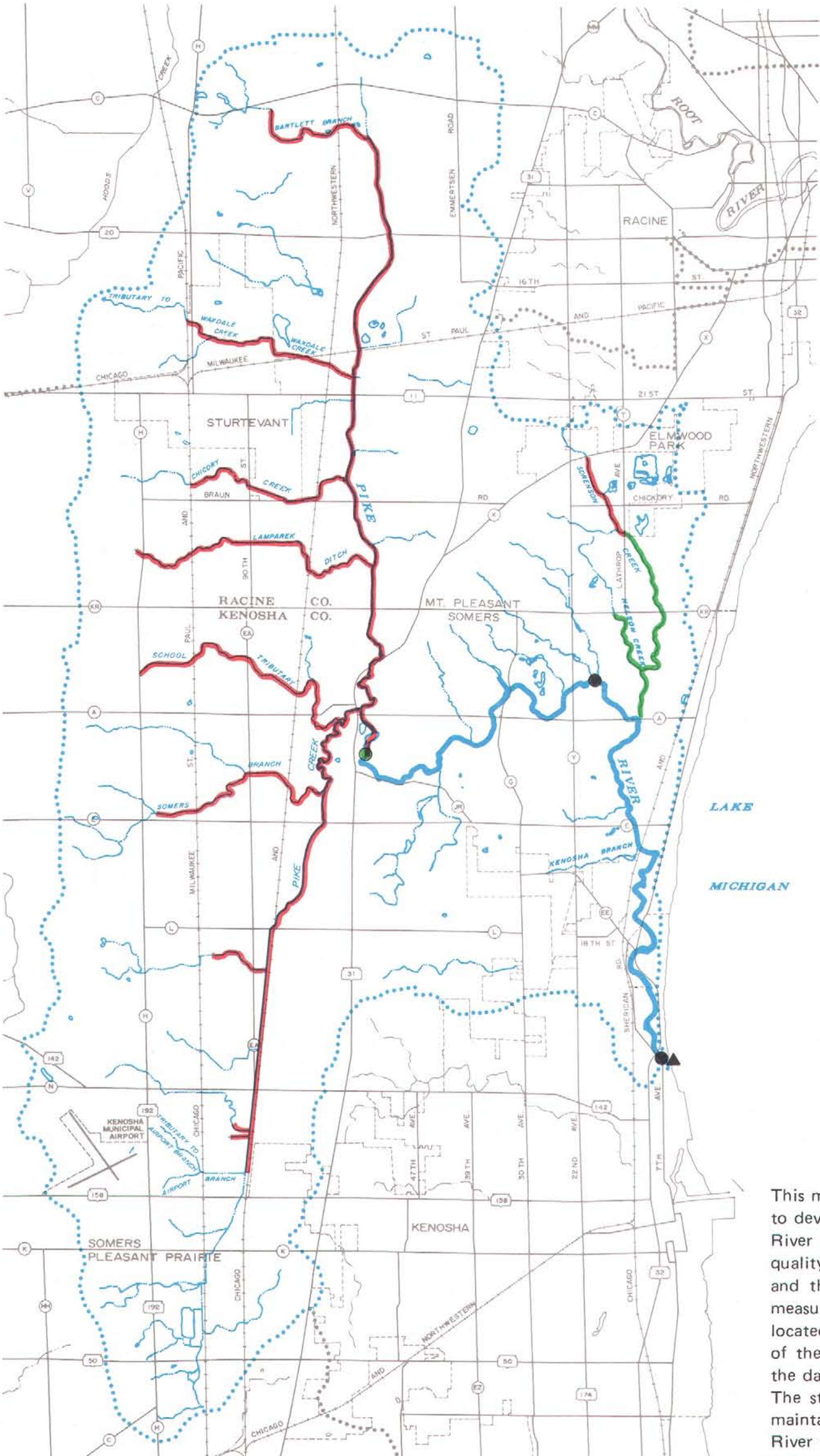
The measures required to maintain an extended minimum and seasonal sport fishery are encompassed in the water resource management and related land use recommendations of the watershed plan with the exception of the removal of the fish gate at Sheridan Road, which would have only a nominal cost; the modification of the Kenosha Country Club dam, estimated to cost $3,000; and the construction of a fish ladder at the Petrifying Springs County Park dam, estimated to cost $4,000.

MEASURES REQUIRED TO MAINTAIN A MAXIMUM FISHERY

The measures required to develop and maintain a maximum fishery in the Pike River watershed include the modification of the Kenosha Country Club and Petrifying Springs County Park dams, as well as extensive rehabilitation of the stream channels in the upper reaches of the Pike River, Pike Creek, and the tributaries of these two streams. Such stream channel rehabilitation would include channel realignment and habitat rehabilitation in order to provide a heterogeneity in the form of alternating riffles, pools, and runs; bottom substrate types; and water velocities in order to encourage a more natural diversity in the forage fish population. Banks adjacent to these stream reaches would need to be stabilized and planted with protective vegetative cover. The growth of instream vegetation would need to be encouraged, and wetlands adjacent to portions of the stream reaches would need to be restored. Because of these extensive efforts and the attendant costs required to undertake the development of a maximum fishery in the Pike River water-

Map I-3

MEASURES REQUIRED TO MAINTAIN AN EXTENDED MINIMUM FISHERY IN THE PIKE RIVER WATERSHED



LEGEND

- EXISTING FISHERY TO BE MAINTAINED
- POTENTIAL WARMWATER AND SEASONAL SPORT FISHERY
- LIMITED FORAGE FISHERY IN WHICH WATER QUALITY CONDITIONS ARE TO BE UPGRADED IN ORDER TO PROTECT THE DOWNSTREAM FISHERY
- STRUCTURE TO BE REMOVED OR MODIFIED
- STRUCTURE TO BE RETAINED
- STRUCTURE TO BE CONSTRUCTED TO MAINTAIN OPENING AT THE CONFLUENCE OF THE PIKE RIVER WITH LAKE MICHIGAN

GRAPHIC SCALE

0 ½ 1 MILE

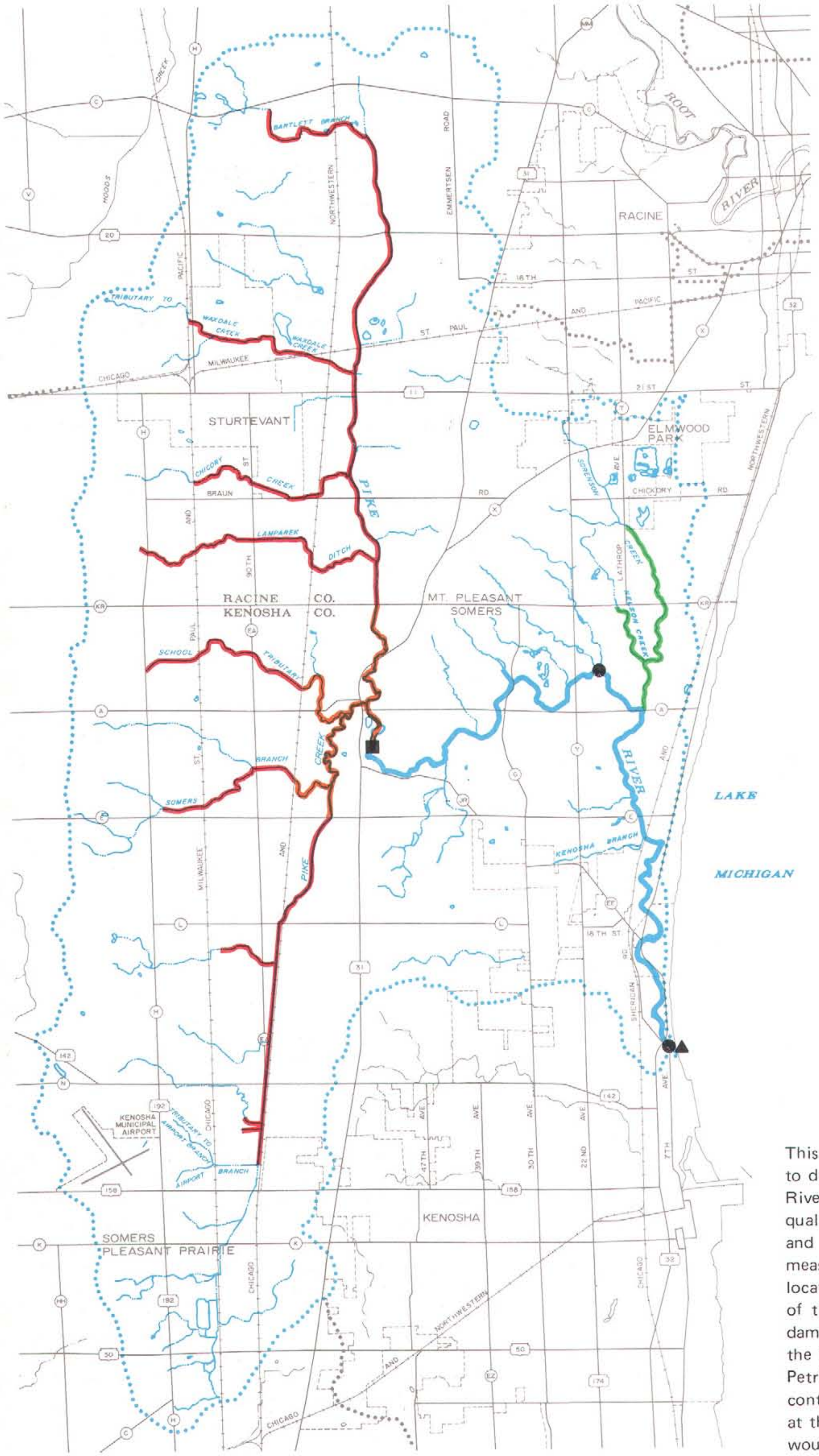
0 2000 4000 6000 8000 FEET

This map indicates the measures that would be required to develop and maintain a minimum fishery in the Pike River watershed. In addition to the upgrading of water quality conditions, the provision of fish shelter areas, and the maintenance of existing wetland areas, these measures would include the removal of the fish gate located under the Sheridan Road bridge near the mouth of the Pike River, and the removal or modification of the dam located on the Kenosha Country Club grounds. The structural flood control measure recommended to maintain the opening at the confluence of the Pike River with Lake Michigan would also assist in maintaining a fishery.

Source: SEWRPC.

Map I-4

MEASURES REQUIRED TO MAINTAIN AN EXTENDED MINIMUM AND SEASONAL SPORT FISHERY IN THE PIKE RIVER WATERSHED



This map indicates the measures that would be required to develop and maintain a minimum fishery in the Pike River watershed. In addition to the upgrading of water quality conditions, the provision of fish shelter areas, and the maintenance of existing wetland areas, these measures would include the removal of the fish gate located under the Sheridan Road bridge near the mouth of the Pike River, the removal or modification of the dam located on the Kenosha Country Club grounds, and the installation of a fish ladder adjacent to the dam in Petrifying Springs County Park. The structural flood control measure recommended to maintain the opening at the confluence of the Pike River with Lake Michigan would also assist in maintaining a fishery.

Source: SEWRPC.

shed, and because of the need to undertake channel improvements on the Pike Creek and Upper Pike River for flood control and drainage purposes, this alternative was not recommended for further consideration by the Watershed Committee.

CONCLUDING REMARKS—FISHERY DEVELOPMENT

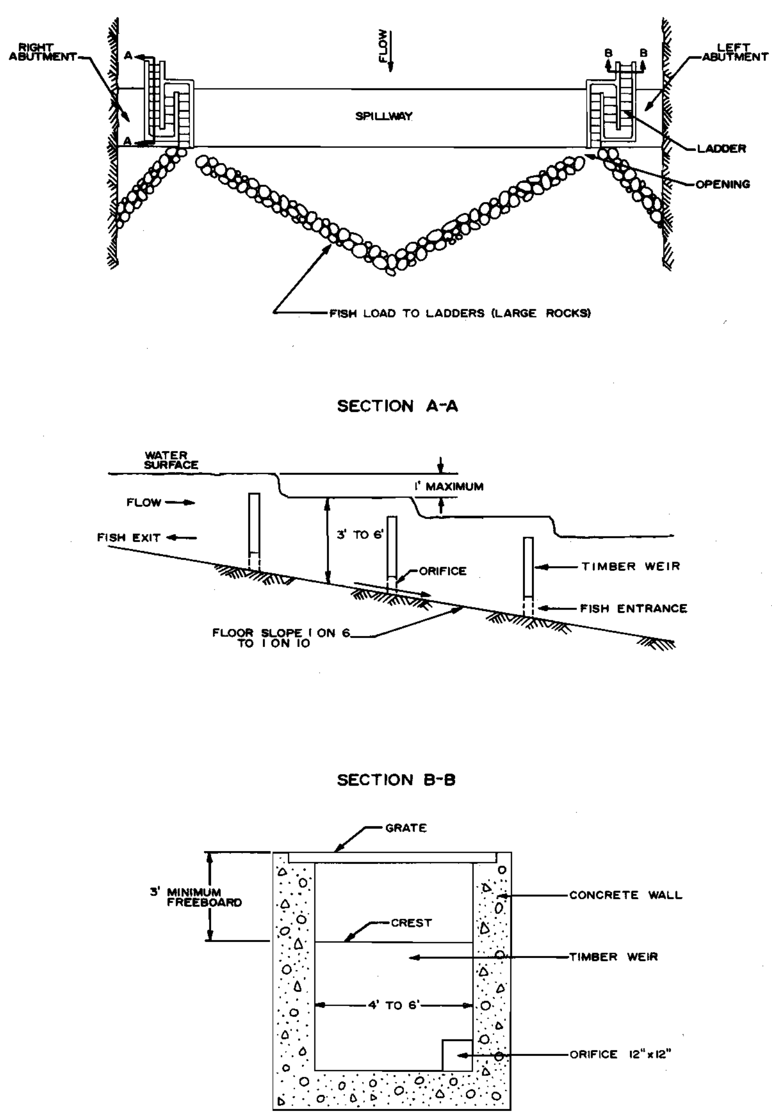
Given the relatively modest costs of enhancing the fishery resource in the Pike River watershed, it is recommended that the following measures be included in the watershed plan:

1. Removal of the fish gate across the Pike River at Sheridan Road in the City of Kenosha.
2. Modification of the Kenosha Country Club dam on the Pike River to permit upstream fish migration.
3. Construction of a fish ladder at the Petrifying Springs County Park dam on the Pike River to permit upstream fish migration.

Figure I-1

INSTALLATION OF A FISH LADDER AT THE PETRIFYING SPRINGS COUNTY PARK DAM ON THE PIKE RIVER

PLAN VIEW



Source: SEWRPC.

Appendix J

MODEL RESOLUTION FOR ADOPTION OF THE COMPREHENSIVE PLAN FOR THE PIKE 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 County Boards of the Counties of Kenosha and Racine in late 1978 approved participation by the Counties in the development of a comprehensive plan by the Southeastern Wisconsin Regional Planning Commission for the Pike River watershed leading to recommendations for the development of water-related community facilities in the watershed, including integrated proposals for water pollution abatement, flood control, land and water use, and park and public open space reservation, to generally promote the orderly and economical development of the Pike River watershed; and

WHEREAS, such plan has been completed and the Southeastern Wisconsin Regional Planning Commission did on the 16th day of June 1983 approve a resolution adopting the comprehensive plan for the Pike 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 preservation; park and outdoor recreation land acquisition and development; channel modification and dike construction; structure floodproofing; bridge replacement or modification; floodway and floodplain regulations; 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 Pike 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. 35, A Comprehensive Plan for the Pike River Watershed, published in June 1983; and

WHEREAS, the Commission has transmitted certified copies of its resolution adopting such comprehensive plan for the Pike River watershed, together with the aforementioned SEWRPC Planning Report No. 35, 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 Pike River watershed prepared by the Commission is a valuable guide to the development of not only the watershed but the community, and that 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 ____________, 19__, hereby adopts the comprehensive plan for the Pike River watershed previously adopted by the Commission as set forth in SEWRPC Planning Report No. 35 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)