COMMUNITY ASSISTANCE
PLANNING REPORT NO. 130

A STORMWATER DRAINAGE AND FLOOD CONTROL POLICY PLAN FOR THE MILWAUKEE METROPOLITAN SEWERAGE DISTRICT

SOUTHEASTERN WISCONSIN REGIONAL PLANNING COMMISSION

MILWAUKEE METROPOLITAN SEWERAGE DISTRICT

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Special acknowledgement is due Gary A. Gagnon, Senior Project Administrator, Milwaukee Metropolitan Sewerage District, for his contribution to the preparation of this report.

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A STORMWATER DRAINAGE AND FLOOD CONTROL POLICY PLAN FOR THE MILWAUKEE METROPOLITAN SEWERAGE DISTRICT

Prepared by the

Southeastern Wisconsin Regional Planning Commission
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March 1986

Inside Region $2.50
Outside Region $5.00

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SOUTHEASTERN WISCONSIN REGIONAL PLANNING COMMISSION

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STATEMENT OF THE EXECUTIVE DIRECTOR

Stormwater drainage and flood control facilities are among the most important of public works influencing the development of an urbanizing region. The location and adequacy of these facilities affect the public health, safety, and welfare; the overall quality of the environment; recreational activities; industrial productivity; and the value and use to which land may be put and, therefore, property values. If not properly attended to, stormwater drainage and flood control systems development will inevitably emerge as a major obstacle to the sound growth and development of the area and become a major issue facing public officials, citizen leaders, and technicians.

Recognizing the need for a plan that could be used to guide the development, over time, of drainage and flood control facilities within the greater Milwaukee area, the Milwaukee Metropolitan Sewerage District on January 25, 1985, requested the Southeastern Wisconsin Regional Planning Commission to prepare, in cooperation with the District, a comprehensive stormwater drainage and flood control plan. That plan was to consist of two elements—a policy plan and a system plan.

This report sets forth the recommended policy plan element of the overall drainage and flood control plan for the greater Milwaukee area. The recommended policy plan identifies those streams and watercourses for which the District, as an areawide agency, should assume jurisdiction; identifies the types of improvements for which the District should assume responsibility; and sets forth the manner in which improvement costs are to be shared between the District and benefited local municipalities. The recommended policy plan also provides a basis for prioritizing and scheduling the needed drainage and flood control improvements to be constructed by the District.

The policy plan was prepared by the staffs of the Regional Planning Commission and Milwaukee Metropolitan Sewerage District, working under the guidance of an Advisory Committee which includes representatives of local municipalities, the County, the Wisconsin Department of Natural Resources, the District, and the Regional Planning Commission, as well as of the citizen body.

The policy plan for drainage and flood control works as set forth in this report provides the basis for the development of the system plan and plan implementation program that will resolve the areawide, multi-community drainage and flood control problems of the greater Milwaukee area in the most cost-effective manner possible, and provide for a fair and equitable distribution of the costs entailed between the District and local municipalities concerned.

The Advisory Committee and the Regional Planning Commission respectfully recommend adoption of this policy plan to the District. The Commission and Commission staff stand ready to assist the District in considering adoption of, and in administering over time, this policy plan.

Respectfully submitted,

Kurt W. Bauer
Executive Director

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Chapter I

INTRODUCTION

The Milwaukee Metropolitan Sewerage District is charged by Section 66.89 of the Wisconsin Statutes with the function and duty of planning, designing, constructing, maintaining, and operating a sewerage system for the collection, transmission, and disposal of all sewage and drainage generated within its service area. Specifically, that function and duty includes the provision and management of a system of facilities for the collection, transmission, and disposal of stormwater and groundwater, as well as of sanitary sewage. The District is accordingly authorized to plan, design, construct, maintain, and operate storm sewers and other facilities and structures for the collection and transmission of stormwater and is authorized to improve watercourses within the District by deepening, widening, or other changes needed to carry off surface or drainage waters.[1] The District is also authorized to make such improvements outside the geographic limits of the District on any watercourses that flow out of the District and may divert stormwater from surface watercourses into drains, conduits, and storm sewers. Sound public administration, as well as good planning and engineering practice, dictates that these broad responsibilities for stormwater management be carried out within explicit policy guidelines set forth by the governing body of the District, as well as within the context of a comprehensive stormwater drainage and flood control system plan consistent with those policies.

Recognizing the need for both a policy plan and system plan that could be used to guide the development over time of drainage and flood control facilities within the greater Milwaukee area, the Milwaukee Metropolitan Sewerage District on January 25, 1985, requested the Southeastern Wisconsin Regional Planning Commission to prepare, in cooperation with the District, a comprehensive stormwater drainage and flood control plan. That plan was to consist of two elements—a policy plan and a system plan. In response to that request, the Commission prepared a prospectus documenting the need for the requested plan, specifying the scope and content of that plan, and identifying the work required to produce the plan, together with means for funding and accomplishing that work.[2] Based upon that prospectus, a contract governing the preparation of the desired policy and system plans was entered into between the District and the Commission on April 22, 1985.

NEED FOR A STORMWATER DRAINAGE AND FLOOD CONTROL PLAN

Stormwater drainage and flood control facilities are among the most important of public works influencing the development of an urbanizing region. The location and adequacy of these facilities affect the public health, safety, and welfare; the overall quality of the environment; recreational activities; industrial productivity; and the value and use to which land may be put and, therefore, property values. If not properly attended to, stormwater drainage and flood control system development will inevitably emerge as a major obstacle to the sound growth and development of an area and become a major issue facing public officials, citizen leaders, and technicians.

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[1] *Implementation of certain drainage and flood control improvements within the existing geographical jurisdiction of the Milwaukee Metropolitan Sewerage District may require the prior approval of certain regulatory agencies, including the Wisconsin Department of Natural Resources and the U. S. Army Corps of Engineers. The regulatory process involved is complex and has been the subject of extended discussion between the District and the regulatory agencies concerned. Accordingly, the District should seek legal counsel prior to proceeding with any drainage or flood control project that involves the construction or hydraulic improvement of artificial waterways connecting to navigable waters; the alteration or enclosure of navigable waterways; the placement of deposits or structures in the bed of navigable waterways; the removal of material from the beds of navigable waterways; or the filling of wetlands.*

[2] *Stormwater Drainage and Flood Control Planning Program Prospectus for the Milwaukee Metropolitan Sewerage District, SEWRPC, March 1985.*

Stormwater drainage and flood control planning efforts of various types are not new to the geographic area served by the Milwaukee Metropolitan Sewerage District. Such studies have been carried out at various times in the past by many of the 18 incorporated municipalities which comprise the District, as well as by Milwaukee County and the District and its predecessor agencies. Importantly, in 1986 the Southeastern Wisconsin Regional Planning Commission will have completed comprehensive watershed plans for the five major watersheds which lie wholly or partly within the District, as shown on Map 1. These watershed plans identify the flooding and water pollution problems existing within each watershed and make recommendations for the resolution of these problems. These watershed plans, which are documented in a series of planning reports, were prepared over an almost 20-year period, with the first of such plans, that for the Root River watershed, having been completed in 1966 and the last in 1986.[3] These watershed plans address flooding as opposed to drainage problems.[4] Nevertheless, if supplemented as necessary to address drainage as well as flood problems, and if integrated over the geographic area of the District, these watershed plans provide a sound basis for the development of a comprehensive stormwater drainage and flood control plan for the District.

The completed watershed studies document potential monetary flood damages along perennial streams within the Milwaukee Metropolitan Sewerage District and environs totaling about $33.3 million for a 100-year recurrence interval flood event and almost $2.5 million on an average annual basis expressed in 1985 dollars. The major flood-prone reaches, as shown on Map 2, include, among others, reaches of the Root, Milwaukee, and Menomonee Rivers and Oak Creek, Underwood Creek, Wilson Park Creek, and Lincoln Creek. These damages affect literally thousands of residences, businesses, and industries, as well as public buildings and facilities, and are accompanied by severe public safety and health hazards. These damages are, moreover, attributable solely to flooding, as defined by the Regional Planning Commission, and exclude damages caused by inadequate drainage or by the surcharging of sanitary sewers. Clearly, drainage and flood control problems within the District are real, costly, and well documented, and deserve resolution by the District and the local municipalities concerned.

In addition to the need to abate the serious and costly flood problems which are known to exist within the District, at least four factors contribute to the need for the preparation of a stormwater drainage and flood control plan for the District at this time. These are:

1. The need to review, update, and integrate into a single policy and system plan and plan implementation program the flood control recommendations contained in the comprehensive watershed plans completed for the five watersheds lying wholly or partly within the Milwaukee Metropolitan Sewerage District.

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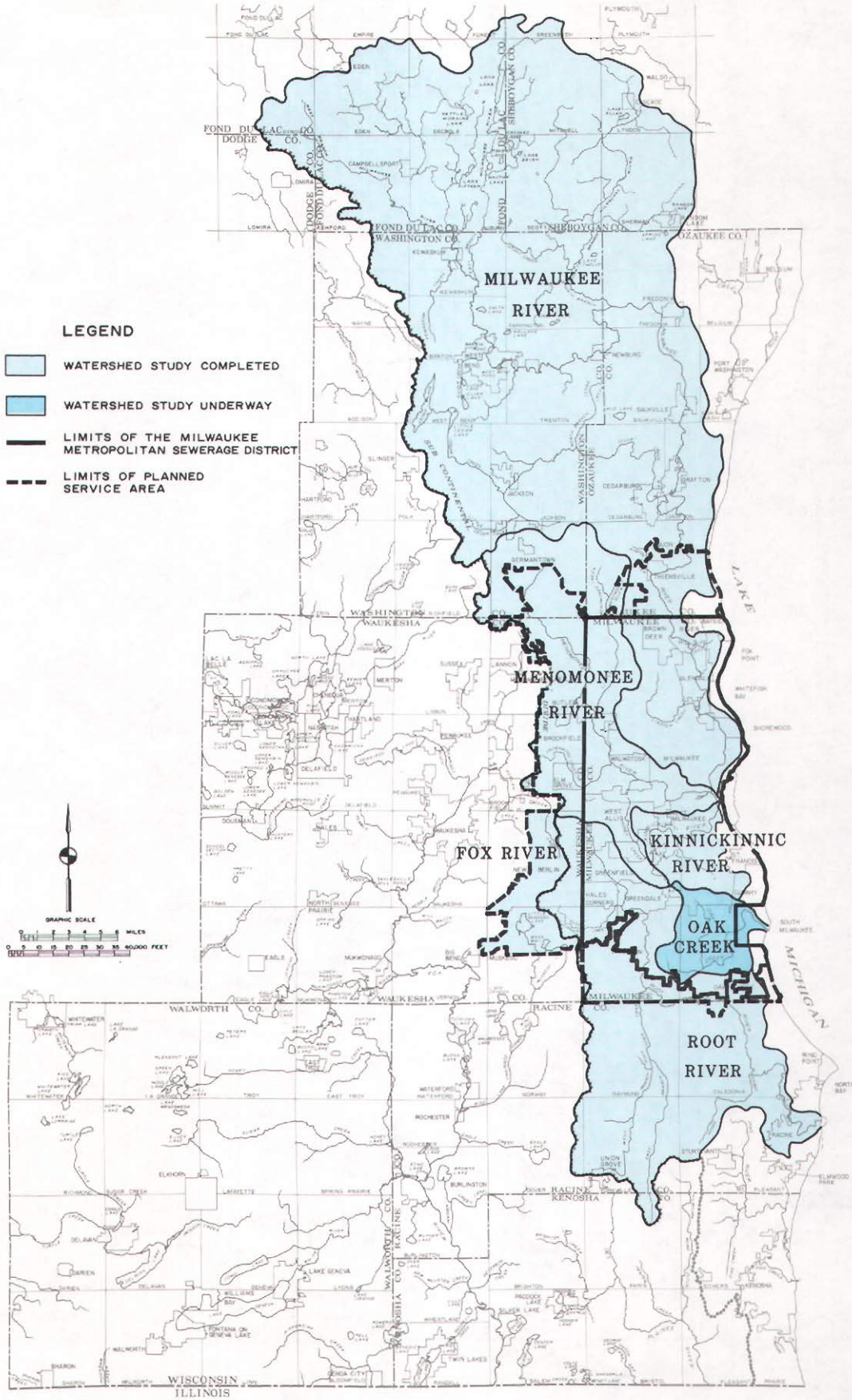
[3] *SEWRPC Planning Report No. 9, A Comprehensive Plan for the Root River Watershed, September 1966; SEWRPC Planning Report No. 13, A Comprehensive Plan for the Milwaukee River Watershed Volume One, Inventory Findings and Forecasts, December 1970, and Volume Two, Alternative Plans and Recommended Plan, October 1971; SEWRPC Planning Report No. 26, A Comprehensive Plan for the Menomonee River Watershed, Volume One, Inventory Findings and Forecasts, October 1976, and Volume Two, Alternative Plans and Recommended Plan, October 1976; SEWRPC Planning Report No. 32, A Comprehensive Plan for the Kinnickinnic River Watershed, December 1978; SEWRPC Planning Report No. 36, A Comprehensive Plan for the Oak Creek Watershed, to be published in 1986; and SEWRPC Community Assistance Planning Report No. 13 (2nd Edition), Flood Control Plan for Lincoln Creek, Milwaukee County, Wisconsin, September 1982.*

[4] *The Regional Planning Commission has, for planning and engineering purposes, differentiated between flooding and stormwater drainage problems. Flooding problems have been defined as caused by the inundation of the natural floodlands of a watershed that occurs along the major river and stream channels as a direct result of water moving out of, and away from, those channels. Stormwater drainage problems have been defined as resulting from inundation that occurs when stormwater runoff moving toward rivers and streams and other low-lying areas of a watershed encounters inadequate conveyance or storage facilities and results in localized ponding and surcharging of natural watersheds and artificial storm sewers. Different techniques are thus required to define and address these two problems.*

Map 1

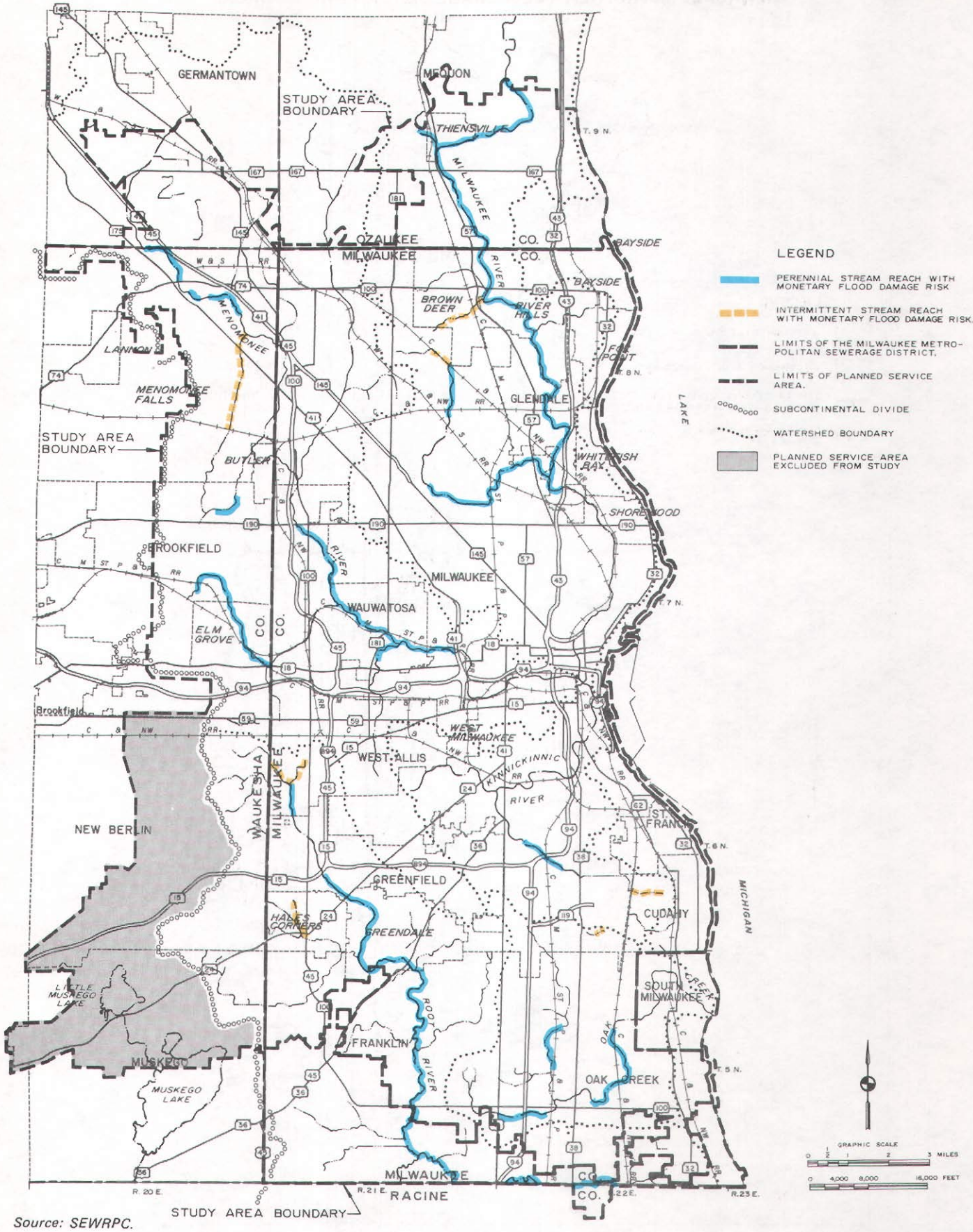
STATUS OF WATERSHED PLANNING WITHIN THE MILWAUKEE METROPOLITAN SEWERAGE DISTRICT AND ENVIRONS



Source: SEWRPC.

Map 2

MAJOR FLOOD DAMAGE PRONE STREAM REACHES WITHIN THE MILWAUKEE METROPOLITAN SEWERAGE DISTRICT AND ENVIRONS



Source: SEWRPC.

Such review, reevaluation, and integration is required in order to determine whether the flood control recommendations contained within the watershed plans are still valid, given changes which may have occurred since the adoption of some of the plans; to bring the costs and benefits to a common base year; and, importantly, to establish priorities for the needed projects between watersheds.

2. The need to expand the scope of the completed comprehensive watershed plans to include consideration of drainage as well as flooding problems, thereby more fully responding to the statutory functions and duties of the District.

3. The need to provide the Milwaukee Metropolitan Sewerage District, as an agency, with the documented stormwater drainage and flood control plan which good public administration and planning and engineering practice would dictate be available as a guide to District actions over time directed at the abatement of drainage and flood control problems.

   It is axiomatic that drainage and flood control facilities must function as integrated systems over entire watersheds and that system plans are, therefore, required for the resolution of drainage and flooding problems. Since the Milwaukee Metropolitan Sewerage District encompasses a number of watersheds, however, it is evident that the proper execution of the District drainage and flood control responsibilities also requires the integration of the flood control recommendations contained in plans for the individual watersheds across the entire District.

4. The need to provide an opportunity for the local municipalities comprising the Milwaukee Metropolitan Sewerage District and Milwaukee County, and for concerned citizens, to participate in the necessary policy and system plan formulation.

   As already noted, drainage and flooding problems are among the most serious and costly problems of concern to local units of government and affected citizens. Such problems not only result in property damage and disruption of socioeconomic activities, but may constitute serious threats to public health and safety. Such problems, moreover, affect the development potential of real property and, therefore, property values. Accordingly, the local municipalities and individual citizens affected by, and concerned about, these problems should be afforded an opportunity to guide the formulation of a District drainage and flood control policy and system plan. Only if a true consensus is achieved on the location, extent, and severity of the problems, and on the most effective solutions thereto, among all of the interests concerned can a plan be said to exist within the District.

PURPOSE OF A STORMWATER DRAINAGE AND FLOOD CONTROL PLAN

The primary purpose of the District drainage and flood control planning program is the development of two separate but interrelated plans to guide the staged development of needed drainage and flood control facilities within the District, while promoting implementation of adopted local and areawide land use plans and assuring the protection and wise use of the natural resource base. The resulting plans are intended to provide the responsible public officials with technically sound guides that can be used in the making of decisions concerning the need for, most effective means of, and desirable scheduling of the construction of needed drainage and flood control works. More specifically, the plans would:

1. Identify those streams and watercourses for which the Milwaukee Metropolitan Sewerage District should assume jurisdiction for the resolution of drainage and flood control problems.[5]

2. Provide the technical staffs concerned with a complete and definitive inventory of the location and capacity of all of the streams and watercourses for which the District should assume jurisdiction. This inventory

[5] *It is recognized that, given the State Statutes governing the operation of the District, the term "jurisdiction" may have certain legal implications. Within the context of this policy plan, however, the term is defined to mean those streams and watercourses for which the District is recommended to act as the primary management agency with respect to the construction and maintenance of needed drainage and flood control works.*

would provide the data on the physical characteristics of the drainage structures and intervening stream reaches necessary to permit calculation of flood flows and stages and channel capacities, identification of reaches of inadequate capacity, and identification of the causes of those inadequacies.

3. Provide elected and appointed public officials and concerned citizens with accurate information on the existing and probable future drainage and flood control problems within the District; on their locations, extent, and severity; and on the most effective means for their resolution.

As already noted, the prospectus specifies that the drainage and flood control plan is to consist of two elements—a policy plan and a system plan. The system plan is to identify the type, general location, and horizontal and vertical alignments of needed drainage and flood control facilities. To this end, the system plan will recommend the approximate elevation, size, grade, and capacity of channels and appurtenant bridge waterway openings, major storm sewers, detention and retention basins, pumping stations, and other appurtenances of areawide significance, and such data on flood stages under existing and planned conditions as may be required for the District to issue sound flood protection elevations. The system plan should be in sufficient depth to provide a sound basis for local flood control planning and design, as well as for proceeding with final engineering for the watercourse and major drainage projects recommended to be constructed by the District. Particularly careful attention will have to be given in the system planning to the provision of needed outlets for existing and committed local drainage facilities. The system plan should identify the costs and benefits of the recommended improvements and identify an order of priority and schedule for their construction over time, constituting, in effect, a capital improvements program for areawide drainage and flood control works within the District and service areas. In addition, the system plan is intended to provide planning and engineering data useful in local drainage and flood control planning, and in the design and resolution of local drainage and flood control problems.

The policy plan provides an important basis for the preparation of the system plan. The policy plan is to 1) recommend those streams and watercourses for which the District, as an areawide agency, should assume jurisdiction; 2) recommend the types of improvements for which the District should assume responsibility; and 3) recommend the manner in which improvement and maintenance costs are to be shared between the District and the benefited local municipalities. The policy plan should also provide a basis for prioritizing and scheduling the needed drainage and flood control improvements to be constructed by the District. This report is intended to document the policy plan element of the overall drainage and flood control plan for the greater Milwaukee area.

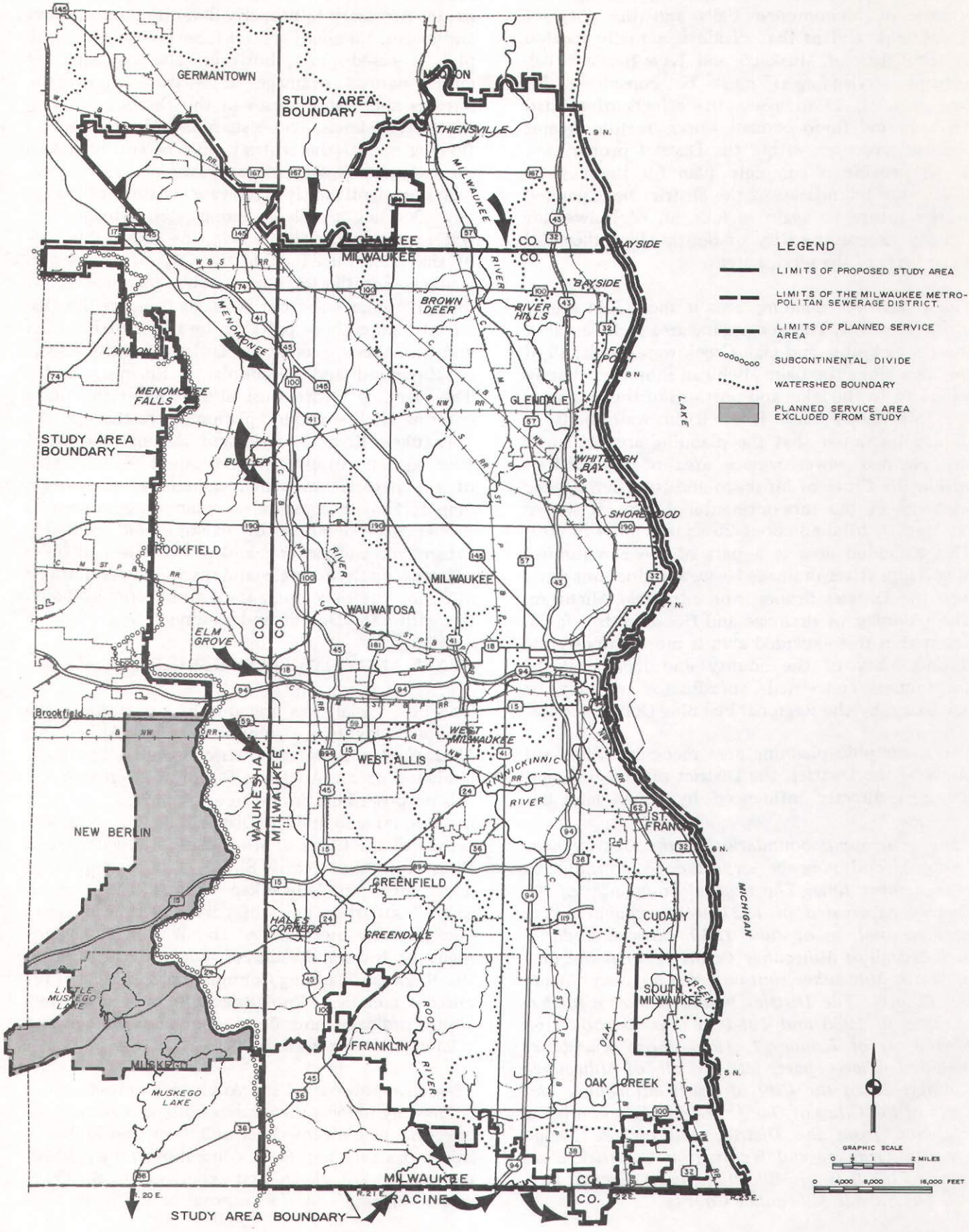
THE GEOGRAPHIC PLANNING UNIT

It is axiomatic that drainage and flood control facilities must function as integrated systems over entire watersheds. Land use patterns which determine the amount and spatial distribution of the hydraulic loadings to be accommodated by such facilities, however, develop over an entire urban region in response to basic social and economic forces and to the operation of the urban land market without regard to either natural watershed boundaries or artificial county and municipal corporate limit lines. The drainage and flood control facilities, in turn, determine to some extent the use to which land may be put, at least in the riverine areas. These facilities often cross corporate limit lines but generally do not cross watershed boundaries. Thus, drainage and flood control planning cannot be accomplished successfully within the context of a single municipality or county if that municipality or county is part of a larger urban complex. Nor can such planning be accomplished successfully solely within natural watershed areas. Rather, such planning must be accomplished on the basis of a geographic area which recognizes the configuration of the natural watersheds; the major factors which influence the pattern of urban development; and the legal and institutional factors that affect the development of drainage and flood control works of areawide significance.

The geographic area delineated for drainage and flood control policy and system planning in the greater Milwaukee area under this study is shown on Map 3. This area includes the Milwaukee Metropolitan Sewerage District; the balance of lands in Milwaukee County not currently in the District, namely the City of South Milwaukee and the southern portions of the Cities of Franklin and Oak Creek; and the existing and proposed District service areas in Ozaukee, Racine, Washington, and Waukesha Counties lying easterly of the subcontinental divide as that divide is approximated by

Map 3

PROPOSED PLANNING AREA



Source: SEWRPC.

the District service area boundary through the Village of Menomonee Falls and the City of Brookfield, and as that divide is actually located in the Cities of Muskego and New Berlin.[6] The District service areas must be considered for two reasons: 1) to assess the effects of needed drainage and flood control works on the streams and watercourses within the District proper; and 2) to provide a complete plan for the District should the boundaries of the District be expanded in the future to again include all of Milwaukee County except the City of South Milwaukee and all or parts of the service areas.

The geographic planning area is about 324 square miles in extent. This geographic area includes all of the Kinnickinnic and Oak Creek watersheds; all of the area along the Lake Michigan shoreline directly tributary to the lake; and portions of the Menomonee, Milwaukee, and Root River watersheds. It should be noted that the planning area excludes the planned sewer service area of the District within the Cities of Muskego and New Berlin lying westerly of the subcontinental divide, as shown on Map 3, totaling about 25 square miles in area. This excluded area is a part of the Fox-Illinois-Mississippi River drainage basin, and does not drain into the District proper, nor into Lake Michigan. The planning of drainage and flood control facilities within this excluded area is more properly the responsibility of the county and local units of government concerned, coordinated, as may be necessary, by the Regional Planning Commission.

The geographic planning area recognizes the legal limits of the District, the District service area, and the area directly influenced by urban land use development in the greater Milwaukee area. To the extent necessary to properly determine flood flows and stages, the analyses and forecasts on which the plan is based must, however, also consider the entire natural drainage areas tributary to the streams and watercourses in the District and District service areas. Those streams and watercourses flowing out of the District must be considered to the extent necessary to demonstrate that the plan will not significantly aggravate existing or create new flooding problems along such streams and watercourses. For this reason, the geographic area of the plan must include the City of South Milwaukee. For this reason also, the planning effort must consider the Root River as it leaves the District to enter those parts of the Cities of Franklin and Oak Creek outside the District and the Towns of Raymond and Caledonia in Racine County. The planning effort must also consider the flows entering the geographic planning area through the Milwaukee River system, and through the Root River system. In effect, this requires consideration of the natural watershed boundaries shown on Map 1. Thus, the geographic planning area permits proper consideration of existing and probable future land use patterns and of the effect of these patterns on hydrologic and hydraulic conditions affecting the development of flood control facilities within the District and its service area.

STAFF AND COMMITTEE STRUCTURE

This policy plan was prepared by the staffs of the Regional Planning Commission and Milwaukee Metropolitan Sewerage District working under the guidance of an Advisory Committee created for this purpose. This Committee, appointed jointly by the Commission and the District, includes representatives of the Cities of Milwaukee, Wauwatosa, and West Allis; the "North Shore" suburban units of government in Milwaukee County; the "South Shore" suburban units of government in Milwaukee County; the County; the Wisconsin Department of Natural Resources; and the District and the Regional Planning Commission; as well as three citizen members knowledgeable and concerned about drainage and flood control problems and related environmental problems.

The basic purpose of the Advisory Committee was to actively involve the various units and agencies of government concerned, as well as citizen interests, in the drainage and flood control planning process, placing the knowledge and experience of the Committee members at the disposal of the study and,

[6] *The geographic boundaries of the District have changed, and may be expected to continue to change, over time. The original boundaries of the District as created in 1921 were expanded over time so that, as of June 1960, those boundaries included all of Milwaukee County except the City of South Milwaukee, but included no areas outside the County. The District boundaries were further changed in 1983 and 1984 so that, as shown on Map 3, as of January 1, 1985, those boundaries included a large part, but not all, of Milwaukee County—all of the City of South Milwaukee and parts of the Cities of Oak Creek and Franklin being excluded from the District—and included small areas of Ozaukee and Washington Counties, areas lying in the City of Milwaukee and Village of Bayside but outside Milwaukee County.*

to the extent practicable, ensuring intergovernmental agreement on policy and system plan recommendations. The full membership of the Advisory Committee is set forth on the inside front cover of this report.

SCHEME OF PRESENTATION

The findings and recommendations of the policy planning effort of the overall drainage and flood control planning effort for the greater Milwaukee area are documented and presented in this report. In addition to this introductory chapter, this report consists of four chapters, one dealing with the identification of the streams and watercourses for which the District, as a matter of public policy, should assume jurisdiction; one identifying the types of drainage and flood control improvements for which the District, as a matter of public policy, should assume responsibility, and setting forth the manner in which drainage and flood control improvement and maintenance costs should be shared between the District and the benefited local municipalities; and one setting forth the basis on which the District should prioritize and schedule needed drainage and flood control improvements which are to be constructed by the District. A final chapter briefly summarizing the recommended policy plan concludes the planning report. The report is intended to set forth for public officials, agency staff personnel, and citizen leaders within the greater Milwaukee area the policies which the Milwaukee Metropolitan Sewerage District will follow in the administration of its drainage and flood control responsibilities within the greater Milwaukee area.

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Chapter II

IDENTIFICATION OF STREAMS AND WATERCOURSES FOR WHICH THE MILWAUKEE METROPOLITAN SEWERAGE DISTRICT SHOULD ASSUME JURISDICTION FOR DRAINAGE AND FLOOD CONTROL

INTRODUCTION

One of the specific purposes of the District drainage and flood control planning program is the identification of the streams and watercourses for which the Milwaukee Metropolitan Sewerage District should assume jurisdiction for the resolution of drainage and flood control problems. Such identification is essential if the development of drainage and flood control facilities by the various concerned units and agencies of government in the greater Milwaukee area is to proceed on a sound and fully coordinated basis. Many different criteria can be advanced for the necessary jurisdictional classification of the streams and watercourses in the greater Milwaukee area. Such criteria could conceivably pertain to such factors as the size and flow characteristics of the streams; the size of the tributary drainage area; whether or not the drainage areas of the streams occupy more than one civil division and whether or not the streams flow through more than one civil division; and the relationship of the streams to existing and planned urban development, among others.

As indicated in Table 1 and shown on Map 4, there are 37 perennial[1] streams within the study area having a total length of 176.4 linear miles, as identified by the U. S. Geological Survey. There are also within the study area an undetermined number of intermittent[2] streams and watercourses having an undetermined total length. The very nature of these intermittent streams and watercourses is such that definitive identification and delineation are difficult, as such streams and watercourses could include very small topographic swales with insignificant tributary drainage areas. For this reason, it was determined by the Advisory Committee that the perennial stream network of the study area should constitute the universe to which the agreed-upon jurisdictional classification criteria are applied. It was further determined that any inclusion of intermittent streams within the jurisdiction of the District would have to be justified on the basis of extraordinary considerations.

JURISDICTIONAL CLASSIFICATION CRITERIA

The Advisory Committee determined that the following four criteria should be utilized to establish the jurisdiction of the Milwaukee Metropolitan Sewerage District for streams and watercourses within the study area for drainage and flood control matters:

1. The nature and extent of the known flood hazard by major stream reach.[3]

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[1] *A perennial stream may be defined as a stream or portion of a stream that maintains a continuous flow throughout the year and from year to year except during periods of extreme drought. The flow in such streams, while responding to precipitation and snowmelt events, is maintained by springs, other groundwater inflow, or other continuous sources.*

[2] *An intermittent stream may be defined as a stream or portion of a stream that flows only in direct response to precipitation. Such a stream receives little or no water from springs or other groundwater inflow and no long continued supply from melting snow or other sources and is dry for a large part of each year, ordinarily more than three months.*

[3] *A stream reach may be defined as a specified length of a stream having similar physical characteristics, such as channel and floodplain cross-sections, channel configuration and slope, and similar adjacent land uses. Stream reaches have been identified in the adopted Commission watershed plans for all of the major streams within the District and environs.*

Table 1

PERENNIAL STREAMS IN THE STUDY AREA BY WATERSHED BY CIVIL DIVISION[a]

Civil Division	Kinnickinnic River Watershed Streams (in miles)							Oak Creek Watershed Streams (in miles)				Menomonee River Watershed Streams (in miles)										
	Kinnickinnic River	Lyons Creek	Wilson Park Creek	Unnamed Tributary Section 12 T6N, R21E	Unnamed Tributary Section 19 T6N, R22E	Unnamed Tributary Section 20 T6N, R22E	Subtotal	Oak Creek	Oak Creek North Branch	Unnamed Tributary Section 9 T5N, R22E	Subtotal	Butler Ditch	Dousman Ditch	Honey Creek	Little Menomonee River	Menomonee River	West Branch of the Menomonee River	Underwood Creek	Unnamed Tributary Section 14 T7N, R20E	Unnamed Tributary Section 35 T7N, R21E	Unnamed Tributary Section 30 T7N, R21E	Subtotal
Bayside (Village)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Brookfield (City)	--	--	--	--	--	--	--	--	--	--	--	2.4	5.5	--	--	--	--	3.3	1.0	--	0.5	12.7
Brown Deer (Village)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Butler (Village)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1.3	--	--	--	--	--	1.3
Caledonia (Town)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Elm Grove (Village)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	2.3	--	--	--	2.3
Fox Point (Village)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Franklin (City)	--	--	--	--	--	--	--	1.3	--	--	1.3	--	--	--	--	--	--	--	--	--	--	--
Germantown (Village)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	3.3	0.3	--	--	--	--	3.6
Glendale (City)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Greendale (Village)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Greenfield (City)	--	--	--	--	0.4	--	0.4	--	--	--	--	--	--	2.3	--	--	--	--	--	--	--	2.3
Hales Corners (Village)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Menomonee Falls (Village)	--	--	--	--	--	--	--	--	--	--	--	1.3	--	--	--	6.5	--	--	--	--	--	7.8
Mequon (City)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Milwaukee (City)	7.9[d]	1.2[e]	3.4[f]	0.3[g]	1.3	1.6	15.7	--	0.9	1.0	1.9	--	--	2.6[h]	6.9	8.8	--	--	--	1.1	--	19.4
Oak Creek (City)	--	--	--	--	--	--	--	7.6	4.8	1.3	13.7	--	--	--	--	--	--	--	--	--	--	--
River Hills (Village)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
South Milwaukee (City)	--	--	--	--	--	--	--	4.2	--	--	4.2	--	--	--	--	--	--	--	--	--	--	--
Thiensville (Village)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Wauwatosa (City)	--	--	--	--	--	--	--	--	--	--	--	--	--	1.3	--	6.9	--	2.6	--	--	--	10.8
West Allis (City)	0.2	--	--	--	--	--	0.2	--	--	--	--	--	--	2.6[i]	--	--	--	--	--	--	0.6	3.2
West Milwaukee (Village)	--	--	--	0.7	--	--	0.7	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Total	8.1	1.2	3.4	1.0	1.7	1.6	17.0	13.1	5.7	2.3	21.1	3.7	5.5	8.8	6.9	26.8	0.3	8.2	1.0	1.1	1.1	63.4

Civil Division	Milwaukee River Watershed Streams (in miles)											Lake Michigan Direct Drainage Area Streams (in miles)		Root River Watershed Streams (in miles)								
	Indian Creek	Lincoln Creek	Milwaukee River	Pigeon Creek	Unnamed Tributary Section 18 T9N, R22E	Unnamed Tributary Section 35 T9N, R21E	Unnamed Tributary Section 36 T9N, R21E	Unnamed Tributary[b] Section 1 T8N, R21E	Unnamed Tributary Section 7 T8N, R22E	Unnamed Tributary Section 2 T7N, R21E	Subtotal	Fish Creek	Subtotal	East Branch Root River	Root River	Root River Canal	Tess Corners Creek	Whitnall Creek	Unnamed Tributary Section 20 T6N, R21E	Unnamed Tributary Section 34 T5N, R22E	Subtotal	Total
Bayside (Village)	--	--	--	--	--	--	--	--	--	--	--	1.8[c]	1.8	--	--	--	--	--	--	--	--	1.8
Brookfield (City)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	12.7
Brown Deer (Village)	--	--	--	--	--	--	--	1.9	--	--	1.9	--	--	--	--	--	--	--	--	--	--	1.9
Butler (Village)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1.3
Caledonia (Town)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0.5	--	--	--	--	--	0.5	0.5
Elm Grove (Village)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	2.3
Fox Point (Village)	0.6	--	--	--	--	--	--	--	--	--	0.6	--	--	--	--	--	--	--	--	--	--	0.6
Franklin (City)	--	--	--	--	--	--	--	--	--	--	--	--	--	4.7	9.7	1.3	1.8	--	--	--	17.5	18.8
Germantown (Village)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	3.6
Glendale (City)	--	0.3	4.7	--	--	--	--	--	--	--	5.0	--	--	--	--	--	--	--	--	--	--	5.0
Greendale (Village)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	4.3	--	0.4	0.1	--	--	4.8	4.8
Greenfield (City)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	2.7	--	--	--	0.4	--	3.1	5.8
Hales Corners (Village)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0.6	--	--	0.6	0.6
Menomonee Falls (Village)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	7.8
Mequon (City)	--	--	7.5	0.4	0.5	2.0	0.2	--	--	--	10.6	1.3	1.3	--	--	--	--	--	--	--	--	11.9
Milwaukee (City)	--	7.8	6.3	--	--	--	--	--	1.1	0.5	15.7	--	--	--	--	--	--	--	--	--	--	52.7
Oak Creek (City)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	2.3	--	--	--	--	1.0	3.3	17.0
River Hills (Village)	1.3	--	5.1	--	--	--	--	--	0.7	--	7.1	--	--	--	--	--	--	--	--	--	--	7.1
South Milwaukee (City)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	4.2
Thiensville (Village)	--	--	--	0.4	--	--	--	--	--	--	0.4	--	--	--	--	--	--	--	--	--	--	0.4
Wauwatosa (City)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	10.8
West Allis (City)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0.7	--	--	--	--	--	0.7	4.1
West Milwaukee (Village)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0.7
Total	1.9	8.1	23.6	0.8	0.5	2.0	0.2	1.9	1.8	0.5	41.3	3.1	3.1	4.7	20.2	1.3	2.2	0.7	0.4	1.0	30.5	176.4

NOTE: There are no perennial streams in the following civil divisions within the study area: the Cities of Cudahy and St. Francis and the Villages of Shorewood and Whitefish Bay in Milwaukee County; and the Cities of Muskego and New Berlin in Waukesha County.

[a] *See Map 4 for dates of USGS quadrangle maps used for identification of perennial streams.*

[b] *Known locally as Beaver Creek.*

[c] *Includes 0.6 mile of Fish Creek which is the common boundary between the Village of Bayside and the City of Mequon.*

[d] *Includes 0.2 mile within an enclosed conduit.*

[e] *Includes 0.2 mile within an enclosed conduit.*

[f] *Includes 0.4 mile within an enclosed conduit.*

[g] *Includes 0.2 mile within an enclosed conduit.*

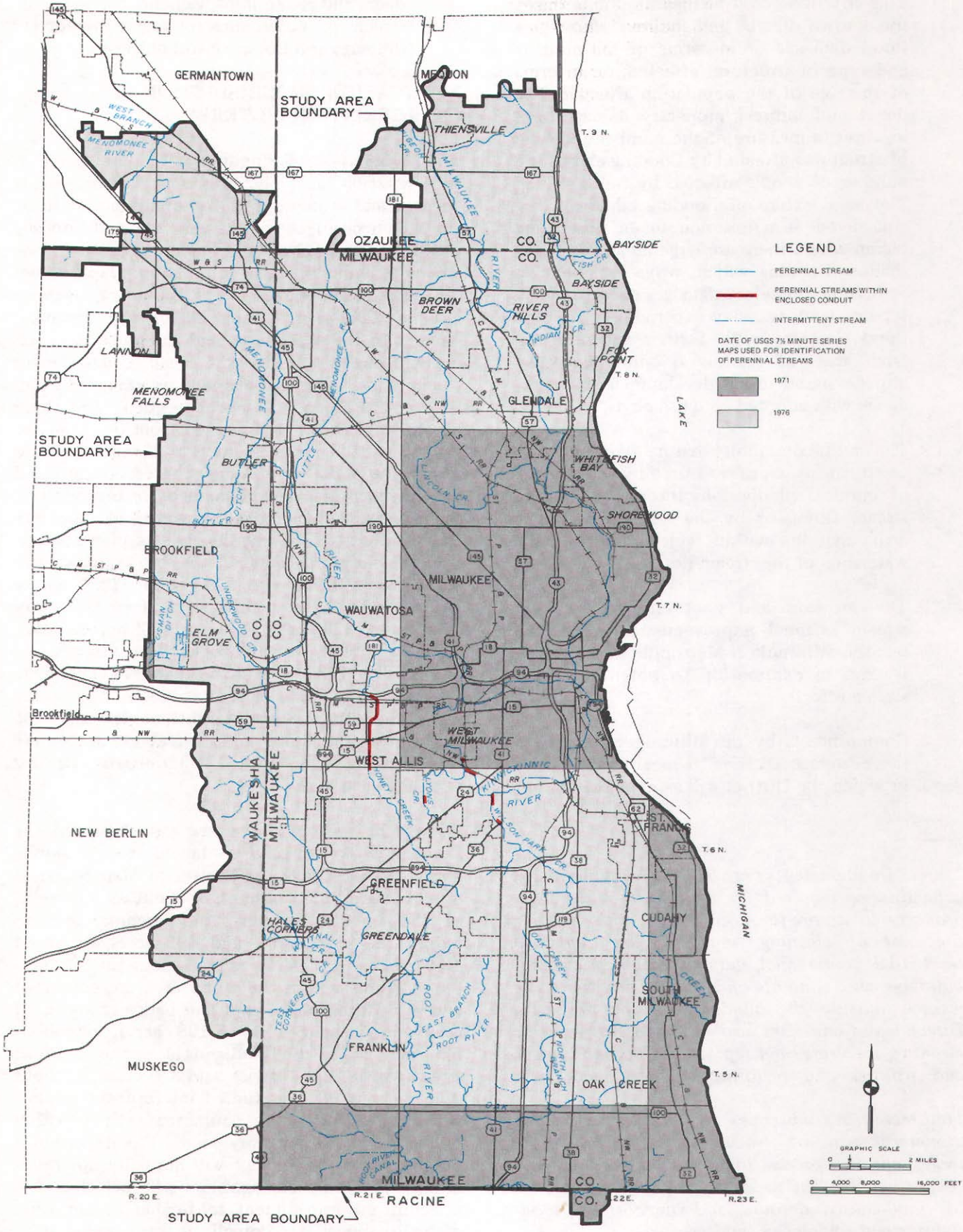
[h] *Includes 0.5 mile within an enclosed conduit.*

[i] *Includes 1.7 miles within an enclosed conduit.*

Source: USGS Standard Quadrangle Maps and SEWRPC.

Map 4

PERENNIAL AND SELECTED INTERMITTENT STREAMS WITHIN THE STUDY AREA: 1985



Source: USGS standard quadrangle maps and SEWRPC.

This criterion could be measured in terms of the known direct[4] and indirect[5] monetary flood damages or in terms of the number and type of structures affected, or in terms of the size of the population affected. The direct and indirect monetary damages are, however, a measure of the number and type of structures affected by flooding and of the number of people affected by the flooding. The areal extent of flooding could also be considered as a criterion in an urbanizing region where there are large areas subject to shallow flooding which, while experiencing little or no monetary damages because of the type of land use, may experience significant flood damages with further urbanization. Such areas of shallow flooding may also impede sound urban development in accordance with adopted land use plans.

2. The multi-community nature of the stream or stream reach, as measured by the number of minor civil divisions through which the stream flows, or by the number of minor civil divisions within which the tributary watershed of the stream lies.

3. The location and continuity of existing stream channel improvements constructed by the Milwaukee Metropolitan Sewerage District in relationship to potential downstream effects.

4. Commitments by the Milwaukee Metropolitan Sewerage District to local communities in which the District will assume jurisdiction over, and make improvements to, a specific stream or watercourse or reach thereof for drainage and flood control purposes.

APPLICATION OF JURISDICTIONAL CLASSIFICATION CRITERIA

The Areal Extent of Flooding

As a criterion for the jurisdictional classification of streams and watercourses for drainage and flood control purposes, the nature and extent of flooding could be measured in terms of the areas along the stream system subject to inundation. Map 5 shows the location and extent of the 100-year recurrence interval floodplains along all of the perennial streams in the study area and along certain intermittent streams studied at local request under Commission watershed planning programs or under the federal flood insurance program. The flood hazard data shown are derived from the Commission watershed plans updated to January 1985 to reflect the actual implementation of certain flood control measures recommended in those plans, such implementation having served to eliminate flood hazards existing at the time of plan preparation. As shown in Table 2, the known floodlands encompass 14,916 acres, or about 23.3 square miles, along the perennial streams of the study area; and 9,823 acres, or about 15.3 square miles, along perennial streams within the District. As indicated in Table 3, known floodlands encompass an additional 3,646 acres, or about 5.7 square miles, along the studied intermittent streams of the study area; and 1,539 acres, or about 2.4 square miles, along the studied intermittent streams within the District.

Within the greater Milwaukee area, however, the floodlands are largely contained within public parks and parkways. As shown on Map 5 and in Tables 2 and 3, 5,951 acres, or about 39.9 percent, of the floodlands along the perennial streams within the study area, and 492 acres, or about 13.5 percent, of the floodlands along the intermittent streams within the study area are contained entirely within public park and parkway lands. Of even more significance, 5,198 acres, or about 52.9 percent, of the floodlands along the perennial streams within the District, and 316 acres, or about 20.5 percent, of the studied intermittent streams within the District are contained entirely within public park and parkway lands. Floods within a public park and parkway will normally not result in large monetary damages, nor will such floods be a significant impediment to further urbanization within the area. Accordingly, it was concluded by

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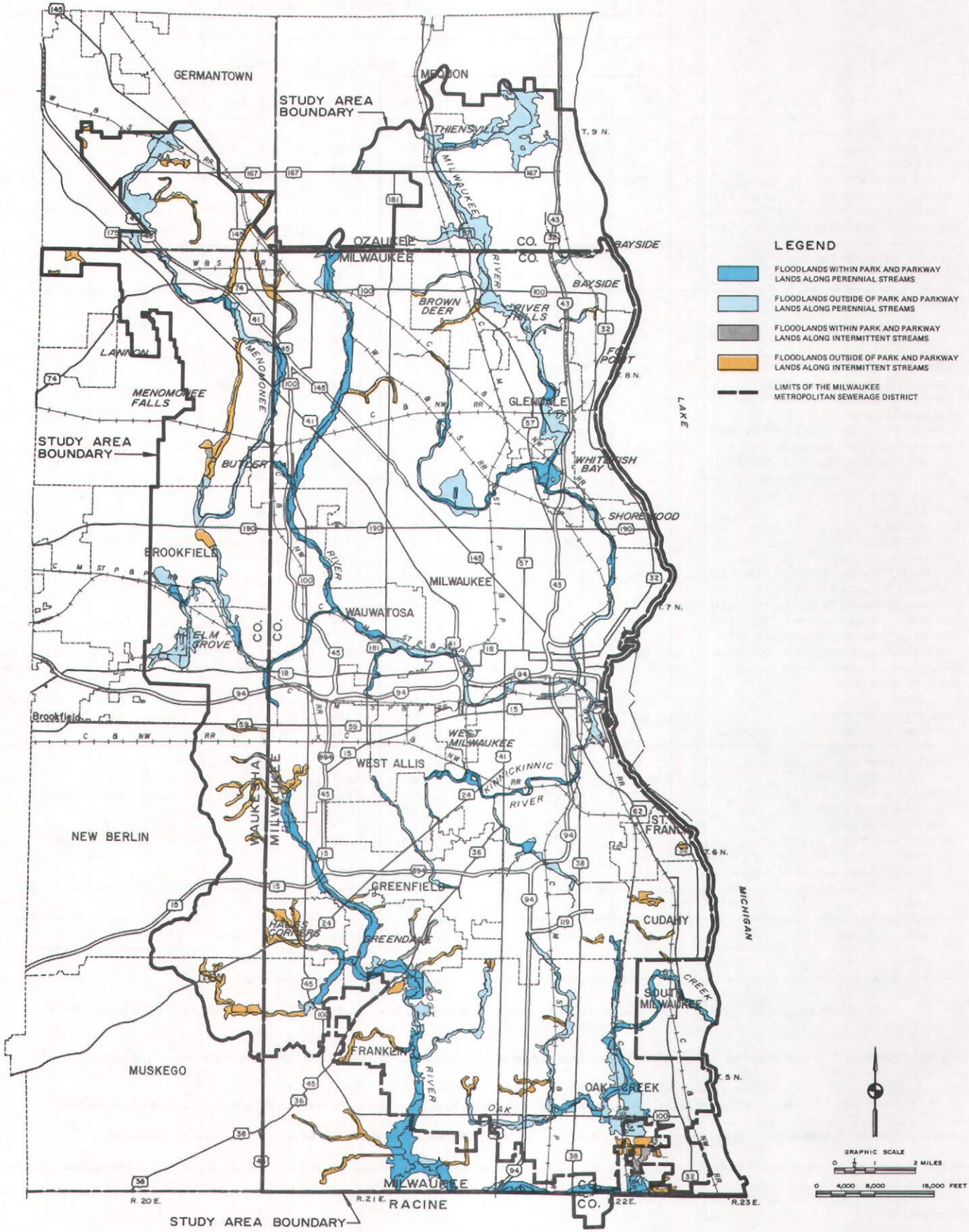
[4] *Direct flood damages may be defined as monetary expenditures required to restore flood-damaged property to its pre-flood condition. This includes the cost of cleaning, repairing, and replacing residential, commercial, industrial, and agricultural buildings and contents and objects and materials located outside the buildings on the property. Direct losses and risks also encompass the cost of cleaning, repairing, and replacing roads and bridges and utilities and restoring damaged parklands.*

[5] *Indirect losses and risks may be defined as the monetary cost of evacuation, relocation, lost wages, and lost production and sales, the increased cost of highway and railway transportation because of flood-caused detours, and the cost of flood-fighting and emergency services.*

Map 5

FLOODLANDS ALONG PERENNIAL AND SELECTED INTERMITTENT STREAMS WITHIN THE STUDY AREA: 1985



Source: Federal Emergency Management Agency and SEWRPC.

Table 2

FLOODLANDS ALONG PERENNIAL STREAMS WITHIN THE STUDY AREA: 1985

Stream	Floodlands Along Perennial Streams											
	Study Area						MMSD Only					
	In Park and Parkway		Other		Total		In Park and Parkway		Other		Total	
	Linear Miles	Acres	Linear Miles	Acres	Linear Miles	Acres	Linear Miles	Acres	Linear Miles	Acres	Linear Miles	Acres
Kinnickinnic River Watershed												
Kinnickinnic River	6.0	216	2.1	144	8.1	360	6.0	216	2.1	144	8.1	360
Lyons Creek	0.1	7	0.8	23	0.9	30	0.1	7	0.8	23	0.9	30
Wilson Park Creek	0.7	43	2.1	109	2.8	152	0.7	43	2.1	109	2.8	152
Unnamed Tributary Section 12, T6N, R21E	--	--	--	--	--	--	--	--	--	--	--	--
Unnamed Tributary Section 19, T6N, R22E	--	--	0.3	8	0.3	8	--	--	0.3	8	0.3	8
Unnamed Tributary Section 20, T6N, R22E	--	--	0.3	12	0.3	12	--	--	0.3	12	0.3	12
Lake Michigan Direct Drainage Area												
Fish Creek	--	--	0.9	47	0.9	47	--	--	0.9	47	0.9	47
Menomonee River Watershed												
Butler Ditch	0.3	14	3.4	298	3.7	312	--	--	--	--	--	--
Dousman Ditch	0.1	--	5.4	444	5.5	444	--	--	--	--	--	--
Honey Creek	3.0	119	2.9	103	5.9	222	3.0	119	2.9	103	5.9	222
Little Menomonee River	6.3	636	0.6	119	6.9	755	6.3	636	0.6	110	6.9	746
Menomonee River	13.2	735	12.8	1,599	26.0[a]	2,334	10.9	635	6.3	557	17.2[b]	1,192
West Branch of the Menomonee River	--	--	0.3	37	0.3	37	--	--	--	--	--	--
Underwood Creek	4.3	252	3.9	387	8.2	639	2.6	115	--	--	2.6	115
Unnamed Tributary Section 14, T7N, R20E	--	--	1.0	65	1.0	65	--	--	--	--	--	--
Unnamed Tributary Section 35, T7N, R21E	--	--	--	--	--	--	--	--	--	--	--	--
Unnamed Tributary Section 30, T7N, R21E	1.0	28	0.1	22	1.1	50	1.0	28	0.1	22	1.1[c]	50
Milwaukee River Watershed												
Indian Creek	--	--	1.5	41	1.5	41	--	--	1.5	41	1.5	41
Lincoln Creek	4.2	265	3.9	255	8.1	520	4.2	265	3.9	255	8.1	520
Milwaukee River	6.1	526	17.5	2,672	23.6	3,198	5.6	491	10.5	1,059	16.1	1,550
Pigeon Creek	--	--	0.4	64	0.4	64	--	--	--	--	--	--
Unnamed Tributary Section 18, T9N, R22E	--	--	0.5	35	0.5	35	--	--	--	--	--	--
Unnamed Tributary Section 35, T9N, R21E	--	--	1.3	114	1.3	114	--	--	--	--	--	--
Unnamed Tributary Section 36, T9N, R21E	--	--	0.2	160	0.2	160	--	--	--	--	--	--
Unnamed Tributary Section 1, T8N, R21E	--	--	1.6	76	1.6	76	--	--	1.6	76	1.6	76
Unnamed Tributary Section 7, T8N, R22E	--	--	--	--	--	--	--	--	--	--	--	--
Unnamed Tributary Section 2, T7N, R21E	0.3	10	0.2	226	0.5	236	0.3	10	0.2	226	0.5	236
Oak Creek Watershed												
Oak Creek	9.6	467	3.5	866	13.1	1,333	5.4	293	3.5	823	8.9[d]	1,116
Oak Creek North Branch	0.2	9	5.3	219	5.5	228	0.2	9	5.3	219	5.5	228
Unnamed Tributary Section 9, T5N, R22E	1.6	83	0.7	58	2.3	141	1.6	83	0.7	58	2.3	141
Root River Watershed												
East Branch Root River	--	--	4.7	210	4.7	210	--	--	4.7	210	4.7	210
Root River	18.0	2,096	2.2	486	20.2[e]	2,582	17.9	2,083	2.2	486	20.1[f]	2,569
Root River Canal	1.3	172	--	--	1.3	172	--	--	--	--	--	--
Tess Corners Creek	1.8	117	0.4	37	2.2	154	1.8	117	0.4	37	2.2	154
Whitnall Park Creek	0.7	48	--	--	0.7	48	0.7	48	--	--	0.7	48
Unnamed Tributary Section 20, T6N, R21E	--	--	--	--	--	--	--	--	--	--	--	--
Unnamed Tributary Section 34, T5N, R22E	1.0	108	--	29	1.0	137	--	--	--	--	--	--
Total	79.8	5,951	80.8	8,965	160.6	14,916	68.3	5,198	50.9	4,625	119.2	9,823
Percent of Total	49.7	39.9	50.3	60.1	100.0	100.0	57.3	52.9	42.7	47.1	100.0	100.0

[a] Does not include a 0.6-mile reach along the main stem of the Menomonee River which flows out of, then back into, the study area.

[b] Includes two reaches with a combined length of 2.3 miles along the main stem of the Menomonee River which flow out of, then back into, the Milwaukee Metropolitan Sewerage District.

[c] Includes one reach with a total length of 0.5 mile along the unnamed tributary to Underwood Creek which flows out of, then back into, the Milwaukee Metropolitan Sewerage District.

[d] Includes one reach with a total length of 0.3 mile along the main stem of Oak Creek which flows out of, then back into, the Milwaukee Metropolitan Sewerage District.

[e] Does not include two reaches with a combined length of 3.0 miles along the main stem of the Root River which flow out of, then back into, the study area.

[f] Includes four reaches with a combined length of 7.0 miles along the main stem of the Root River which flow out of, then back into, the Milwaukee Metropolitan Sewerage District.

Source: SEWRPC.

Table 3

FLOODLANDS ALONG SELECTED INTERMITTENT STREAMS WITHIN THE STUDY AREA: 1985

Stream	Floodlands Along Selected Intermittent Streams											
	Study Area						MMSD Only					
	In Park and Parkway		Other		Total		In Park and Parkway		Other		Total	
	Linear Miles	Acres	Linear Miles	Acres	Linear Miles	Acres	Linear Miles	Acres	Linear Miles	Acres	Linear Miles	Acres
Kinnickinnic River Watershed												
Section 27, T6N, R22E	--	--	0.8	75	0.8	75	--	--	0.8	75	0.8	75
Section 34, T6N, R22E	--	5	0.4	27	0.4	32	--	5	0.4	27	0.4	32
Lake Michigan Direct Drainage Area												
Section 23, T6N, R22E	--	--	--	16	--	16	--	--	--	16	--	16
Section 35, T6N, R22E	--	--	0.3	13	0.3	13	--	--	0.3	13	0.3	13
Section 35, T6N, R22E	0.3	13	0.4	16	0.7	29	0.3	13	0.4	16	0.7	29
Menomonee River Watershed												
Section 1, T6N, R20E	--	--	0.8	45	0.8	45	--	--	--	--	--	--
Section 11, T7N, R20E	--	--	0.2	82	0.2	82	--	--	--	--	--	--
Section 6, T8N, R20E	--	--	0.7	66	0.7	66	--	--	--	--	--	--
Section 11, T8N, R20E	--	--	3.4	158	3.4	158	--	--	--	--	--	--
Section 13, T8N, R20E	0.1	25	3.8	361	3.9	386	--	--	--	--	--	--
Section 18, T8N, R21E	1.2	83	2.2	137	3.4	220	1.2	83	0.8	47	2.0	130
Section 21, T8N, R21E	0.3	6	2.1	90	2.4	96	0.3	6	2.1	90	2.4	96
Section 17, T9N, R20E	--	--	0.8	31	0.8	31	--	--	--	--	--	--
Section 22, T9N, R20E	--	--	0.8	66	0.8	66	--	--	--	--	--	--
Section 28, T9N, R20E	--	--	2.6	109	2.6	109	--	--	--	--	--	--
Milwaukee River Watershed												
Section 10, T8N, R21E	--	--	0.3	10	0.3	10	--	--	0.3	10	0.3	10
Section 12, T8N, R21E	--	--	1.3	61	1.3	61	--	--	1.3	61	1.3	61
Section 14, T8N, R21E	--	--	0.5	27	0.5	27	--	--	0.5	27	0.5	27
Section 8, T8N, R22E	--	--	0.4	20	0.4	20	--	--	0.4	20	0.4	20
Oak Creek River Watershed												
Section 24, T5N, R21E	--	--	0.8	44	0.8	44	--	--	0.8	44	0.8	44
Section 8, T5N, R22E	--	--	0.6	23	0.6	23	--	--	0.6	23	0.6	23
Section 20, T5N, R22E	--	--	1.9	82	1.9	82	--	--	1.9	82	1.9	82
Section 33, T6N, R22E	--	--	0.5	35	0.5	35	--	--	0.5	35	0.5	35
Root River Watershed												
Section 1, T5N, R21E	--	--	0.4	19	0.4	19	--	--	0.4	19	0.4	19
Section 3, T5N, R21E	0.1	6	0.3	42	0.4	48	0.1	6	0.3	42	0.4	48
Section 3, T5N, R21E	0.4	14	1.1	51	1.5	65	0.4	14	1.1	51	1.5	65
Section 7, T5N, R21E	--	2	4.5	317	4.5	319	--	--	1.0	60	1.0	60
Section 15, T5N, R21E	0.2	6	2.6	125	2.8	131	0.2	6	2.6	125	2.8	131
Section 27, T5N, R21E	0.7	26	3.0	132	3.7	158	--	--	--	--	--	--
Section 34, T5N, R21E	0.4	7	1.9	74	2.3	81	--	--	--	--	--	--
Section 35, T5N, R21E	1.1	43	--	--	1.1	43	1.1	43	--	--	1.1	43
Section 34, T5N, R22E	0.4	92	0.4	221	0.8	313	--	--	--	--	--	--
Section 35, T5N, R22E	--	--	1.0	52	1.0	52	--	--	--	--	--	--
Section 13, T6N, R20E	--	--	0.6	24	0.6	24	--	--	--	--	--	--
Section 7, T6N, R21E	1.4	50	0.5	39	1.9	89	0.7	26	0.2	14	0.9	40
Section 7, T6N, R21E	--	--	0.7	95	0.7	95	--	--	0.7	95	0.7	95
Section 18, T6N, R21E	--	--	3.6	161	3.6	161	--	--	0.7	23	0.7	23
Section 28, T6N, R21E	--	--	0.4	13	0.4	13	--	--	0.4	13	0.4	13
Section 28, T6N, R21E	--	--	0.4	10	0.4	10	--	--	0.4	10	0.4	10
Section 32, T6N, R21E	0.6	24	2.8	175	3.4	199	0.6	24	2.8	175	3.4	199
Section 34, T6N, R21E	1.7	90	--	10	1.7	100	1.7	90	--	10	1.7	100
Total	8.9	492	49.8	3,154	58.7	3,646	6.6	316	21.7	1,223	28.3	1,539
Percent of Total	15.2	13.5	84.8	86.5	100.0	100.0	23.3	20.5	76.7	79.5	100.0	100.0

Source: SEWRPC.

the Advisory Committee that the extent of flooding along the streams and watercourses of the study area and the District should not be considered in applying the jurisdictional classification criterion relating to the nature and extent of the known flood hazard. However, if this measure were used, 160.6 miles, or 91.0 percent, of the perennial streams and watercourses within the study area would come under the jurisdiction of the District for drainage and flood control purposes.

The application of this criterion to perennial streams within the District would result in 119.2 miles of perennial streams, or 67.6 percent of the total miles of such streams in the study area, being considered for District jurisdiction.

The criterion relating to the nature and extent of the known flood hazard can also be measured in terms of the known direct and indirect monetary flood damages. Map 6 shows the location of the stream reaches within the study area which, based upon the findings of the Commission watershed studies, experience significant monetary flood damages. Table 4 indicates the linear miles of stream channel and the monetary damages involved. If the District were to assume jurisdiction over the reaches actually subject to monetary flood damage, good planning and engineering practice would dictate that the District also assume jurisdiction over those downstream reaches which may be expected to experience stage increases as a result of the drainage or flood control improvement projects completed by the District. For purposes of this study, it was assumed that the effects of such improvements on downstream reaches end at the stream's confluence with a larger stream.

As shown on Map 7 and indicated in Table 5, the application of the criterion relating to the nature and extent of the known flood hazard as measured in terms of the reaches subject to monetary flood damage would place 103.6 miles of perennial streams, or 58.7 percent of the total miles of such streams within the study area, under District jurisdiction. As shown on Map 8 and indicated in Table 6, the application of this criterion to streams within the District would result in 77.6 miles of perennial streams, or 44.0 percent of the total miles of such streams in the study area, being considered for District jurisdiction. In addition, 11.3 miles of intermittent streams within the study area and 8.7 miles within the District could be subject to District jurisdiction.

The Multi-Community Nature of the Stream

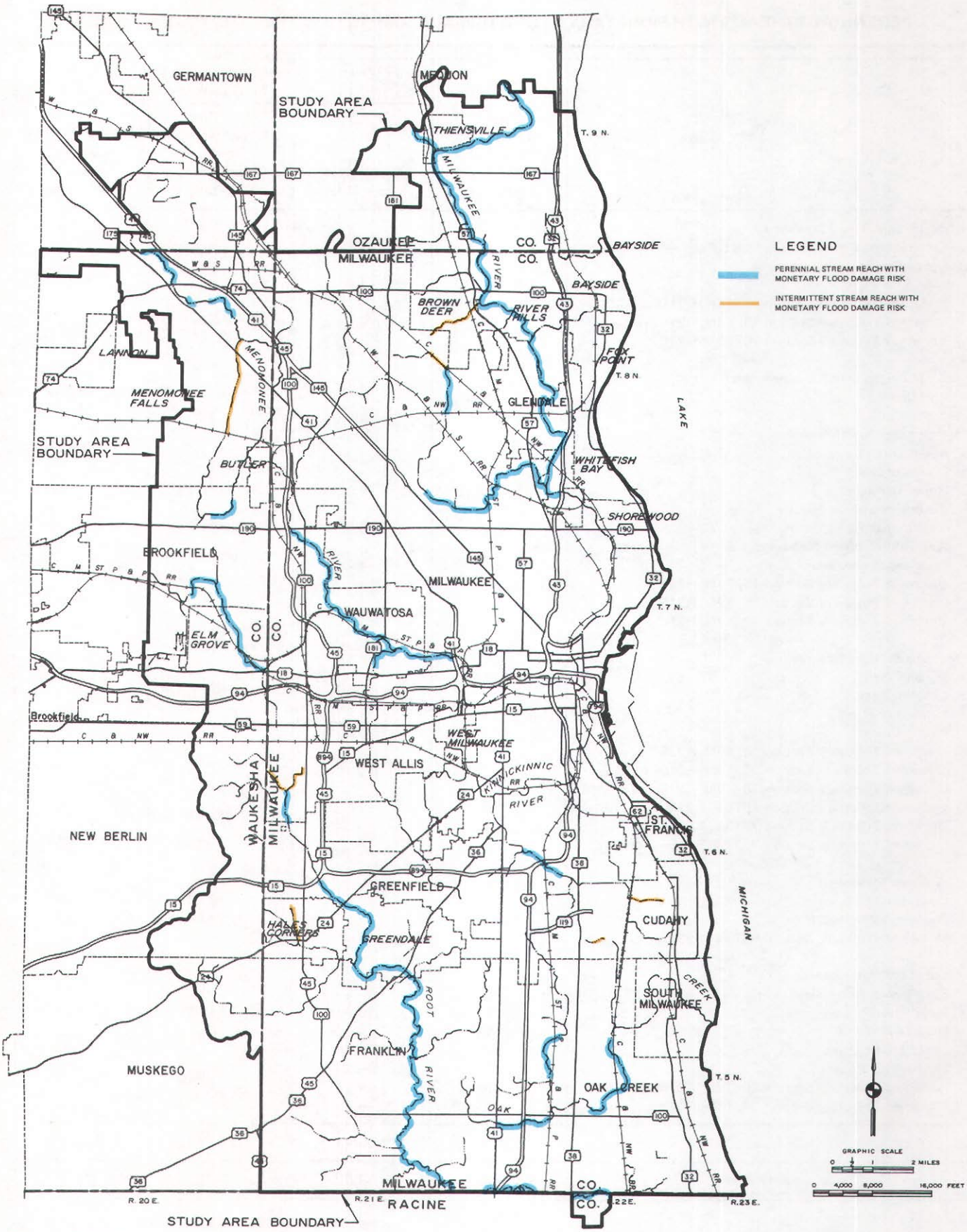
As a criterion for the jurisdictional classification of streams and watercourses for drainage and flood control purposes, the multi-community nature of a stream could be measured in terms of either the number of minor civil divisions through which the stream flows or the number of minor civil divisions in which the tributary drainage area of the stream is located. Both of these means of measurement were applied in the application of this jurisdictional criterion.

In order to identify the streams within the study area which flow through more than one community, the following procedure was used. All perennial streams within the study area were identified using the latest available U. S. Geological Survey 7½-minute quadrangle maps, the publication dates of those maps being 1971 for some portions of the study area and 1976 for others (see Map 4). The identified perennial streams were then mapped on Commission 1 inch equals 2,000 feet scale planning base maps, which included the location of the corporate limits of the minor civil divisions within the study area as of January 1, 1985. The perennial stream lengths by civil division were then determined utilizing either the river mile data published in applicable Commission watershed plan reports or direct measurement on the planning base map. The findings of this procedure are graphically summarized on Map 9 and quantitatively summarized in Table 7. Table 7 indicates that the application of this criterion as measured by the number of minor civil divisions through which the stream flows—including streams within one civil division within the study area but having reaches located in another civil division outside the study area—would result in 152.1 miles, or 86.2 percent of the total perennial stream length within the study area, being considered for District jurisdiction for drainage and flood control purposes.

The application of this criterion to streams within the District only would limit the jurisdiction of the District to those perennial streams which flow through more than one minor civil division within the District, including streams within one civil division within the District but having reaches located in another civil division outside the District, and to streams which flow out of and then again into the District. As shown on Map 10 and summarized in Table 8, the application of the criterion in this manner would result in a total of 117.8 miles of perennial streams, or 66.8 percent

Map 6

PERENNIAL AND SELECTED INTERMITTENT STREAMS WITH MONETARY FLOOD DAMAGE RISK WITHIN THE STUDY AREA: 1985



Source: SEWRPC.

Table 4

PERENNIAL STREAMS WITH MONETARY FLOOD DAMAGE RISK WITHIN THE STUDY AREA: 1985

Stream	Total Length of Perennial Streams in Study Area	Perennial Stream Reaches With Monetary Flood Damage Risk in $1,000's Within the Study Area		
		Linear Miles	100-Year Recurrence Interval Flood Event 1985 Dollars	Average Annual 1985 Dollars
Kinnickinnic River Watershed				
Kinnickinnic River	8.1	--	--	--
Lyons Creek	1.2	--	--	--
Wilson Park Creek	3.4	1.3[a]	N/A	N/A
Unnamed Tributary Section 12, T6N, R21E	1.0	--	--	--
Unnamed Tributary Section 19, T6N, R22E	1.7	--	--	--
Unnamed Tributary Section 20, T6N, R22E	1.6	--	--	--
Lake Michigan Direct Drainage Area				
Fish Creek	3.1	--	--	--
Menomonee River Watershed				
Butler Ditch	3.7	1.3	10.8	3.5
Dousman Ditch	5.5	--	--	--
Honey Creek	8.8	0.9	7.5	1.0
Little Menomonee River	6.9	--	--	--
Menomonee River	26.8[b]	9.9[c]	6,414.8	563.9
West Branch of the Menomonee River	0.3	--	--	--
Underwood Creek	8.2	4.2	3,292.9	560.2
Unnamed Tributary Section 14, T7N, R20E	1.0	--	--	--
Unnamed Tributary Section 35, T7N, R21E	1.1	--	--	--
Unnamed Tributary Section 30, T7N, R21E	1.1	--	--	--
Milwaukee River Watershed				
Indian Creek	1.9	--	--	--
Lincoln Creek	8.1	5.4[d]	17,265.0[e]	615.7[e]
Milwaukee River	23.6	17.2[f]	4,327.7	246.7
Pigeon Creek	0.8	0.8	--[g]	--[g]
Unnamed Tributary Section 18, T9N, R22E	0.5	--	--	--
Unnamed Tributary Section 35, T9N, R21E	2.0	--	--	--
Unnamed Tributary Section 36, T9N, R21E	0.2	--	--	--
Unnamed Tributary Section 1, T8N, R21E	1.9	--	--	--
Unnamed Tributary Section 7, T8N, R22E	1.8	--	--	--
Unnamed Tributary Section 2, T7N, R21E	0.5	--	--	--
Oak Creek Watershed				
Oak Creek	13.1	4.4[h]	132.0	14.7
Oak Creek North Branch	5.7	1.5	200.8	9.9
Unnamed Tributary Section 9, T5N, R22E	2.3	--	--	--
Root River Watershed				
East Branch Root River	4.7	--	--	--
Root River	20.2[i]	18.4[j]	1,659.3[k]	466.4[k]
Root River Canal	1.3	--	--	--
Tess Corners Creek	2.2	--	--	--
Whitnall Park Creek	0.7	--	--	--
Unnamed Tributary Section 20, T6N, R21E	0.4	--	--	--
Unnamed Tributary Section 34, T5N, R22E	1.0	--	--	--
Total	176.4	65.3	33,310.8	2,482.0
Percent of Total in Study Area	100.0	37.0	100.0	100.0

Footnotes to Table 4

NOTE: N/A Indicates data not applicable.

[a] *Does not include a 0.8-mile intermittent reach of the Edgerton Channel, which has an average annual monetary flood damage risk of $78,000 and a 100-year recurrence interval flood damage risk of $398,400.*

[b] *Does not include a 0.6-mile reach of the main stem of the Menomonee River which flows out of, then back into, the study area.*

[c] *Does not include a 2.6-mile intermittent reach of Lilly Creek, which has an average annual monetary flood damage risk of $83,300 and a 100-year recurrence interval flood damage risk of $461,400.*

[d] *Does not include a 0.4-mile intermittent reach of Lincoln Creek.*

[e] *Includes monetary flood damage risk for a 0.4-mile intermittent reach of Lincoln Creek.*

[f] *Does not include a 1.7-mile intermittent reach of South Branch Creek in the Village of Brown Deer, which has approximately 50 structures within its tributary drainage area subject to monetary flood damage risk.*

[g] *Monetary flood damage risk for Pigeon Creek included in figure for Milwaukee River.*

[h] *Does not include a 0.2-mile intermittent reach of an unnamed tributary to Oak Creek, which has an average annual monetary flood damage risk of $6,300 and a 100-year recurrence interval flood damage risk of $22,300.*

[i] *Does not include two reaches with a combined length of 3.0 miles along the main stem of the Root River which flow out of, then back into, the study area.*

[j] *Does not include a 0.9-mile intermittent reach of an unnamed tributary to Whitnall Park Creek in the Village of Hales Corners, which has approximately 40 structures within its tributary drainage area subject to monetary flood damage risk, and does not include a 0.9-mile intermittent reach of Hale Creek and a 0.8-mile intermittent reach of the Root River.*

[k] *Includes monetary flood damage risk for a 0.9-mile intermittent reach of Hale Creek and a 0.8-mile intermittent reach of the Root River.*

Source: SEWRPC.

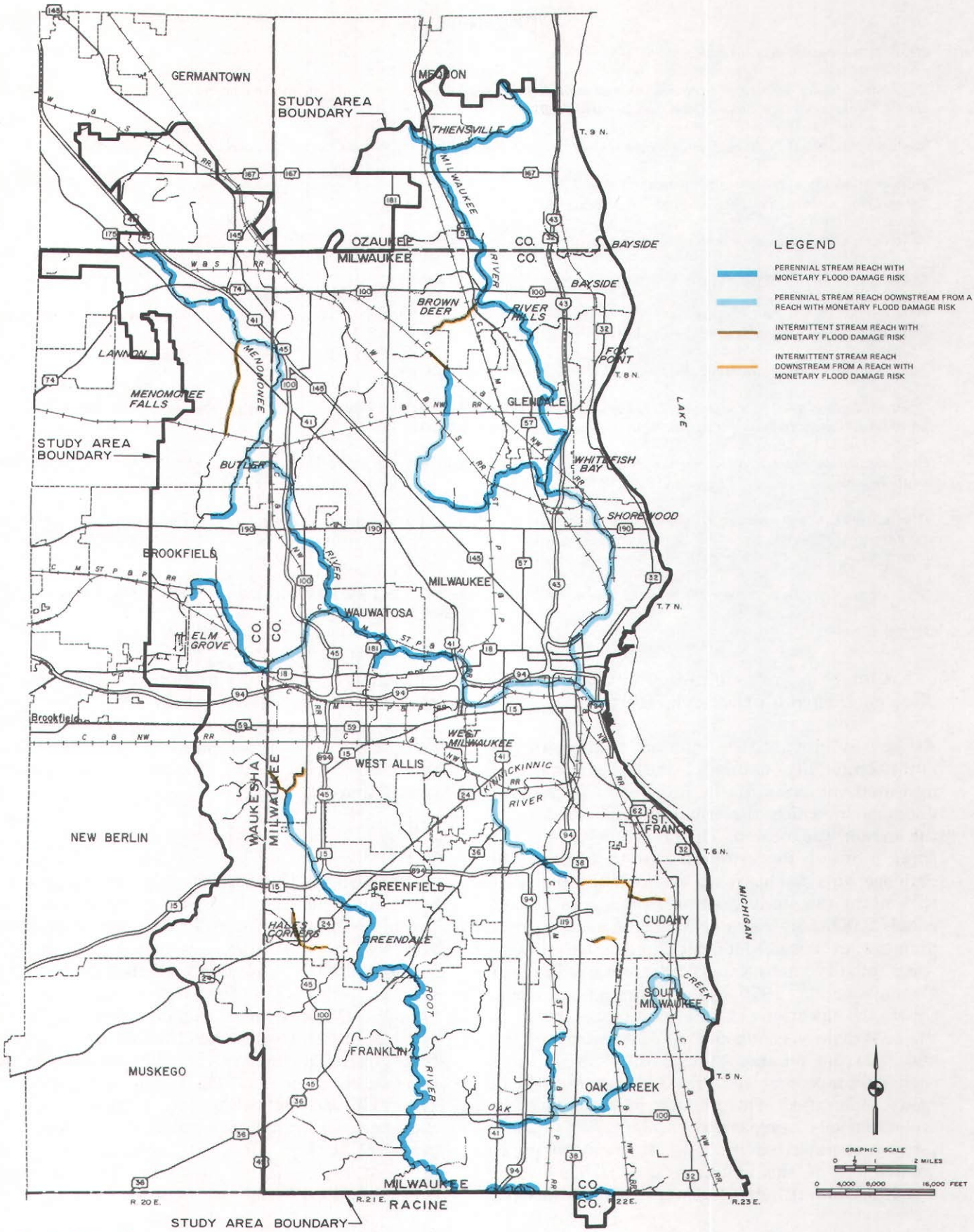
of the total miles of such streams in the study area, being considered for District jurisdiction.

As already noted, the criterion relating to the multi-community nature of the stream was also measured in terms of the number of minor civil divisions in which the tributary drainage area of the stream was located. The procedure used in this application of the criterion was to identify the drainage area tributary to each of the perennial streams in the study area on Commission 1 inch equals 2,000 feet scale planning base maps as those drainage areas were delineated under the areawide water quality management plan prepared by the Commission in 1979. The planning base maps show the location of the corporate limits of the civil divisions concerned as of January 1, 1985, and thus the number of civil divisions in which each tributary drainage area is located could be readily identified. The findings of this procedure are graphically summarized on Map 11 and quantitatively summarized in Table 9. Included in the application of this criterion in this manner are streams whose tributary drainage area is within one civil division within the study area and in another civil division outside the study area. This application would result in 172.6 linear miles, or 97.8 percent of the total perennial stream length within the study area, being considered for District jurisdiction.

The application of this criterion in this way to streams within the District only would limit the jurisdiction of the District to those perennial streams within the District having tributary drainage areas in more than one minor civil division. Included in the application of this criterion are stream reaches which flow out of and then again into the District, and streams whose tributary drainage area is within one civil division within the District and in another civil division outside the District. As shown on Map 12 and summarized in Table 10, the application of the criterion in this manner would result in a total of 130.5 miles of perennial streams, or 74.0 percent of the total miles of such streams in the study area, being considered for District jurisdiction.

Map 7

PERENNIAL AND SELECTED INTERMITTENT STREAMS AFFECTED BY MONETARY FLOOD DAMAGE RISK WITHIN THE STUDY AREA: 1985



Source: SEWRPC.

Table 5

PERENNIAL STREAMS AFFECTED BY MONETARY FLOOD DAMAGE RISK WITHIN THE STUDY AREA: 1985

Stream	Perennial Stream Reaches Affected by Monetary Flood Damage Risk			Perennial Stream Reaches Not Affected by Monetary Flood Damage Risk (linear miles)
	Stream Reaches with Monetary Flood Damage Risk (linear miles)	Stream Reaches Downstream from a Reach with Monetary Flood Damage Risk (linear miles)	Total Linear Miles	
Kinnickinnic River Watershed				
Kinnickinnic River	--	--	--	8.1
Lyons Creek	--	--	--	1.2
Wilson Park Creek	1.3	1.5	2.8	0.6
Unnamed Tributary Section 12, T6N, R21E	--	--	--	1.0
Unnamed Tributary Section 19, T6N, R22E	--	--	--	1.7
Unnamed Tributary Section 20, T6N, R22E	--	--	--	1.6
Lake Michigan Direct Drainage Area				
Fish Creek	--	--	--	3.1
Menomonee River Watershed				
Butler Ditch	1.3	1.4	2.7	1.0
Dousman Ditch	--	--	--	5.5
Honey Creek	0.9	--	0.9	7.9
Little Menomonee River	--	--	--	6.9
Menomonee River	9.9	13.6	23.5	3.3[a]
West Branch of the Menomonee River	--	--	--	0.3
Underwood Creek	4.2	2.6	6.8	1.4
Unnamed Tributary Section 14, T7N, R20E	--	--	--	1.0
Unnamed Tributary Section 35, T7N, R21E	--	--	--	1.1
Unnamed Tributary Section 30, T7N, R21E	--	--	--	1.1
Milwaukee River Watershed				
Indian Creek	--	--	--	1.9
Lincoln Creek	5.4	2.7	8.1	--
Milwaukee River	17.2	6.4	23.6	--
Pigeon Creek	0.8	--	0.8	--
Unnamed Tributary Section 18, T9N, R22E	--	--	--	0.5
Unnamed Tributary Section 35, T9N, R21E	--	--	--	2.0
Unnamed Tributary Section 36, T9N, R21E	--	--	--	0.2
Unnamed Tributary Section 1, T8N, R21E	--	--	--	1.9
Unnamed Tributary Section 7, T8N, R22E	--	--	--	1.8
Unnamed Tributary Section 2, T7N, R21E	--	--	--	0.5
Oak Creek Watershed				
Oak Creek	4.4	7.4	11.8	1.3
Oak Creek North Branch	1.5	0.9	2.4	3.3
Unnamed Tributary Section 9, T5N, R22E	--	--	--	2.3
Root River Watershed				
East Branch Root River	--	--	--	4.7
Root River	18.4[b]	1.8	20.2	--
Root River Canal	--	--	--	1.3
Tess Corners Creek	--	--	--	2.2
Whitnall Park Creek	--	--	--	0.7
Unnamed Tributary Section 20, T6N, R21E	--	--	--	0.4
Unnamed Tributary Section 34, T5N, R22E	--	--	--	1.0
Total	65.3	38.3	103.6	72.8
Percent of Total in Study Area	37.0	21.7	58.7	41.3

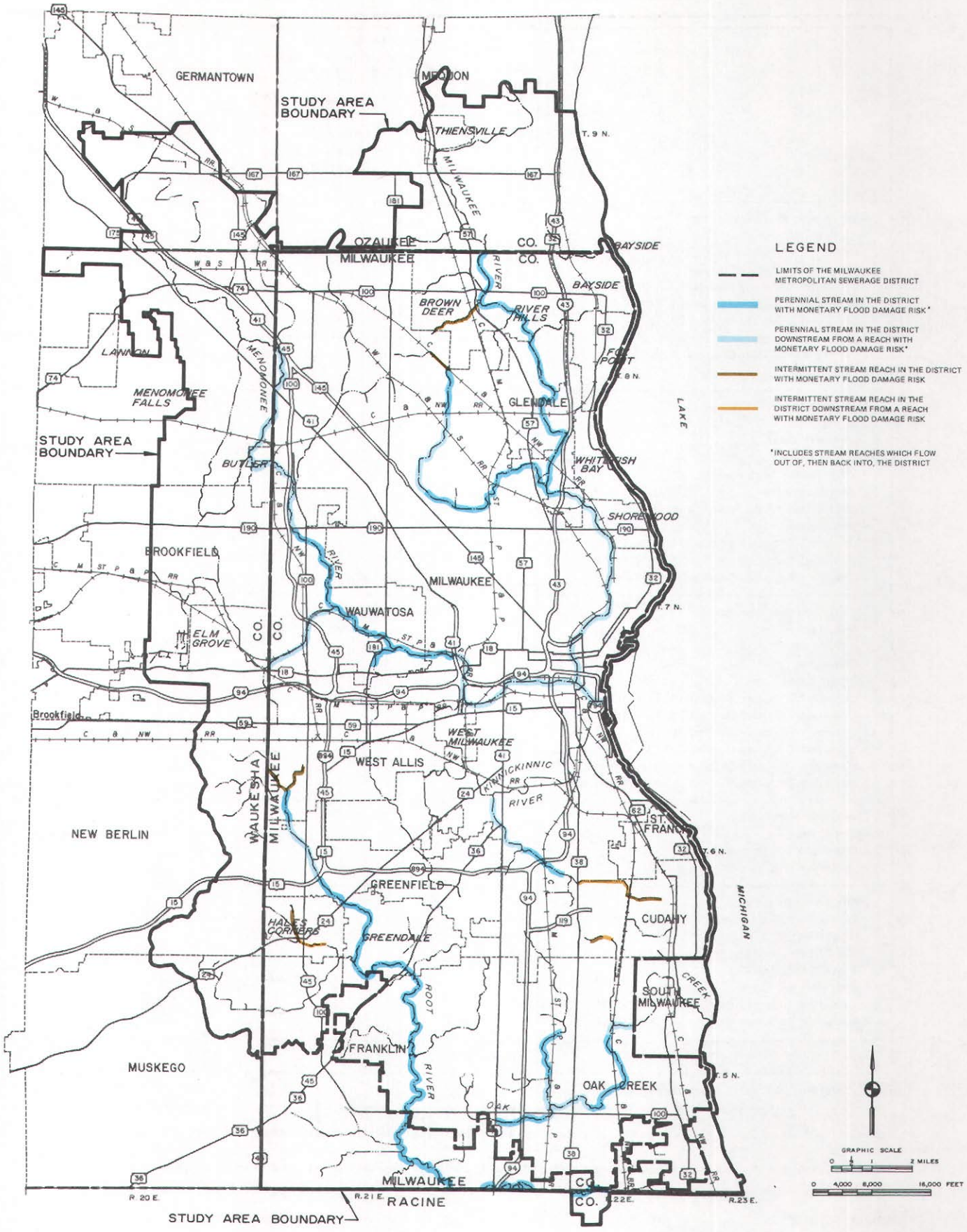
[a] *Does not include a 0.6-mile reach along the main stem of the Menomonee River which flows out of, then back into, the study area.*

[b] *Does not include two reaches with a combined length of 3.0 miles along the main stem of the Root River which flow out of, then back into, the study area.*

Source: SEWRPC.

Map 8

PERENNIAL AND SELECTED INTERMITTENT STREAMS AFFECTED BY MONETARY FLOOD DAMAGE RISK WITHIN THE MILWAUKEE METROPOLITAN SEWERAGE DISTRICT: 1985



Source: SEWRPC.

Table 6

PERENNIAL STREAMS AFFECTED BY MONETARY FLOOD DAMAGE RISK WITHIN THE MILWAUKEE METROPOLITAN SEWERAGE DISTRICT: 1985

Stream	Perennial Stream Reaches Affected by Monetary Flood Damage Risk			Perennial Stream Within the District Not Affected by Monetary Flood Damage Risk (linear miles)	Length of Perennial Stream Outside the District but Within the Study Area (linear miles)
	Stream Reaches with Monetary Flood Damage Risk (linear miles)	Stream Reaches Downstream from a Reach with Monetary Flood Damage Risk (linear miles)	Total Linear Miles		
Kinnickinnic River Watershed					
Kinnickinnic River	--	--	--	8.1	--
Lyons Creek	--	--	--	1.2	--
Wilson Park Creek	1.3	1.5	2.8	0.6	--
Unnamed Tributary Section 12, T6N, R21E	--	--	--	1.0	--
Unnamed Tributary Section 19, T6N, R22E	--	--	--	1.7	--
Unnamed Tributary Section 20, T6N, R22E	--	--	--	1.6	--
Lake Michigan Direct Drainage Area					
Fish Creek	--	--	--	3.1	--
Menomonee River Watershed					
Butler Ditch	--	--	--	--	3.7
Dousman Ditch	--	--	--	--	5.5
Honey Creek	0.9	--	0.9	7.9	--
Little Menomonee River	--	--	--	6.9	--
Menomonee River	6.8	10.2[a]	17.0	--	9.8[b]
West Branch of the Menomonee River	--	--	--	--	0.3
Underwood Creek	--	2.6	2.6	--	5.6
Unnamed Tributary Section 14, T7N, R20E	--	--	--	--	1.0
Unnamed Tributary Section 35, T7N, R21E	--	--	--	1.1	--
Unnamed Tributary Section 30, T7N, R21E	--	--	--	0.6	6.5
Milwaukee River Watershed					
Indian Creek	--	--	--	1.9	--
Lincoln Creek	5.4	2.7	8.1	--	--
Milwaukee River	9.7	6.4	16.1	--	7.5
Pigeon Creek	--	--	--	--	0.8
Unnamed Tributary Section 18, T9N, R22E	--	--	--	--	0.5
Unnamed Tributary Section 35, T9N, R21E	--	--	--	--	2.0
Unnamed Tributary Section 36, T9N, R21E	--	--	--	--	0.2
Unnamed Tributary Section 1, T8N, R21E	--	--	--	1.9	--
Unnamed Tributary Section 7, T8N, R22E	--	--	--	1.8	--
Unnamed Tributary Section 2, T7N, R21E	--	--	--	0.5	--
Oak Creek Watershed					
Oak Creek	4.4	3.2	7.6	1.0	4.5
Oak Creek North Branch	1.5	0.9	2.4	3.3	--
Unnamed Tributary Section 9, T5N, R22E	--	--	--	2.3	--
Root River Watershed					
East Branch Root River	--	--	--	4.7	--
Root River	18.3[c]	1.8	20.1	--	0.1
Root River Canal	--	--	--	--	1.3
Tess Corners Creek	--	--	--	2.2	--
Whitnall Park Creek	--	--	--	0.7	--
Unnamed Tributary Section 20, T6N, R21E	--	--	--	0.4	--
Unnamed Tributary Section 34, T5N, R22E	--	--	--	--	1.0
Total	48.3	29.3	77.6	54.5	44.3
Percent of Total in Study Area	27.4	16.6	44.0	30.9	25.1

[a] *Includes two reaches with a combined length of 2.3 miles along the main stem of the Menomonee River which flow out of, then back into, the Milwaukee Metropolitan Sewerage District.*

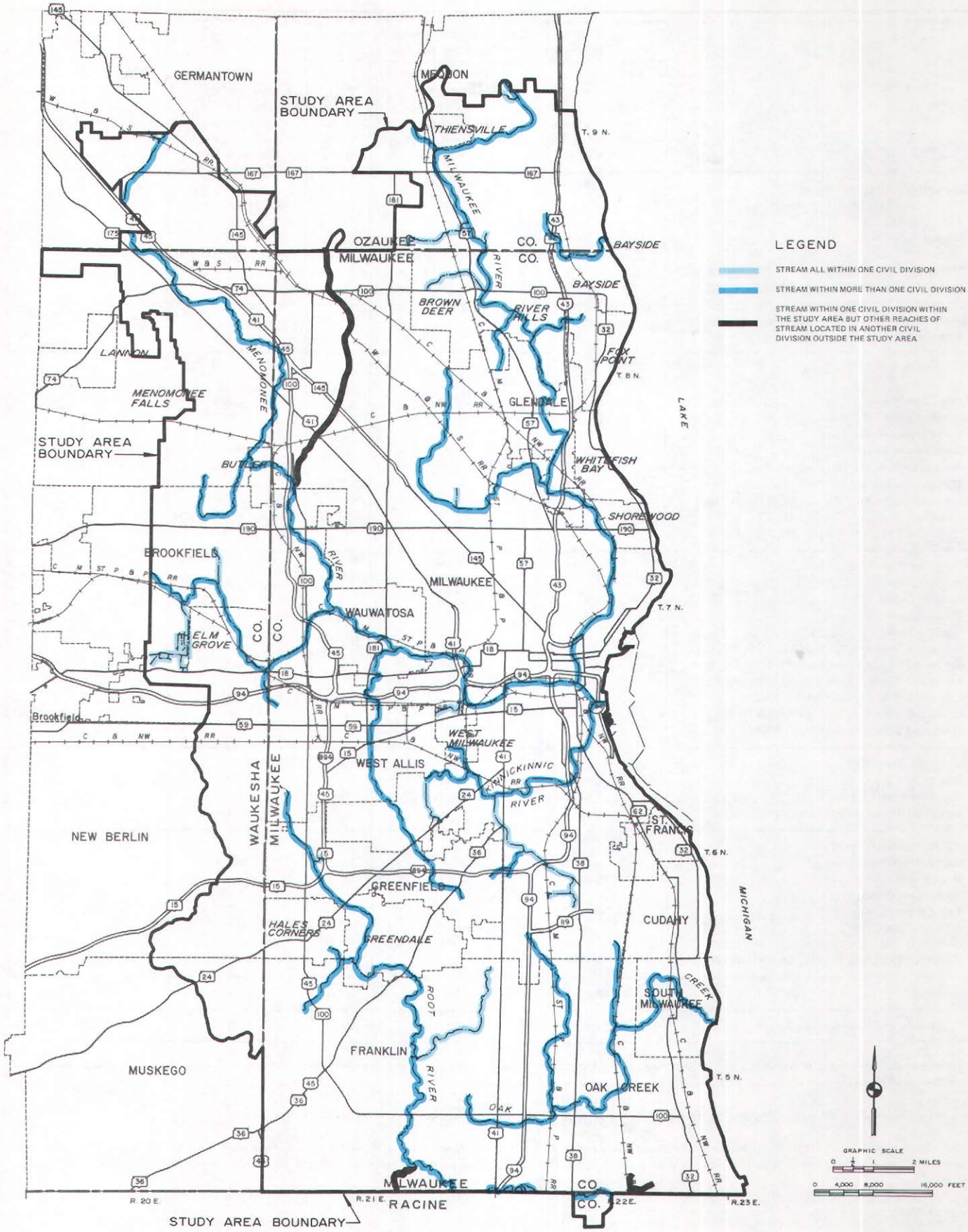
[b] *Does not include a 0.6-mile reach along the main stem of the Menomonee River which flows out of, then back into, the study area.*

[c] *Includes four reaches with a combined length of 7.0 miles along the main stem of the Root River which flow out of, then back into, the Milwaukee Metropolitan Sewerage District, but does not include two reaches with a combined length of 3.0 miles along the main stem of the Root River which flow out of, then back into, the study area.*

Source: SEWRPC.

Map 9

PERENNIAL STREAMS FLOWING THROUGH ONE OR MORE CIVIL DIVISIONS WITHIN THE STUDY AREA: 1985



Source: SEWRPC.

Table 7

PERENNIAL STREAMS FLOWING THROUGH ONE OR MORE CIVIL DIVISIONS WITHIN THE STUDY AREA: 1985

Stream	Stream Within One Civil Division (linear miles)	Stream Within More than One Civil Division (linear miles)	Stream Within One Civil Division Within the Study Area but Having Reaches Located in Another Civil Division Outside the Study Area (linear miles)
Kinnickinnic River Watershed			
Kinnickinnic River	--	8.1	--
Lyons Creek	1.2	--	--
Wilson Park Creek	3.4	--	--
Unnamed Tributary Section 12, T6N, R21E	--	1.0	--
Unnamed Tributary Section 19, T6N, R22E	--	1.7	--
Unnamed Tributary Section 20, T6N, R22E	1.6	--	--
Lake Michigan Direct Drainage Area			
Fish Creek	--	3.1	--
Menomonee River Watershed			
Butler Ditch	--	3.7	--
Dousman Ditch	5.5	--	--
Honey Creek	--	8.8	--
Little Menomonee River	--	--	6.9
Menomonee River	--	26.8[a]	--
West Branch of the Menomonee River	0.3	--	--
Underwood Creek	--	8.2	--
Unnamed Tributary Section 14, T7N, R20E	1.0	--	--
Unnamed Tributary Section 35, T7N, R21E	1.1	--	--
Unnamed Tributary Section 30, T7N, R21E	--	1.1	--
Milwaukee River Watershed			
Indian Creek	--	1.9	--
Lincoln Creek	--	8.1	--
Milwaukee River	--	23.6	--
Pigeon Creek	--	0.8	--
Unnamed Tributary Section 18, T9N, R22E	0.5	--	--
Unnamed Tributary Section 35, T9N, R21E	2.0	--	--
Unnamed Tributary Section 36, T9N, R21E	0.2	--	--
Unnamed Tributary Section 1, T8N, R21E	1.9	--	--
Unnamed Tributary Section 7, T8N, R22E	--	1.8	--
Unnamed Tributary Section 2, T7N, R21E	0.5	--	--
Oak Creek Watershed			
Oak Creek	--	13.1	--
Oak Creek North Branch	--	5.7	--
Unnamed Tributary Section 9, T5N, R22E	--	2.3	--
Root River Watershed			
East Branch Root River	4.7	--	--
Root River	--	20.2[b]	--
Root River Canal	--	--	1.3
Tess Corners Creek	--	2.2	--
Whitnall Park Creek	--	0.7	--
Unnamed Tributary Section 20, T6N, R21E	0.4	--	--
Unnamed Tributary Section 34, T5N, R22E	--	--	1.0
Total	24.3	142.9	9.2
Percent of Total in Study Area	13.8	81.0	5.2

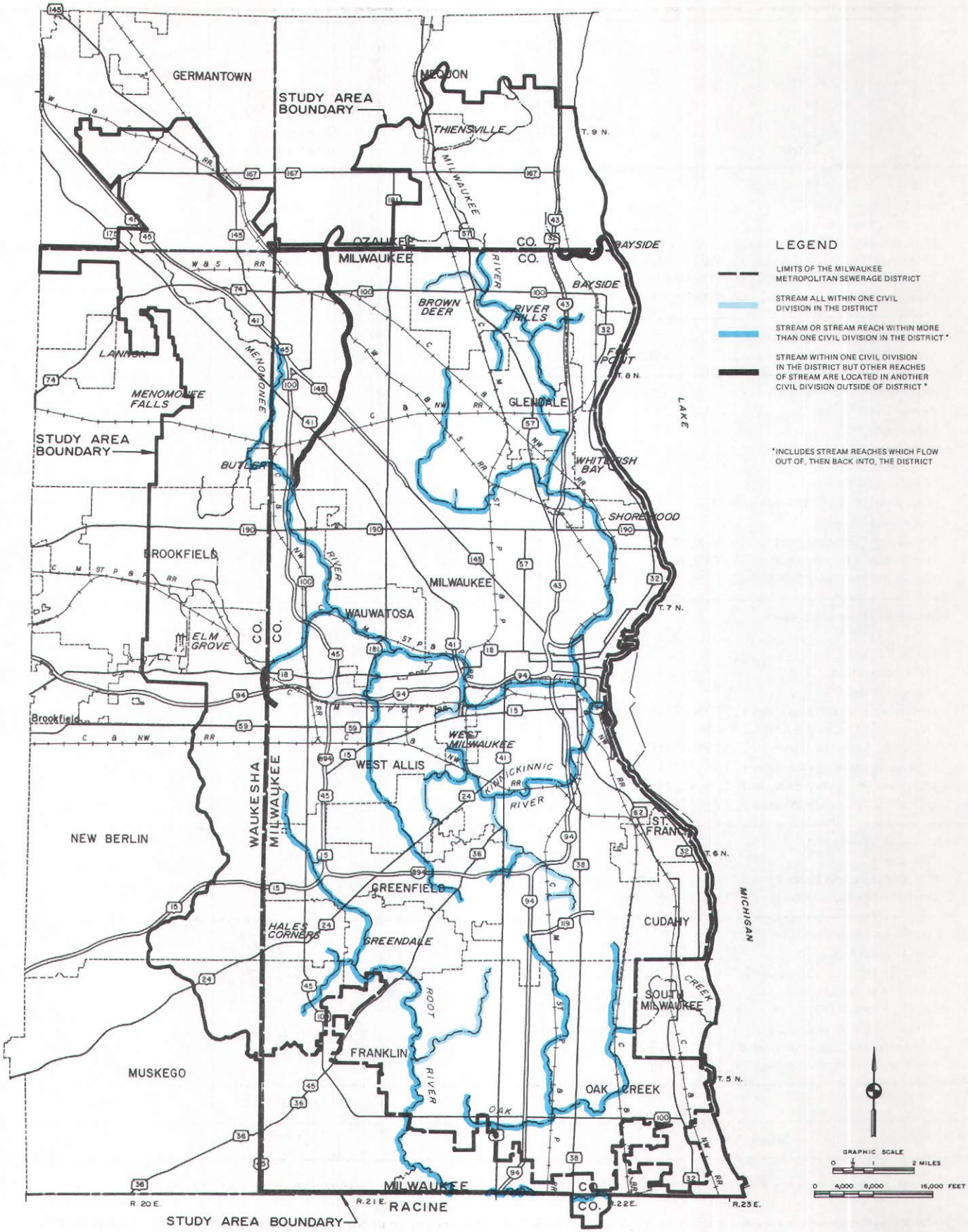
[a] *Does not include a 0.6-mile reach along the main stem of the Menomonee River which flows out of, then back into, the study area.*

[b] *Does not include two reaches with a combined length of 3.0 miles along the main stem of the Root River which flow out of, then back into, the study area.*

Source: SEWRPC.

Map 10

PERENNIAL STREAMS FLOWING THROUGH ONE OR MORE CIVIL DIVISIONS WITHIN THE MILWAUKEE METROPOLITAN SEWERAGE DISTRICT: 1985



Source: SEWRPC.

Table 8

PERENNIAL STREAMS FLOWING THROUGH ONE OR MORE CIVIL DIVISIONS WITHIN THE MILWAUKEE METROPOLITAN SEWERAGE DISTRICT: 1985

Stream	Stream Reaches Within the District			Stream or Stream Reach Outside the District but Within the Study Area (linear miles)	Total Stream Length Within the Study Area (linear miles)
	Stream Within One Civil Division in the District (linear miles)	Stream or Stream Reach Within More than One Civil Division in the District (linear miles)	Stream Within One Civil Division Within the District but Having Reaches Located in Another Civil Division Outside the District (linear miles)		
Kinnickinnic River Watershed					
Kinnickinnic River	--	8.1	--	--	8.1
Lyons Creek	1.2	--	--	--	1.2
Wilson Park Creek	3.4	--	--	--	3.4
Unnamed Tributary Section 12, T6N, R21E	--	1.0	--	--	1.0
Unnamed Tributary Section 19, T6N, R22E	--	1.7	--	--	1.7
Unnamed Tributary Section 20, T6N, R22E	1.6	--	--	--	1.6
Lake Michigan Direct Drainage Area					
Fish Creek	--	--	1.8	1.3	3.1
Menomonee River Watershed					
Butler Ditch	--	--	--	3.7	3.7
Dousman Ditch	--	--	--	5.5	5.5
Honey Creek	--	8.8	--	--	8.8
Little Menomonee River	--	--	6.9	--	6.9
Menomonee River	--	18.0[a]	--	8.8	26.8
West Branch of the Menomonee River	--	--	--	0.3	0.3
Underwood Creek	--	2.6	--	5.6	8.2
Unnamed Tributary Section 14, T7N, R20E	--	--	--	1.0	1.0
Unnamed Tributary Section 35, T7N, R21E	1.1	--	--	--	1.1
Unnamed Tributary Section 30, T7N, R21E	--	--	1.1[b]	--	1.1
Milwaukee River Watershed					
Indian Creek	--	1.9	--	--	1.9
Lincoln Creek	--	8.1	--	--	8.1
Milwaukee River	--	16.1	--	7.5	23.6
Pigeon Creek	--	--	--	0.8	0.8
Unnamed Tributary Section 18, T9N, R22E	--	--	--	0.5	0.5
Unnamed Tributary Section 35, T9N, R21E	--	--	--	2.0	2.0
Unnamed Tributary Section 36, T9N, R21E	--	--	--	0.2	0.2
Unnamed Tributary Section 1, T8N, R21E	1.9	--	--	--	1.9
Unnamed Tributary Section 7, T8N, R22E	--	1.8	--	--	1.8
Unnamed Tributary Section 2, T7N, R21E	0.5	--	--	--	0.5
Oak Creek Watershed					
Oak Creek	--	8.9[c]	--	4.2	13.1
Oak Creek North Branch	--	5.7	--	--	5.7
Unnamed Tributary Section 9, T5N, R22E	--	2.3	--	--	2.3
Root River Watershed					
East Branch Root River	4.7	--	--	--	4.7
Root River	--	20.1[d]	--	0.1	20.2
Root River Canal	--	--	--	1.3	1.3
Tess Corners Creek	--	2.2	--	--	2.2
Whitnall Park Creek	--	0.7	--	--	0.7
Unnamed Tributary Section 20, T6N, R21E	0.4	--	--	--	0.4
Unnamed Tributary Section 34, T5N, R22E	--	--	--	1.0	1.0
Total	14.8	108.0	9.8	43.8	176.4
Percent of Total in Study Area	8.4	61.2	5.6	24.8	100.0

[a] *Includes two reaches with a combined length of 2.3 miles along the main stem of the Menomonee River which flow out of, then back into, the Milwaukee Metropolitan Sewerage District, but does not include a 0.6-mile reach of the main stem of the Menomonee River which flows out of, then back into, the study area.*

[b] *Includes one reach with a total length of 0.5 mile along the unnamed tributary to Underwood Creek which flows out of, then back into, the Milwaukee Metropolitan Sewerage District.*

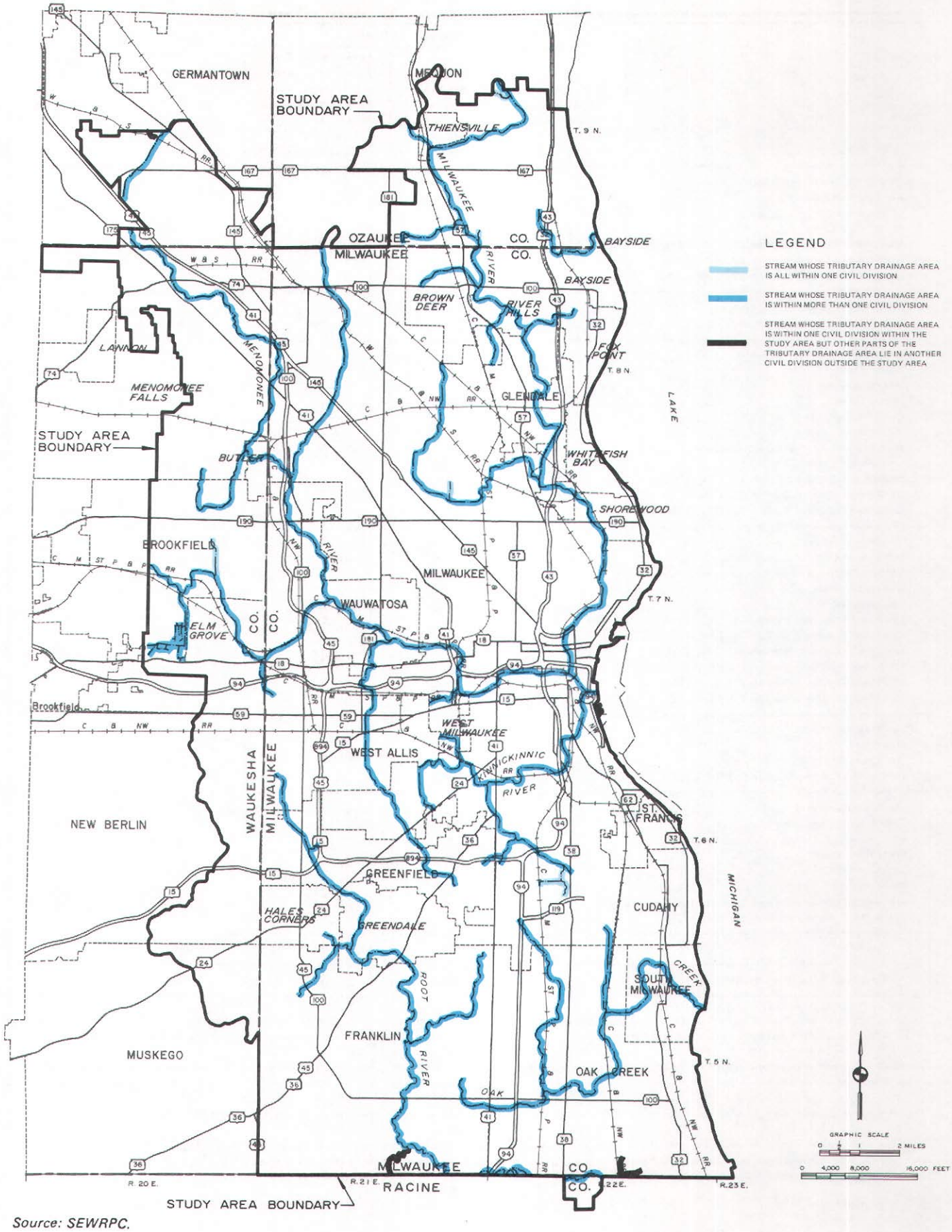
[c] *Includes one reach with a length of 0.3 mile along the main stem of Oak Creek which flows out of, then back into, the Milwaukee Metropolitan Sewerage District.*

[d] *Includes four reaches with a combined length of 7.0 miles along the main stem of the Root River which flow out of, then back into, the Milwaukee Metropolitan Sewerage District, but does not include two reaches with a combined length of 3.0 miles along the main stem of the Root River which flow out of, then back into, the study area.*

Source: SEWRPC.

Map 11

PERENNIAL STREAMS HAVING TRIBUTARY DRAINAGE AREAS IN ONE OR MORE CIVIL DIVISIONS WITHIN THE STUDY AREA: 1985



Source: SEWRPC.

Table 9

PERENNIAL STREAMS HAVING TRIBUTARY DRAINAGE AREAS IN ONE OR MORE CIVIL DIVISIONS WITHIN THE STUDY AREA: 1985

Stream	Stream Whose Tributary Drainage Area is Within One Civil Division	Stream Whose Tributary Drainage Area is Within More than One Civil Division	Stream Whose Tributary Drainage Area is Within One Civil Division Within the Study Area and in Another Civil Division Outside the Study Area
Kinnickinnic River Watershed			
Kinnickinnic River	--	8.1	--
Lyons Creek	--	1.2	--
Wilson Park Creek	--	3.4	--
Unnamed Tributary Section 12, T6N, R21E	--	1.0	--
Unnamed Tributary Section 19, T6N, R22E	--	1.7	--
Unnamed Tributary Section 20, T6N, R22E	1.6	--	--
Lake Michigan Direct Drainage Area			
Fish Creek	--	3.1	--
Menomonee River Watershed			
Butler Ditch	--	3.7	--
Dousman Ditch	--	5.5	--
Honey Creek	--	8.8	--
Little Menomonee River	--	6.9	--
Menomonee River	--	26.8[a]	--
West Branch of the Menomonee River	--	--	0.3
Underwood Creek	--	8.2	--
Unnamed Tributary Section 14, T7N, R20E	1.0	--	--
Unnamed Tributary Section 35, T7N, R21E	--	1.1	--
Unnamed Tributary Section 30, T7N, R21E	--	1.1	--
Milwaukee River Watershed			
Indian Creek	--	1.9	--
Lincoln Creek	--	8.1	--
Milwaukee River	--	23.6	--
Pigeon Creek	--	0.8	--
Unnamed Tributary Section 18, T9N, R22E	0.5	--	--
Unnamed Tributary Section 35, T9N, R21E	--	2.0	--
Unnamed Tributary Section 36, T9N, R21E	0.2	--	--
Unnamed Tributary Section 1, T8N, R21E	--	1.9	--
Unnamed Tributary Section 7, T8N, R22E	--	1.8	--
Unnamed Tributary Section 2, T7N, R21E	0.5	--	--
Oak Creek Watershed			
Oak Creek	--	13.1	--
Oak Creek North Branch	--	5.7	--
Unnamed Tributary Section 9, T5N, R22E	--	2.3	--
Root River Watershed			
East Branch Root River	--	4.7	--
Root River	--	20.2[b]	--
Root River Canal	--	--	1.3
Tess Corners Creek	--	2.2	--
Whitnall Park Creek	--	0.7	--
Unnamed Tributary Section 20, T6N, R21E	--	0.4	--
Unnamed Tributary Section 34, T5N, R22E	--	--	1.0
Total	3.8	170.0	2.6
Percent of Total in Study Area	2.2	96.3	1.5

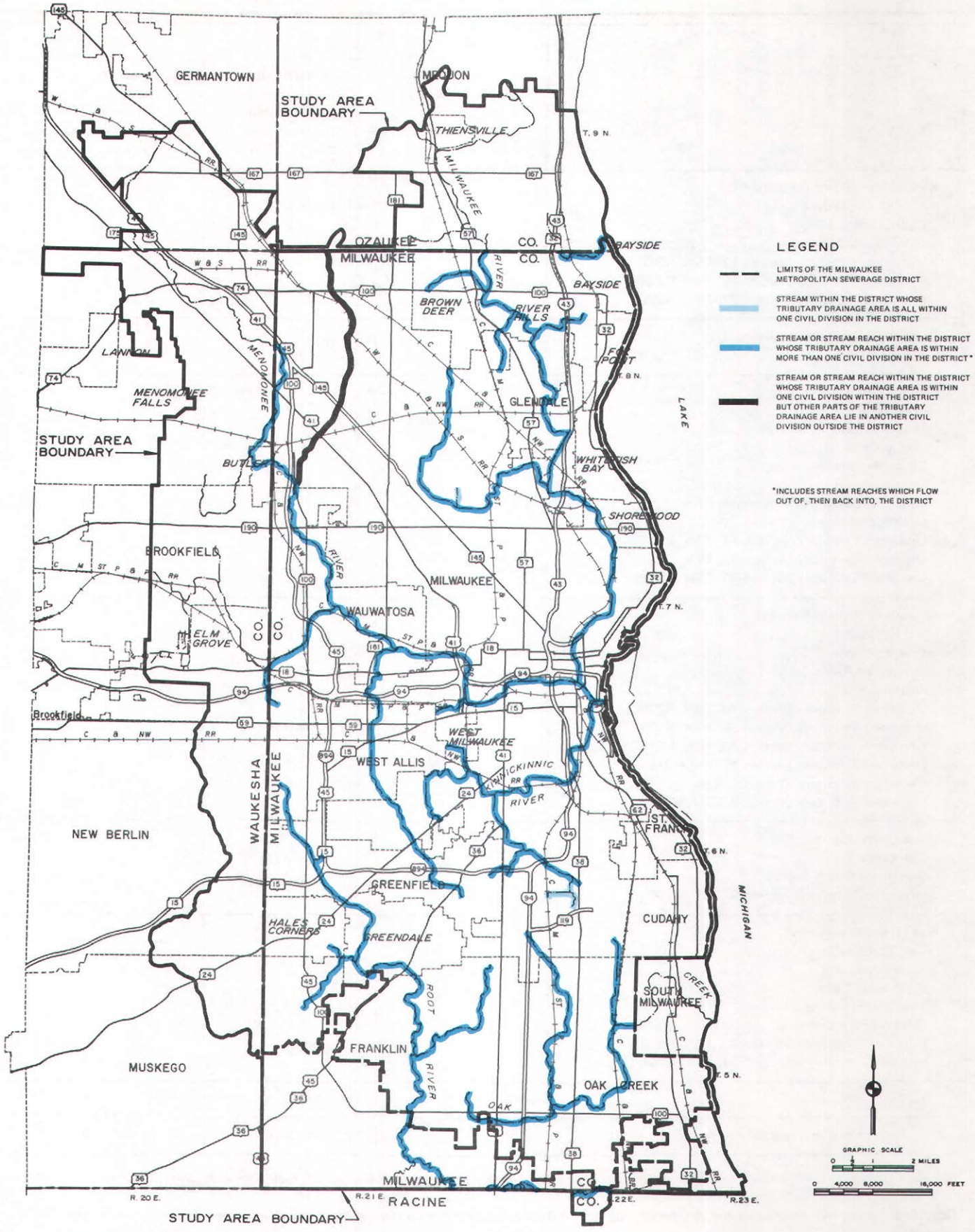
[a] *Does not include a 0.6-mile reach along the main stem of the Menomonee River which flows out of, then back into, the study area.*

[b] *Does not include two reaches with a combined length of 3.0 miles along the main stem of the Root River which flow out of, then back into, the study area.*

Source: SEWRPC.

Map 12

PERENNIAL STREAMS HAVING TRIBUTARY DRAINAGE AREAS IN ONE OR MORE CIVIL DIVISIONS WITHIN THE MILWAUKEE METROPOLITAN SEWERAGE DISTRICT: 1985



Source: SEWRPC.

Table 10

PERENNIAL STREAMS HAVING TRIBUTARY DRAINAGE AREAS IN ONE OR MORE CIVIL DIVISIONS WITHIN THE MILWAUKEE METROPOLITAN SEWERAGE DISTRICT: 1985

Stream	Linear Miles of Streams				
	Tributary Drainage Area in One MMSD Civil Division	Tributary Drainage Area in More than One MMSD Civil Division	Tributary Drainage Area in One MMSD Civil Division and One or More Non-MMSD Civil Divisions	Stream Reach Within Study Area but Outside MMSD	Total
Kinnickinnic River Watershed					
Kinnickinnic River	--	8.1	--	--	8.1
Lyons Creek	--	1.2	--	--	1.2
Wilson Park Creek	--	3.4	--	--	3.4
Unnamed Tributary Section 12, T6N, R21E	--	1.0	--	--	1.0
Unnamed Tributary Section 19, T6N, R22E	--	1.7	--	--	1.7
Unnamed Tributary Section 20, T6N, R22E	1.6	--	--	--	1.6
Lake Michigan Direct Drainage Area					
Fish Creek	--	1.8	--	1.3	3.1
Menomonee River Watershed					
Butler Ditch	--	--	--	3.7	3.7
Dousman Ditch	--	--	--	5.5	5.5
Honey Creek	--	8.8	--	--	8.8
Little Menomonee River	--	--	6.9	--	6.9
Menomonee River	--	18.0[a]	--	8.8	26.8
West Branch of the Menomonee River	--	--	--	0.3	0.3
Underwood Creek	--	2.6	--	5.6	8.2
Unnamed Tributary Section 14, T7N, R20E	--	--	--	1.0	1.0
Unnamed Tributary Section 35, T7N, R21E	--	1.1	--	--	1.1
Unnamed Tributary Section 30, T7N, R21E	--	1.1[b]	--	--	1.1
Milwaukee River Watershed					
Indian Creek	--	1.9	--	--	1.9
Lincoln Creek	--	8.1	--	--	8.1
Milwaukee River	--	16.1	--	7.5	23.6
Pigeon Creek	--	--	--	0.8	0.8
Unnamed Tributary Section 18, T9N, R22E	--	--	--	0.5	0.5
Unnamed Tributary Section 35, T9N, R21E	--	--	--	2.0	2.0
Unnamed Tributary Section 36, T9N, R21E	--	--	--	0.2	0.2
Unnamed Tributary Section 1, T8N, R21E	--	1.9	--	--	1.9
Unnamed Tributary Section 7, T8N, R22E	--	1.8	--	--	1.8
Unnamed Tributary Section 2, T7N, R21E	0.5	--	--	--	0.5
Oak Creek Watershed					
Oak Creek	--	8.9[c]	--	4.2	13.1
Oak Creek North Branch	--	5.7	--	--	5.7
Unnamed Tributary Section 9, T5N, R22E	--	2.3	--	--	2.3
Root River Watershed					
East Branch Root River	--	4.7	--	--	4.7
Root River	--	20.1[d]	--	0.1	20.2
Root River Canal	--	--	--	1.3	1.3
Tess Corners Creek	--	2.2	--	--	2.2
Whitnall Park Creek	--	0.7	--	--	0.7
Unnamed Tributary Section 20, T6N, R21E	--	0.4	--	--	0.4
Unnamed Tributary Section 34, T5N, R22E	--	--	--	1.0	1.0
Total	2.1	123.6	6.9	43.8	176.4
Percent of Total in Study Area	1.2	70.1	3.9	24.8	100.0

[a] *Includes two reaches with a combined length of 2.3 miles along the main stem of the Menomonee River which flow out of, then back into, the Milwaukee Metropolitan Sewerage District, but does not include a 0.6-mile reach of the main stem of the Menomonee River which flows out of, then back into, the study area.*

[b] *Includes one reach with a total length of 0.5 mile along the unnamed tributary to Underwood Creek which flows out of, then back into, the Milwaukee Metropolitan Sewerage District.*

[c] *Includes one reach with a total length of 0.3 mile along the main stem of Oak Creek which flows out of, then back into, the Milwaukee Metropolitan Sewerage District.*

[d] *Includes four reaches with a combined length of 7.0 miles along the main stem of the Root River which flow out of, then back into, the Milwaukee Metropolitan Sewerage District, but does not include two reaches with a combined length of 3.0 miles along the main stem of the Root River which flow out of, then back into, the study area.*

Source: SEWRPC.

Location and Continuity of Existing Stream Channel Improvements

The criterion relating to the location and continuity of existing stream channel improvements constructed by the Milwaukee Metropolitan Sewerage District in relation to potential downstream effects was applied using the following procedure. A list of all channel improvements completed by the Milwaukee Metropolitan Sewerage District as of January 1, 1985, was compiled, as set forth in Table 11, and the locations of the improved stream segments plotted on Commission 1 inch equals 2,000 feet scale planning base maps, as shown on Map 13. As noted in Table 11, these improvements total 25.1 linear miles, or 14.2 percent of the total miles of perennial streams in the study area. As further indicated in Table 11, a total of about $69.8 million, in 1985 dollars, has been invested in these channel improvements. In addition, as shown on Map 13, 2.2 miles of intermittent streams have been improved by the District at a cost of about $10.0 million.

The downstream channel reaches that could be affected by the existing District channel improvements were determined, and the affected reaches plotted on Commission 1 inch equals 2,000 feet scale planning base maps, as shown on Map 14. For purposes of this study, it was assumed that the effects of the channel improvements on downstream reaches end at a stream's confluence with a larger stream. As indicated in Table 12, a total of 9.0 miles, or 5.1 percent of the total miles of perennial streams in the study area, are located downstream of the improved channel reaches. Thus, together with the already improved reaches, a total of 33.0 miles of perennial streams, or 18.7 percent of such streams in the study area, would be considered for District jurisdiction with application of this criterion.

It should be noted that the application of this criterion to streams within the District would also result in a total of 33.0 miles of perennial streams, or 18.7 percent of the total miles of perennial streams in the study area, being under District jurisdiction since all channel improvement projects completed solely by the District involved streams within the District limits or streams which flow out of, then back into, the District.

A list of stream reaches for which the Milwaukee Metropolitan Sewerage District as of January 1, 1985, had completed planning and design studies was then compiled, as set forth in Table 13. The stream reaches so studied were plotted on Commission 1 inch equals 2,000 feet scale planning base maps, as shown on Map 15. As noted in Table 13, such planning and design studies were completed for a total of 25.6 miles, or 14.5 percent of the total miles of perennial streams in the study area. As further indicated in Table 13, the cost of the improvements identified in the studies approximated $39.9 million in 1985 dollars. In addition, as shown on Map 15, such studies have been completed by the District for 1.1 miles of intermittent stream. The cost of improvements identified in the studies—all channel improvements—approximated $2.3 million. It should be noted that the completion of planning and design studies cannot be construed as a commitment to District improvement of the reaches concerned. Indeed, there is no known official District commitment to complete any channel improvements within the District limits. There may have been some unofficial commitments made to local units of government by the staff of the predecessor agency to the Milwaukee Metropolitan Sewerage District concerning improvements to certain stream reaches within the District. There were, however, no formal commitments made by the governing body of that predecessor agency. The District staff has carefully searched the records of the District and its predecessor agency and has found no official resolutions of the governing body of the District or the predecessor agency supporting such staff commitments.

SUMMARY OF FINDINGS OF APPLICATION OF JURISDICTIONAL CRITERIA

As indicated in Table 14, the independent application of the four jurisdictional classification criteria, including different measures of some of these criteria, to all perennial streams within the study area would result in from 33.0 miles to 172.6 miles of perennial stream mileage within the study area being subject to potential District jurisdiction, or from 18.7 to 97.8 percent of such mileage within the study area. Application of the four jurisdictional classification criteria only to perennial streams within the District would result in from 33.0 miles to 130.5 miles of the total perennial stream mileage within the study area being subject to potential District jurisdiction, or from 18.7 percent to 74.0 percent of the perennial stream mileage within the study area.

STREAMS RECOMMENDED FOR MILWAUKEE METROPOLITAN SEWERAGE DISTRICT JURISDICTION

Prior to agreeing upon a recommendation of those streams and watercourses for which the Milwaukee

Metropolitan Sewerage District should assume jurisdiction with respect to the resolution of drainage and flood control problems, the Advisory Committee concluded that it was unreasonable for the District to assume jurisdiction over those reaches of perennial streams of which a majority of the tributary drainage area lies outside the study area. The Committee noted that the drainage or flood control problems of such reaches should be the responsibility of a state or federal agency having a broader geographic authority in addressing such matters. Similarly, the Advisory Committee deemed it unreasonable for the District to assume jurisdiction over the estuary reaches of the Kinnickinnic, Menomonee, and Milwaukee Rivers because the U. S. Army Corps of Engineers maintains navigational responsibility for the majority of these reaches, and because these reaches are subject to the influence of Lake Michigan water levels.

The Advisory Committee thus recommended that major stream reaches having 50 percent or more of their tributary drainage area outside the study area be excluded from District jurisdiction. Similarly, the Advisory Committee recommended that the estuary reaches of the Kinnickinnic, Menomonee, and Milwaukee Rivers be excluded from District jurisdiction. The Advisory Committee then recommended that the Milwaukee Metropolitan Sewerage District jurisdiction for perennial streams for drainage and flood control purposes include, with the exception of the above-mentioned overriding considerations, all perennial streams which meet at least one of the following three criteria:[6]

1. Streams within the District for which the District has completed channel improvements.[7]

2. Streams within the District with significant monetary flood damage risk.[8]

3. Streams within the District having a tributary drainage area in more than one community.

In addition, the Advisory Committee recommended that the Milwaukee Metropolitan Sewerage District jurisdiction for intermittent streams with respect to the resolution of drainage and flood control problems include all intermittent streams which meet any two of the above three criteria.

As indicated in Table 15 and shown on Map 16, the application of the overriding considerations and three criteria to perennial streams within the District would result in a total of 103.3 miles of perennial streams, or 58.6 percent of the total miles of perennial streams in the study area, being recommended for District jurisdiction. In addition, 8.3 miles of intermittent streams would be recommended for District jurisdiction. Should the geographic limits of the District ultimately be expanded to include all lands within the study area, the jurisdiction of the District would increase to 138.4 miles of perennial streams, or 78.5 percent of the total miles of perennial streams in the study area. A total of 8.3 miles of intermittent streams are recommended for District jurisdiction within the possible expanded geographic limits of the District, the same mileage as within the current District boundaries (see Table 16 and Map 17).

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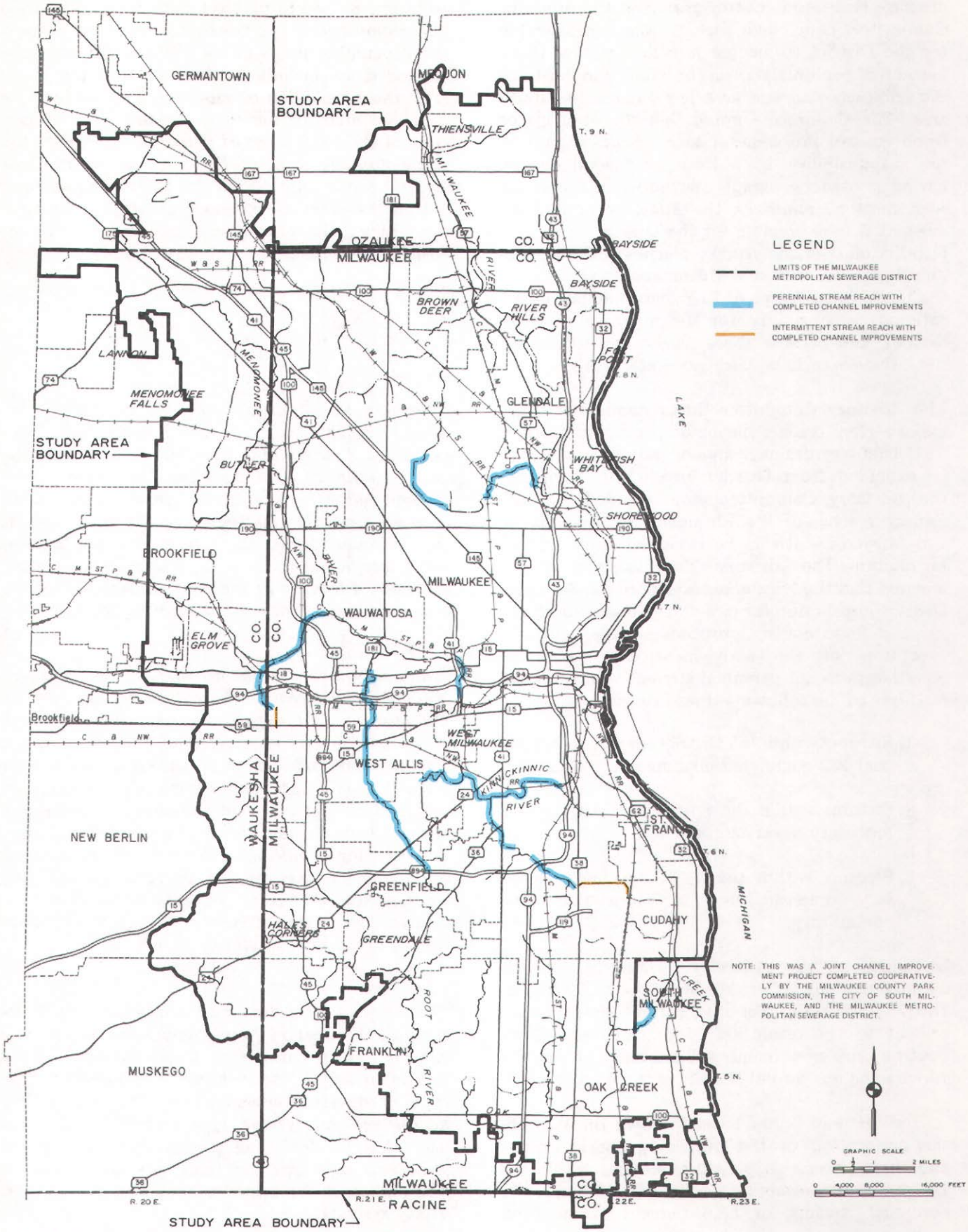
[6] *Through the application of the overriding considerations, 2.4 miles of the Kinnickinnic River estuary, 1.8 miles of the Menomonee River estuary, and 3.4 miles of the Milwaukee River estuary were recommended to be excluded from District jusisdiction. Similarly, 20.2 miles of the main stem of the Milwaukee River—the remainder of the Milwaukee River in the study area outside of the estuary area; and 4.8 miles of the Root River were recommended to excluded from District jurisdiction.*

[7] *Implicitly included but not specifically identified are any downstream reaches which ultimately leave the District, and experience stage increases as a result of projects completed within the District. The number and length of such reaches can be identified only upon completion of a systems plan in which any downstream increases in flood stages under planned land use and channel conditions over existing conditions will be determined. Based upon the findings of the completed watershed studies, however, it is not anticipated that such downstream stage increases will require the addition of substantial lengths of stream reaches.*

[8] *Included in the determination of what constitutes significant monetary flood damage are such factors as: the dollar amount of flood damage relative to stream length and tributary drainage area; the type of damage, including any hazards to public health and safety; the type and extent of land uses affected, including the number and type of structures affected; the frequency and depth of flooding; and the impacts on transportation and utility systems.*

Map 13

CHANNEL IMPROVEMENTS COMPLETED BY THE MILWAUKEE METROPOLITAN SEWERAGE DISTRICT: 1985



Source: Milwaukee Metropolitan Sewerage District and SEWRPC.

Table 11

CHANNEL IMPROVEMENTS ALONG PERENNIAL STREAMS COMPLETED BY THE MILWAUKEE METROPOLITAN SEWERAGE DISTRICT: 1985

Stream	Total Length of Perennial Streams (linear miles)	Reaches with Completed Channel Improvements	
		Length (linear miles)	Cost (1985 dollars)
Kinnickinnic River Watershed			
Kinnickinnic River	8.1	5.4	$12,586,460
Lyons Creek	1.2	--	--
Wilson Park Creek	3.4	3.0[a]	6,418,702
Unnamed Tributary Section 12, T6N, R21E	1.0	--	--
Unnamed Tributary Section 19, T6N, R22E	1.7	--	--
Unnamed Tributary Section 20, T6N, R22E	1.6	--	--
Lake Michigan Direct Drainage Area			
Fish Creek	3.1	--	--
Menomonee River Watershed			
Butler Ditch	3.7	--	--
Dousman Ditch	5.5	--	--
Honey Creek	8.8	6.4	27,736,821
Little Menomonee River	6.9	--	--
Menomonee River	26.8[b]	1.3	8,401,378
West Branch of the Menomonee River	0.3	--	--
Underwood Creek	8.2	2.6	5,614,906
Unnamed Tributary Section 14, T7N, R20E	1.0	--	--
Unnamed Tributary Section 35, T7N, R21E	1.1	--	--
Unnamed Tributary Section 30, T7N, R21E	1.1	1.1[c]	1,174,559
Milwaukee River Watershed			
Indian Creek	1.9	--	--
Lincoln Creek	8.1	4.2	7,344,055
Milwaukee River	23.6	--	--
Pigeon Creek	0.8	--	--
Unnamed Tributary Section 18, T9N, R22E	0.5	--	--
Unnamed Tributary Section 35, T9N, R21E	2.0	--	--
Unnamed Tributary Section 36, T9N, R21E	0.2	--	--
Unnamed Tributary Section 1, T8N, R21E	1.9	--	--
Unnamed Tributary Section 7, T8N, R22E	1.8	--	--
Unnamed Tributary Section 2, T7N, R21E	0.5	--	--
Oak Creek Watershed			
Oak Creek	13.1	1.1[d]	556,641
Oak Creek North Branch	5.7	--	--
Unnamed Tributary Section 9, T5N, R22E	2.3	--	--
Root River Watershed			
East Branch Root River	4.7	--	--
Root River	20.2[e]	--	--
Root River Canal	1.3	--	--
Tess Corners Creek	2.2	--	--
Whitnall Park Creek	0.7	--	--
Unnamed Tributary Section 20, T6N, R21E	0.4	--	--
Unnamed Tributary Section 34, T5N, R22E	1.0	--	--
Total	176.4	25.1	$69,833,522
Percent of Total in Study Area	100.0	14.2	--

[a] *Does not include the channel improvements along a 1.7-mile intermittent reach of the Edgerton Channel at a 1985 cost of $6,388,991.*

[b] *Does not include a 0.6-mile reach along the main stem of the Menomonee River which flows out of, then back into, the study area.*

[c] *Does not include the channel improvements along a 0.5-mile intermittent reach of the unnamed tributary to Underwood Creek, at a 1985 cost of $3,635,114.*

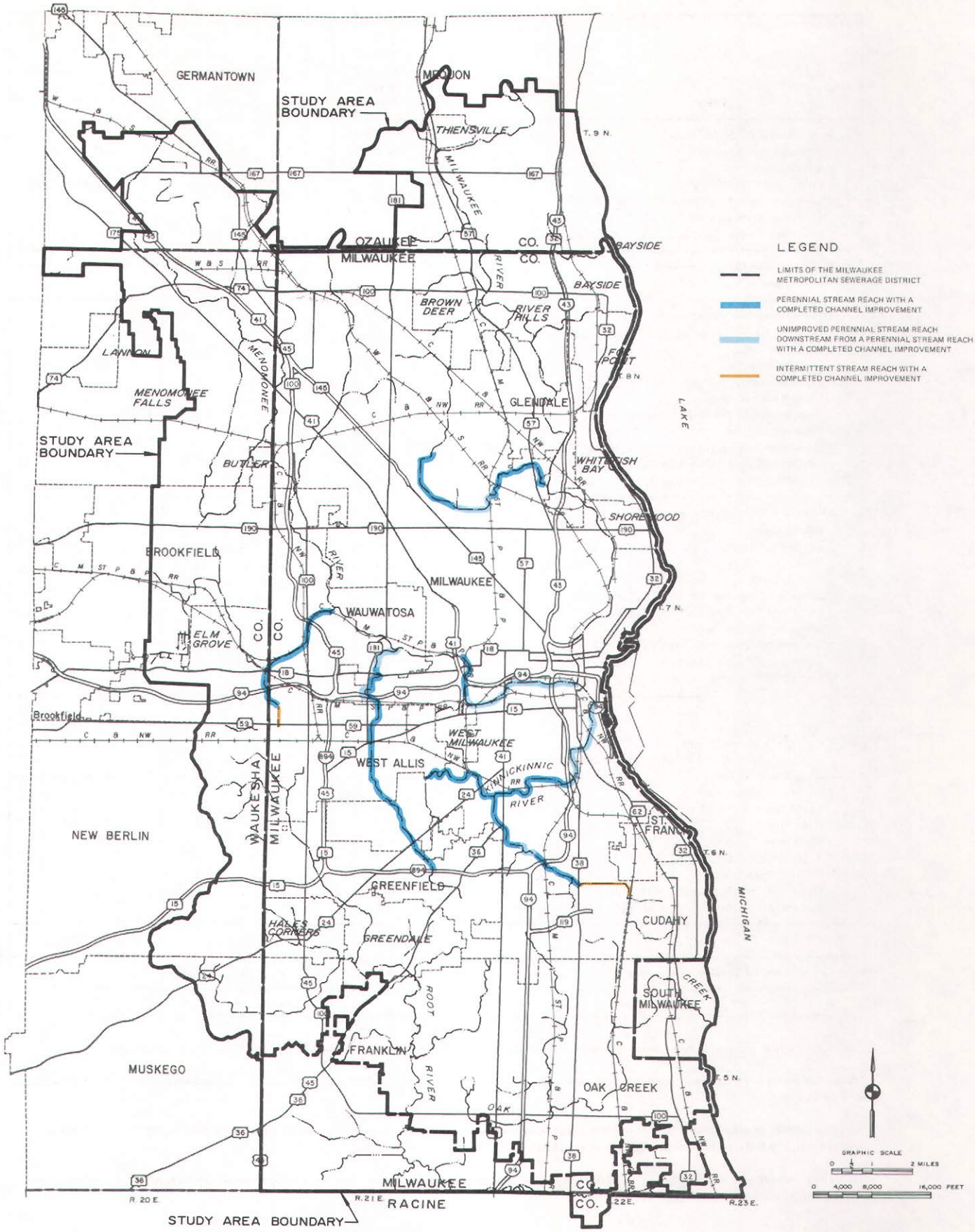
[d] *This is a joint channel improvement project completed cooperatively by the Milwaukee County Park Commission, the City of South Milwaukee, and the Milwaukee Metropolitan Sewerage District.*

[e] *Does not include two reaches with a combined length of 3.0 miles along the main stem of the Root River which flow out of, then back into, the study area.*

Source: SEWRPC.

Map 14

STREAMS AFFECTED BY CHANNEL IMPROVEMENTS COMPLETED BY THE MILWAUKEE METROPOLITAN SEWERAGE DISTRICT: 1985



Source: Milwaukee Metropolitan Sewerage District and SEWRPC.

Table 12

PERENNIAL STREAMS IN THE STUDY AREA AFFECTED BY CHANNEL IMPROVEMENTS COMPLETED BY THE MILWAUKEE METROPOLITAN SEWERAGE DISTRICT: 1985

Stream	Perrennial Stream Reaches Affected by Completed Channel Improvements			Perennial Stream Reaches Not Affected by Completed Channel Improvement (linear miles)
	Stream Reaches with Completed Channel Improvements (linear miles)	Unimproved Reaches Downstream from a Reach with a Completed Channel Improvement (linear miles)	Total Linear Miles	
Kinnickinnic River Watershed				
Kinnickinnic River	5.4	2.7	8.1	--
Lyons Creek	--	--	--	1.2
Wilson Park Creek	3.0	0.4	3.4	--
Unnamed Tributary Section 12, T6N, R21E	--	--	--	1.0
Unnamed Tributary Section 19, T6N, R22E	--	--	--	1.7
Unnamed Tributary Section 20, T6N, R22E	--	--	--	1.6
Lake Michigan Direct Drainage Area				
Fish Creek	--	--	--	3.1
Menomonee River Watershed				
Butler Ditch	--	--	--	3.7
Dousman Ditch	--	--	--	5.5
Honey Creek	6.4	1.1	7.5	1.3
Little Menomonee River	--	--	--	6.9
Menomonee River	1.3	3.4	4.7	22.1[a]
West Branch of the Menomonee River	--	--	--	0.3
Underwood Creek	2.6	--	2.6	5.6
Unnamed Tributary Section 14, T7N, R20E	--	--	--	1.0
Unnamed Tributary Section 35, T7N, R21E	--	--	--	1.1
Unnamed Tributary Section 30, T7N, R21E	1.1	--	1.1	--
Milwaukee River Watershed				
Indian Creek	--	--	--	1.9
Lincoln Creek	4.2	1.4	5.6	2.5
Milwaukee River	--	--	--	23.6
Pigeon Creek	--	--	--	0.8
Unnamed Tributary Section 18, T9N, R22E	--	--	--	0.5
Unnamed Tributary Section 35, T9N, R21E	--	--	--	2.0
Unnamed Tributary Section 36, T9N, R21E	--	--	--	0.2
Unnamed Tributary Section 1, T8N, R21E	--	--	--	1.9
Unnamed Tributary Section 7, T8N, R22E	--	--	--	1.8
Unnamed Tributary Section 2, T7N, R21E	--	--	--	0.5
Oak Creek Watershed				
Oak Creek	--[b]	--	--	13.1
Oak Creek North Branch	--	--	--	5.7
Unnamed Tributary Section 9, T5N, R22E	--	--	--	2.3
Root River Watershed				
East Branch Root River	--	--	--	4.7
Root River	--	--	--	20.2[c]
Root River Canal	--	--	--	1.3
Tess Corners Creek	--	--	--	2.2
Whitnall Park Creek	--	--	--	0.7
Unnamed Tributary Section 20, T6N, R21E	--	--	--	0.4
Unnamed Tributary Section 34, T5N, R22E	--	--	--	1.0
Total	24.0	9.0	33.0	143.4
Percent of Total in Study Area	13.6	5.1	18.7	81.3

[a] *Does not include a 0.6-mile reach along the main stem of the Menomonee River which flows out of, then back into, the study area.*

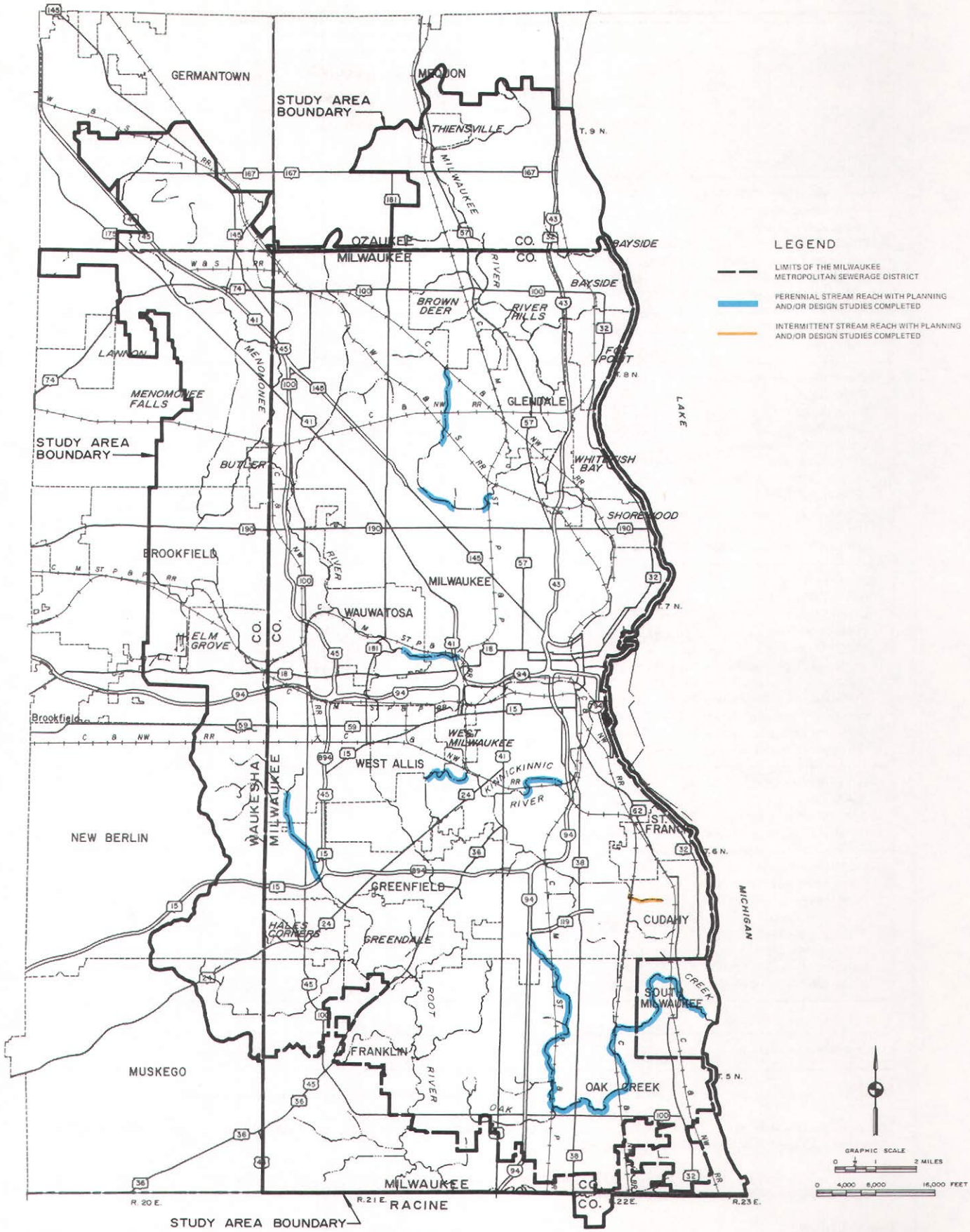
[b] *Does not include joint channel improvement project completed cooperatively by the Milwaukee County Park Commission, the City of South Milwaukee, and the Milwaukee Metropolitan Sewerage District.*

[c] *Does not include two reaches with a combined length of 3.0 miles along the main stem of the Root River which flow out of, then back into, the study area.*

Source: SEWRPC.

Map 15

STREAM REACHES FOR WHICH PLANNING AND/OR DESIGN STUDIES HAVE BEEN COMPLETED BY THE MILWAUKEE METROPOLITAN SEWERAGE DISTRICT: 1985



Source: Milwaukee Metropolitan Sewerage District and SEWRPC.

Table 13

STREAM REACHES FOR WHICH PLANNING AND/OR DESIGN STUDIES HAVE BEEN COMPLETED BY THE MILWAUKEE METROPOLITAN SEWERAGE DISTRICT: 1985

Stream	Total Length of Perennial Streams (linear miles)	Reaches with Proposed Channel Improvements	
		Reach Length (linear miles)	Cost (1985 dollars)
Kinnickinnic River Watershed			
Kinnickinnic River	8.1	3.0	$ 2,359,196
Lyons Creek	1.2	--	--
Wilson Park Creek	3.4	--[a]	--
Unnamed Tributary Section 12, T6N, R21E	1.0	--	--
Unnamed Tributary Section 19, T6N, R22E	1.7	--	--
Unnamed Tributary Section 20, T6N, R22E	1.6	--	--
Lake Michigan Direct Drainage Area			
Fish Creek	3.1	--	--
Menomonee River Watershed			
Butler Ditch	3.7	--	--
Dousman Ditch	5.5	--	--
Honey Creek	8.8	--	--
Little Menomonee River	6.9	--	--
Menomonee River	26.8[b]	1.5	2,705,500
West Branch of the Menomonee River	0.3	--	--
Underwood Creek	8.2	--	--
Unnamed Tributary Section 14, T7N, R20E	1.0	--	--
Unnamed Tributary Section 35, T7N, R21E	1.1	--	--
Unnamed Tributary Section 30, T7N, R21E	1.1	--	--
Milwaukee River Watershed			
Indian Creek	1.9	--	--
Lincoln Creek	8.1	3.9	4,706,024
Milwaukee River	23.6	--	--
Pigeon Creek	0.8	--	--
Unnamed Tributary Section 18, T9N, R22E	0.5	--	--
Unnamed Tributary Section 35, T9N, R21E	2.0	--	--
Unnamed Tributary Section 36, T9N, R21E	0.2	--	--
Unnamed Tributary Section 1, T8N, R21E	1.9	--	--
Unnamed Tributary Section 7, T8N, R22E	1.8	--	--
Unnamed Tributary Section 2, T7N, R21E	0.5	--	--
Oak Creek Watershed			
Oak Creek	13.1	8.6	15,608,414
Oak Creek North Branch	5.7	5.7	11,612,190
Unnamed Tributary Section 9, T5N, R22E	2.3	--	--
Root River Watershed			
East Branch Root River	4.7	--	--
Root River	20.2[c]	2.9	2,904,934[d]
Root River Canal	1.3	--	--
Tess Corners Creek	2.2	--	--
Whitnall Park Creek	0.7	--	--
Unnamed Tributary Section 20, T6N, R21E	0.4	--	--
Unnamed Tributary Section 34, T5N, R22E	1.0	--	--
Total	176.4	25.6	$39,896,258
Percent of Total in Study Area	100.0	14.5	--

[a] *Channel improvements are proposed along a 1.1-mile reach of an unnamed intermittent tributary to Wilson Park Creek at a cost of $2,346,828.*

[b] *Does not include a 0.6-mile reach along the main stem of the Menomonee River which flows out of, then back into, the study area.*

[c] *Does not include two reaches with a combined length of 3.0 miles along the main stem of the Root River which flow out of, then back into, the study area.*

[d] *Cost data are not available for proposed channel improvements along the reach of the Root River in West Allis from W. Cleveland Avenue to W. Morgan Avenue.*

Source: SEWRPC.

Table 14

SUMMARY OF THE APPLICATION OF CRITERIA TO ESTABLISH MILWAUKEE METROPOLITAN SEWERAGE DISTRICT JURISDICTION OF PERENNIAL STREAMS WITHIN THE MILWAUKEE METROPOLITAN SEWERAGE DISTRICT STUDY AREA: 1985

Stream	Total Perennial Stream Length in Study Area (linear miles)	Streams Affected by Monetary Flood Damage Risk		Streams Flowing Through More than One Civil Division		Streams with Tributary Drainage Areas in More than One Civil Division		Streams Affected by Channel Improvements Completed by the District	
		Study Area (linear miles)	MMSD Only (linear miles)	Study Area (linear miles)	MMSD Only (linear miles)	Study Area (linear miles)	MMSD Only (linear miles)	Study Area (linear miles)	MMSD Only (linear miles)
Kinnickinnic River Watershed									
Kinnickinnic River	8.1	--	--	8.1	8.1	8.1	8.1	8.1	8.1
Lyons Creek	1.2	--	--	--	--	1.2	1.2	--	--
Wilson Park Creek	3.4	2.8	2.8	--	--	3.4	3.4	3.4	3.4
Unnamed Tributary Section 12, T6N, R21E	1.0	--	--	1.0	1.0	1.0	1.0	--	--
Unnamed Tributary Section 19, T6N, R22E	1.7	--	--	1.7	1.7	1.7	1.7	--	--
Unnamed Tributary Section 20, T6N, R22E	1.6	--	--	--	--	--	--	--	--
Lake Michigan Direct Drainage Area									
Fish Creek	3.1	--	--	3.1	1.8	3.1	1.8	--	--
Menomonee River Watershed									
Butler Ditch	3.7	2.7	--	3.7	--	3.7	--	--	--
Dousman Ditch	5.5	--	--	--	--	5.5	--	--	--
Honey Creek	8.8	0.9	0.9	8.8	8.8	8.8	8.8	7.5	7.5
Little Menomonee River	6.9	--	--	6.9	6.9	6.9	6.9	--	--
Menomonee River	26.8	23.5	17.0	26.8	18.0	26.8	18.0	4.7	4.7
West Branch of the Menomonee River	0.3	--	--	--	--	0.3	--	--	--
Underwood Creek	8.2	6.8	2.6	8.2	2.6	8.2	2.6	2.6	2.6
Unnamed Tributary Section 14, T7N, R20E	1.0	--	--	--	--	--	--	--	--
Unnamed Tributary Section 35, T7N, R21E	1.1	--	--	--	--	1.1	1.1	--	--
Unnamed Tributary Section 30, T7N, R21E	1.1	--	--	1.1	1.1	1.1	1.1	1.1	1.1
Milwaukee River Watershed									
Indian Creek	1.9	--	--	1.9	1.9	1.9	1.9	--	--
Lincoln Creek	8.1	8.1	8.1	8.1	8.1	8.1	8.1	5.6	5.6
Milwaukee River	23.6	23.6	16.1	23.6	16.1	23.6	16.1	--	--
Pigeon Creek	0.8	0.8	--	0.8	--	0.8	--	--	--
Unnamed Tributary Section 18, T9N, R22E	0.5	--	--	--	--	--	--	--	--
Unnamed Tributary Section 35, T9N, R21E	2.0	--	--	--	--	2.0	--	--	--
Unnamed Tributary Section 36, T9N, R21E	0.2	--	--	--	--	--	--	--	--
Unnamed Tributary Section 1, T8N, R21E	1.9	--	--	--	--	1.9	1.9	--	--
Unnamed Tributary Section 7, T8N, R22E	1.8	--	--	1.8	1.8	1.8	1.8	--	--
Unnamed Tributary Section 2, T7N, R21E	0.5	--	--	--	--	--	--	--	--
Oak Creek Watershed									
Oak Creek	13.1	11.8	7.6	13.1	8.9	13.1	8.9	--	--
Oak Creek North Branch	5.7	2.4	2.4	5.7	5.7	5.7	5.7	--	--
Unnamed Tributary Section 9, T5N, R22E	2.3	--	--	2.3	2.3	2.3	2.3	--	--
Root River Watershed									
East Branch Root River	4.7	--	--	--	--	4.7	4.7	--	--
Root River	20.2	20.2	20.1	20.2	20.1	20.2	20.1	--	--
Root River Canal	1.3	--	--	1.3	--	1.3	--	--	--
Tess Corners Creek	2.2	--	--	2.2	2.2	2.2	2.2	--	--
Whitnall Park Creek	0.7	--	--	0.7	0.7	0.7	0.7	--	--
Unnamed Tributary Section 20, T6N, R21E	0.4	--	--	--	--	0.4	0.4	--	--
Unnamed Tributary Section 34, T5N, R22E	1.0	--	--	1.0	--	1.0	--	--	--
Total	176.4	103.6	77.6	152.1	117.8	172.6	130.5	33.0	33.0
Percent of Total in Study Area	100.0	58.7	44.0	86.2	66.8	97.8	74.0	18.7	18.7

Source: SEWRPC.

Table 15

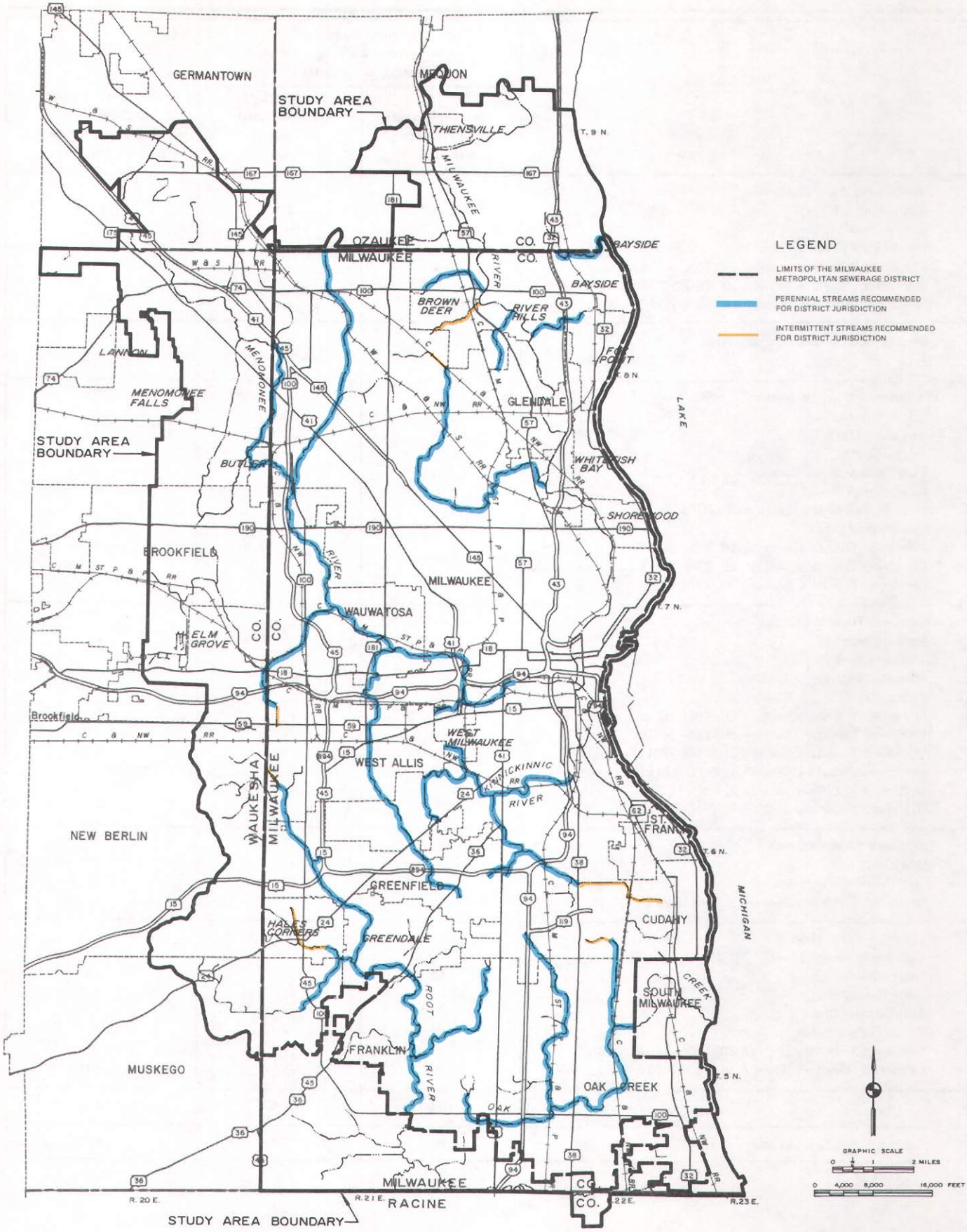
PERENNIAL STREAMS WITHIN THE EXISTING MILWAUKEE METROPOLITAN SEWERAGE DISTRICT BOUNDARIES RECOMMENDED FOR DISTRICT JURISDICTION

Stream	Perennial Streams Within Existing District Boundaries		Perennial Streams in Study Area Outside Existing District Boundaries
	Recommended for District Jurisdiction	Not Recommended for District Jurisdiction	
Kinnickinnic River Watershed			
Kinnickinnic River	5.7	2.4	--
Lyons Creek	1.2	--	--
Wilson Park Creek	3.4	--	--
Unnamed Tributary Section 12, T6N, R21E	1.0	--	--
Unnamed Tributary Section 19, T6N, R22E	1.7	--	--
Unnamed Tributary Section 20, T6N, R22E	--	1.6	--
Lake Michigan Direct Drainage Area			
Fish Creek	1.8	--	1.3
Menomonee River Watershed			
Butler Ditch	--	--	3.7
Dousman Ditch	--	--	5.5
Honey Creek	8.8	--	--
Little Menomonee River	6.9	--	--
Menomonee River	16.2	1.8	8.8
West Branch of the Menomonee River	--	--	0.3
Underwood Creek	2.6	--	5.6
Unnamed Tributary Section 14, T7N, R20E	--	--	1.0
Unnamed Tributary Section 35, T7N, R21E	1.1	--	--
Unnamed Tributary Section 30, T7N, R21E	1.1	--	--
Milwaukee River Watershed			
Indian Creek	1.9	--	--
Lincoln Creek	8.1	--	--
Milwaukee River	--	16.1	7.5
Pigeon Creek	--	--	0.8
Unnamed Tributary Section 18, T9N, R22E	--	--	0.5
Unnamed Tributary Section 35, T9N, R21E	--	--	2.0
Unnamed Tributary Section 36, T9N, R21E	--	--	0.2
Unnamed Tributary Section 1, T8N, R21E	1.9	--	--
Unnamed Tributary Section 7, T8N, R22E	1.8	--	--
Unnamed Tributary Section 2, T7N, R21E	--	0.5	--
Oak Creek Watershed			
Oak Creek	8.9	--	4.2
Oak Creek North Branch	5.7	--	--
Unnamed Tributary Section 9, T5N, R22E	2.3	--	--
Root River Watershed			
East Branch Root River	4.7	--	--
Root River	13.2	--	7.0
Root River Canal	--	--	1.3
Tess Corners Creek	2.2	--	--
Whitnall Park Creek	0.7	--	--
Unnamed Tributary Section 20, T6N, R21E	0.4	--	--
Unnamed Tributary Section 34, T5N, R22E	--	--	1.0
Total	103.3	22.4	50.7
Percent of Total in Study Area	58.6	12.7	28.7

Source: SEWRPC.

Map 16

PERENNIAL AND SELECTED INTERMITTENT STREAMS WITHIN THE EXISTING MILWAUKEE METROPOLITAN SEWERAGE DISTRICT BOUNDARIES RECOMMENDED FOR DISTRICT JURISDICTION: 1985



Source: Milwaukee Metropolitan Sewerage District and SEWRPC.

Table 16

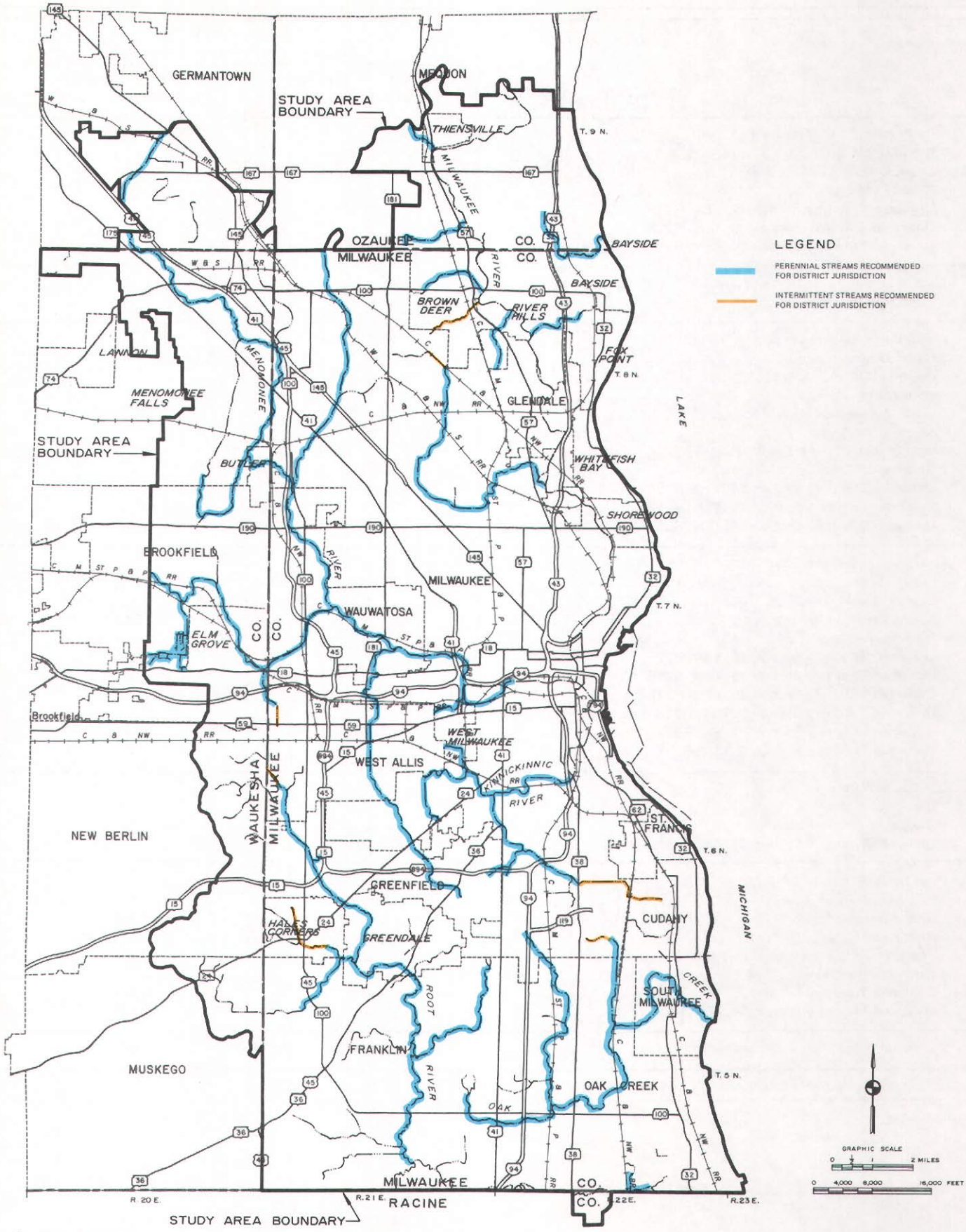
PERENNIAL STREAMS WITHIN POSSIBLE FUTURE MILWAUKEE METROPOLITAN SEWERAGE DISTRICT BOUNDARIES RECOMMENDED FOR DISTRICT JURISDICTION

Stream	Perennial Streams Within Possible Future District Boundaries	
	Recommended for District Jurisdiction	Not Recommended for District Jurisdiction
Kinnickinnic River Watershed		
Kinnickinnic River	5.7	2.4
Lyons Creek	1.2	--
Wilson Park Creek	3.4	--
Unnamed Tributary Section 12, T6N, R21E	1.0	--
Unnamed Tributary Section 19, T6N, R22E	1.7	--
Unnamed Tributary Section 20, T6N, R22E	--	1.6
Lake Michigan Direct Drainage Area		
Fish Creek	3.1	--
Menomonee River Watershed		
Butler Ditch	3.7	--
Dousman Ditch	5.5	--
Honey Creek	8.8	--
Little Menomonee River	6.9	--
Menomonee River	25.0	1.8
West Branch of the Menomonee River	--	0.3
Underwood Creek	8.2	--
Unnamed Tributary Section 14, T7N, R20E	--	1.0
Unnamed Tributary Section 35, T7N, R21E	1.1	--
Unnamed Tributary Section 30, T7N, R21E	1.1	--
Milwaukee River Watershed		
Indian Creek	1.9	--
Lincoln Creek	8.1	--
Milwaukee River	--	23.6
Pigeon Creek	0.8	--
Unnamed Tributary Section 18, T9N, R22E	--	0.5
Unnamed Tributary Section 35, T9N, R21E	2.0	--
Unnamed Tributary Section 36, T9N, R21E	--	0.2
Unnamed Tributary Section 1, T8N, R21E	1.9	--
Unnamed Tributary Section 7, T8N, R22E	1.8	--
Unnamed Tributary Section 2, T7N, R21E	--	0.5
Oak Creek Watershed		
Oak Creek	13.1	--
Oak Creek North Branch	5.7	--
Unnamed Tributary Section 9, T5N, R22E	2.3	--
Root River Watershed		
East Branch Root River	4.7	--
Root River	15.4	4.8
Root River Canal	--	1.3
Tess Corners Creek	2.2	--
Whitnall Park Creek	0.7	--
Unnamed Tributary Section 20, T6N, R21E	0.4	--
Unnamed Tributary Section 34, T5N, R22E	1.0	--
Total	138.4	38.0
Percent of Total in Study Area	78.5	21.5

Source: SEWRPC.

Map 17

PERENNIAL AND SELECTED INTERMITTENT STREAMS WITHIN POSSIBLE FUTURE MILWAUKEE METROPOLITAN SEWERAGE DISTRICT BOUNDARIES RECOMMENDED FOR DISTRICT JURISDICTION: 1985



Source: SEWRPC.

Chapter III

ELIGIBLE DRAINAGE AND FLOOD CONTROL IMPROVEMENTS

INTRODUCTION

One of the specific purposes of the policy planning phase of the District drainage and flood control planning program is to identify the types of drainage and flood control improvements for which the District should, as a matter of public policy, assume responsibility. Such identification is essential if a drainage and flood control system plan is to be evolved which is practicable and amenable to effective implementation. The lack of agreement in the past between certain levels and agencies of government in the Milwaukee area concerning the types of drainage and flood control improvements which should be undertaken by the various levels, units, and agencies of government has seriously hindered the implementation of flood control plans. The serious effect of such lack of agreement has been most evident for that reach of the Root River extending between W. Layton Avenue and W. Forest Home Avenue in the City of Greenfield, where implementation of needed flood control works—not only in Greenfield but in upstream West Allis as well—has been delayed for almost two decades because of the lack of such agreement between Milwaukee County, the Milwaukee Metropolitan Sewerage District, and the City of Greenfield. Similar, although less marked, examples in other areas and along other streams and watercourses of the District could be cited.

TYPES OF DRAINAGE AND FLOOD CONTROL MEASURES

Drainage and flood control measures may be broadly subdivided into two categories: structural measures and nonstructural measures. Structural measures include floodwater storage facilities, such as detention and retention basins; diversions; containment facilities, such as earthen dikes and concrete floodwalls; conveyance facilities, such as major channel modifications; and bridge, culvert, and dam modifications or replacements. Nonstructural measures include preservation of floodlands for recreational and other open space uses; land use regulation, both within and outside floodland areas; utility extension policies; extension of information; and structure floodproofing and removal. Table 17 lists available structural and nonstructural measures for flood control that may be applied individually or in various combinations to portions of the streams and watercourses within the planning area. Structural measures tend to be more effective in achieving the objectives of flood control in riverine areas that have already been urbanized, while nonstructural measures are generally more effective in riverine areas that have not been converted to flood-prone development but have the potential for such development. Each of the five structural and 10 nonstructural measures deserves brief discussion.

Structural Measures

Storage: The function of floodwater storage facilities is to detain floodwaters upstream of flood-damage-prone areas for subsequent gradual release, thereby substantially decreasing downstream discharges and stages and attendant flood damages. A key consideration in applying this alternative is the existence of sites of sufficient storage volume that are properly positioned upstream of flood-prone riverine areas and are located so as to control the runoff from a significant portion of the total drainage area tributary to the flood-prone reaches. In addition, the site must be available; it must not contain significant urban development. Centralized floodwater storage facilities, consisting of a relatively few but large facilities, may be directly located on the stream system, such as the case of a conventional reservoir, or may be located off the channel system as in an abandoned quarry or in excavated chambers in the underlying bedrock. Decentralized storage facilities, consisting of relatively many but small facilities, may also be provided in the headwater areas of a stream system. Storage reservoirs may be of the detention, or dry, type, or of the retention, or wet, type. The former type is designed to fill during a runoff event and to subsequently drain dry, with the entire volume of the reservoir being available for temporary storage of floodwaters. The latter is designed to store floodwaters on top of a permanent pool of water used for other purposes.

Storage facilities have the advantage of being able to potentially mitigate flooding in several downstream communities, in contrast with other struc-

Table 17

ALTERNATIVE FLOODLAND MANAGEMENT MEASURES

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 the watershed	May entail legal problems.
	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, including construction of a new length of channel for the purpose of bypassing a reach of natural stream
	Bridge and culvert alteration or replacement	To reduce the backwater effect of bridges and culverts	May be accomplished by increasing the waterway opening or otherwise substantially altering the crossing or by replacing it
Nonstructural	Reservation of floodlands for recreational and related open space use	To minimize flood damage by using floodlands for compatible recreational and related open space uses and also to retain floodwater storage and conveyance	May be accomplished through private development, such as a golf course, or by public acquisition of the land or of an easement
	Floodland regulations	To control the manner in which new urban development is carried out in the flood-lands so as to assure that it does not aggravate upstream and downstream flood problems	May be accomplished through zoning, land subdivision control, sanitary and building ordinances
	Control of land use outside of the floodlands	To control the manner in which urban development occurs outside of the flood-lands so as to minimize the hydrologic impact on downstream floodlands	--
	Flood insurance	To minimize monetary loss or reduce monetary impact on structure owner	Premiums may be subsidized or actuarially determined
	Lending institution policies	To discourage acquisition or construction of flood-prone structures by means of mortgage granting procedures	--
	Realtor policies	To discourage acquisition or construction of flood-prone structures by providing flood hazard information to prospective buyers	--
	Community utility policies	To discourage construction in flood-prone areas by controlling the extension of utilities and services	--
	Emergency programs	To minimize the danger, damage, and disruption from impending flood events	Such a program may include installation of remote stage sensors and alarms, road closures, and evacuation of residents
	Structure floodproofing	To minimize damage to structures by applying a combination of protective measures and procedures on a structure-by-structure basis	--
	Structure removal	To eliminate damage to existing structures by removing them from flood-prone areas	--

Source: SEWRPC.

tural measures which generally provide only local flood relief. Storage facilities may also be multi-use, providing recreational, low-flow augmentation, and water supply as well as flood control benefits. The wet-type storage facilities may also provide nonpoint source water pollution control benefits. Negative aspects of storage include high capital costs; large land area requirements; potentially adverse water quality conditions, both within and downstream of the impoundments; potentially unfavorable impacts on fisheries; and relatively high ongoing maintenance costs.

A typical storage facility is shown in Figure 1.

Diversion: The function of a diversion is to intercept potentially damaging flood flows at a location upstream of the flood-prone reach and to convey those floodwaters to an acceptable receiving watercourse beyond the flood-prone reach or outside the watershed in which the flood mitigation is required. Diversion alternatives require a control structure located on the stream channel that establishes the stage at which the diversion process will begin and the rate at which it will occur; and an open channel or closed conduit conveyance facility to carry the diverted floodwaters from the stream to the point of discharge. A key consideration in assessing the applicability of diversion is the availability of a receiving watercourse to which the floodwaters may be diverted without harmful physical effects or legal challenge.

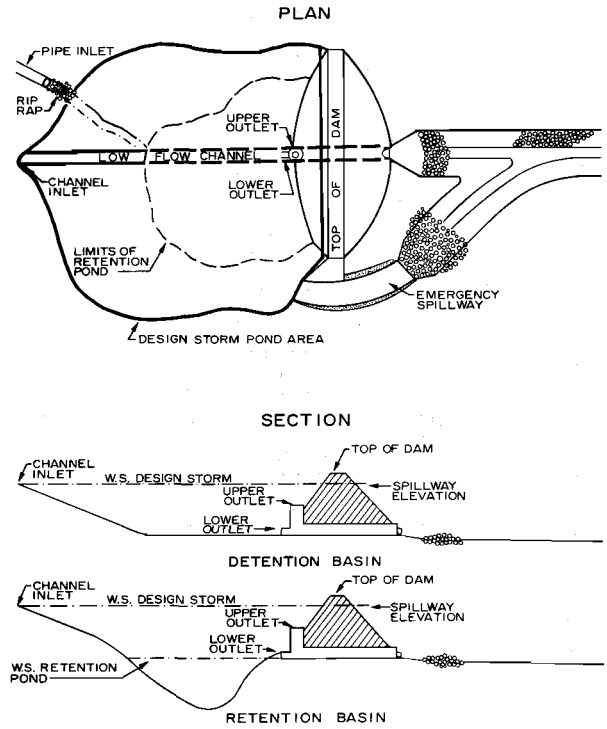
Diversion, like storage, has the potential to abate flooding in several downstream communities. Negative aspects include high capital costs and potential legal liabilities entailed in the transfer of water between watersheds. This alternative does not lend itself to the ready incorporation of nonpoint water pollution abatement actions.

A typical diversion facility is shown in Figure 2.

Dikes and Floodwalls: Earthen dikes and concrete or sheet steel floodwalls are technically feasible means of providing flood control in certain damage-prone stream reaches. The function of dikes and floodwalls is to contain the floodwaters; that is, to prevent the occurrence of lateral overland flow from the channel to adjacent floodland areas containing flood-damage-prone structures and facilities. A key consideration in the application of this measure 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.

Figure 1

TYPICAL STORMWATER STORAGE STRUCTURES



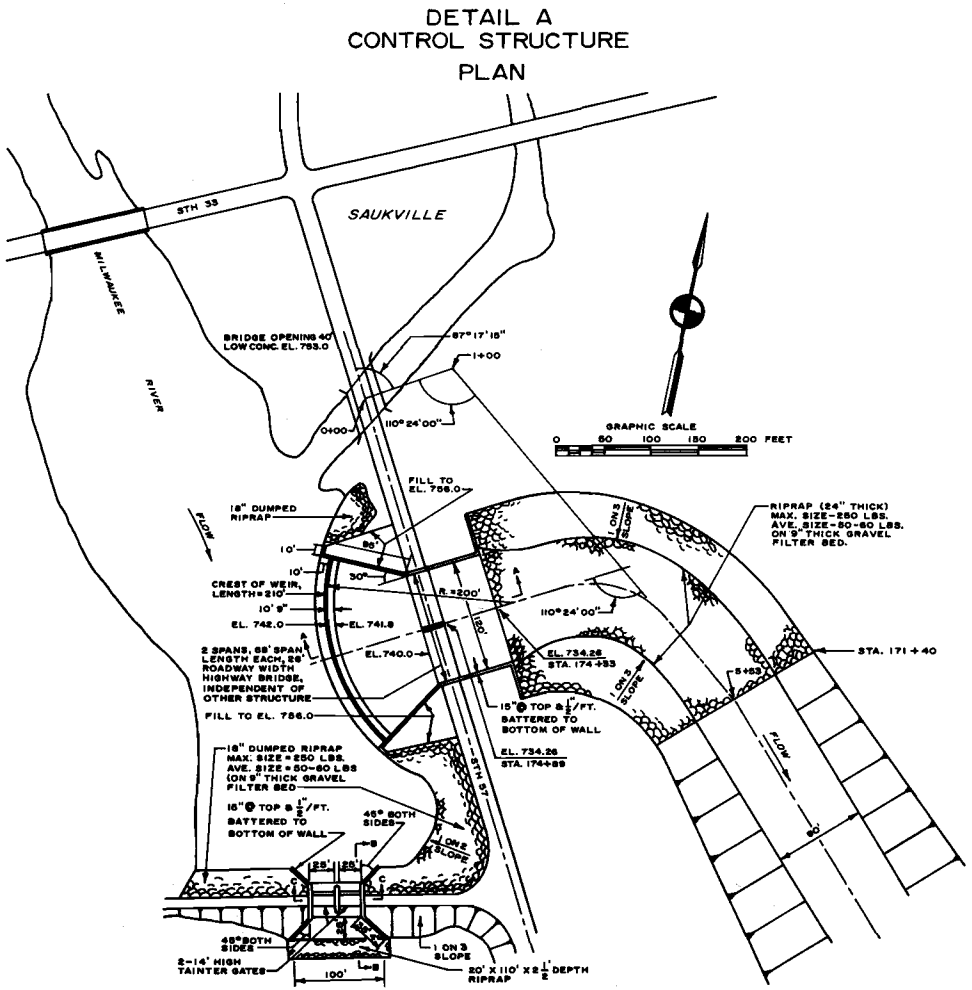
Source: SEWRPC.

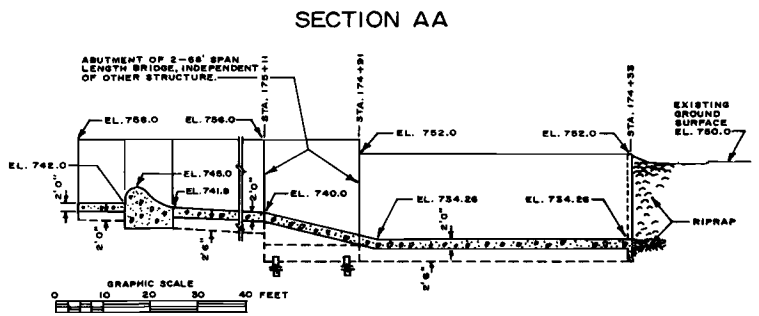
To be effective, dikes and floodwalls normally must be supplemented by backwater gates on storm sewer outfalls and other drainage outlets penetrating the dikes and floodwalls that have street inlets or other entry points in the area to be protected, at elevations approximating the design flood stage. Without such protective measures, flood stages may reverse the flow in the local stormwater drainage system, resulting in the movement of floodwaters from the stream into developed riverine areas, causing inundation and damage. Backwater gates may, however, create local drainage problems attributable to the accumulation of stormwater runoff which does not have access to the stream because of the closed storm sewer gate. Areas susceptible to the resulting inundation can be afforded protection through the provision of temporary or permanent pumping stations to convey the impounded storm drainage over the dikes and floodwalls to the stream during major flood events.

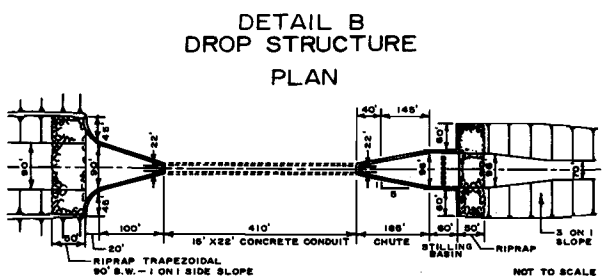
An important factor which must be considered in the design of dikes and floodwalls is the flood stage against which protection is to be provided. This

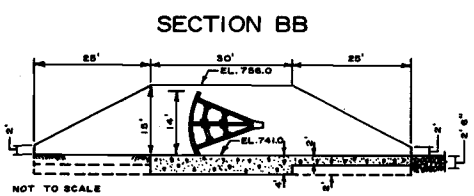
Figure 2

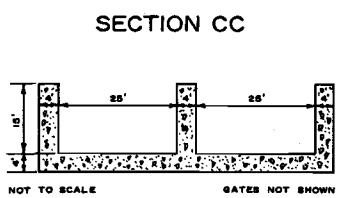
TYPICAL DIVERSION CHANNEL AND APPURTENANT STRUCTURES











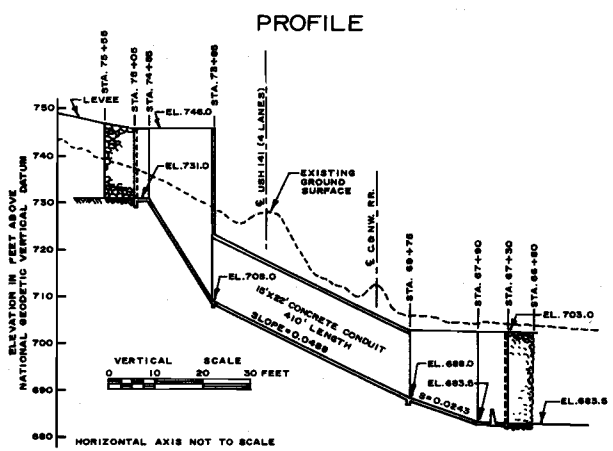
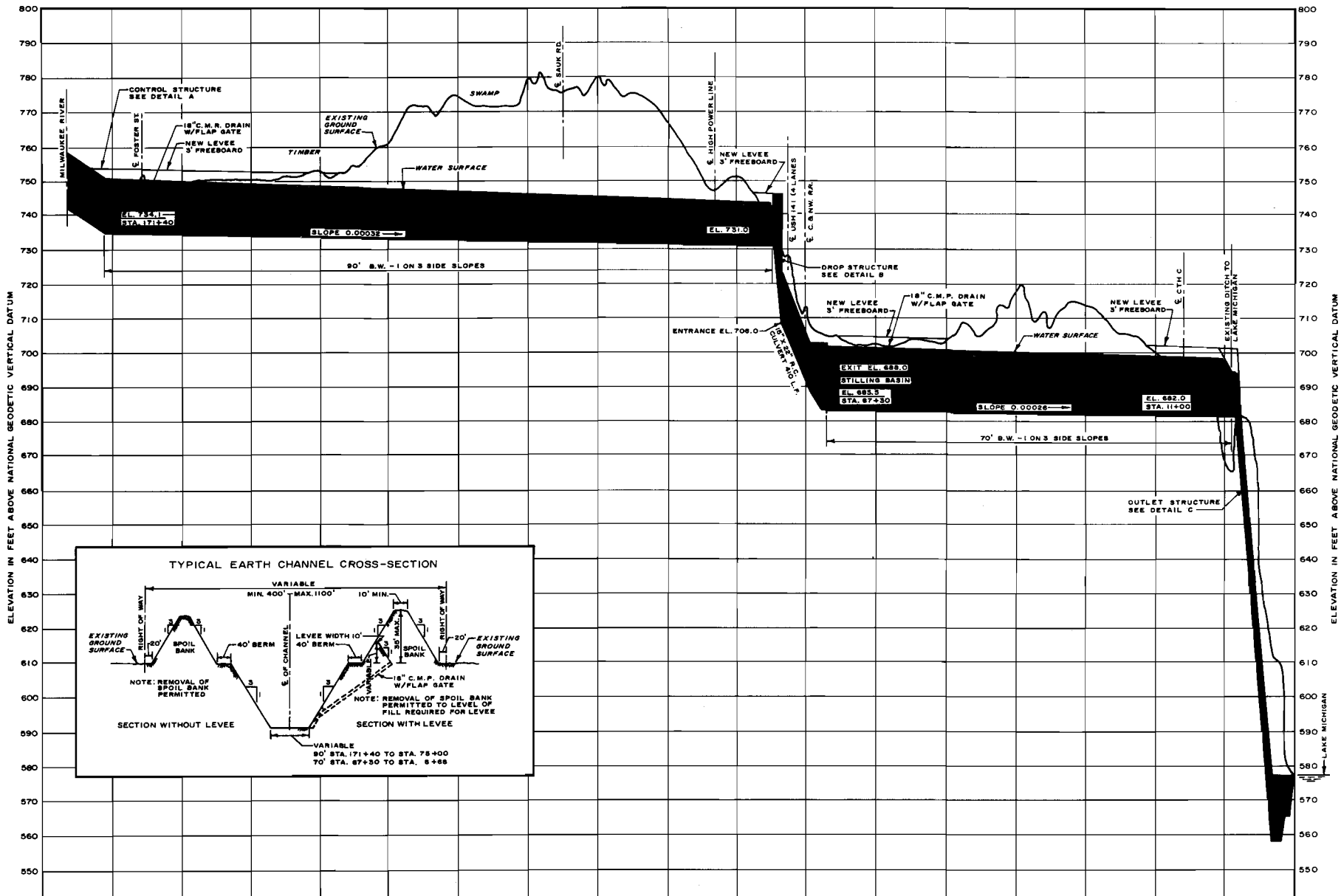
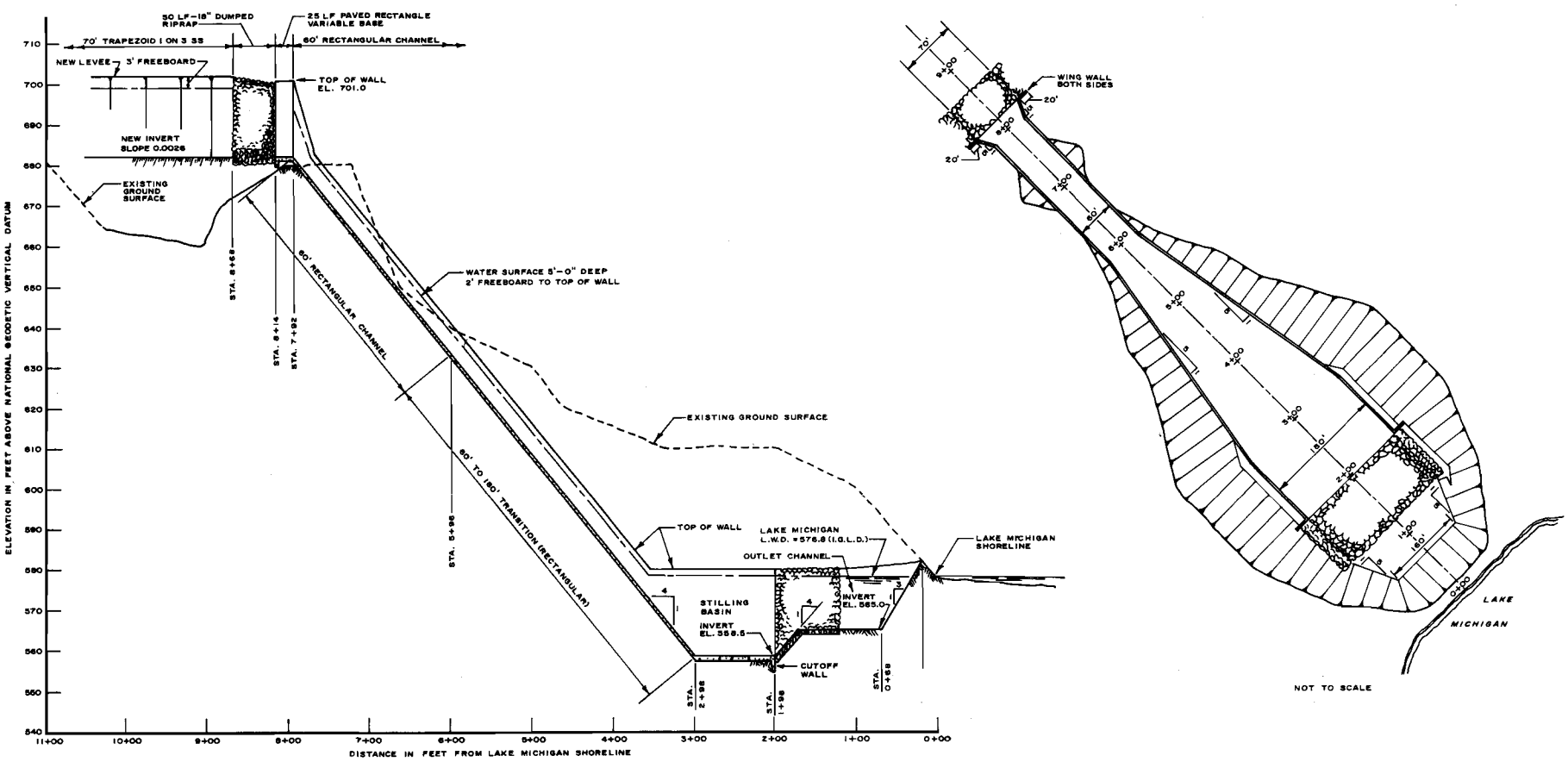


Figure 2 (continued)

PROFILE



DETAIL C
OUTLET STRUCTURE



NOTE: (1) THIS DIVERSION SYSTEM PLAN IS REPRODUCED, WITH THE DELETION OF SOME MINOR DETAILS, FROM PLATES 4, 5, AND 6 AS PUBLISHED IN SURVEY REPORT FOR FLOOD CONTROL-MILWAUKEE RIVER AND ITS TRIBUTARIES, WISCONSIN, U.S. ARMY ENGINEER DISTRICT-CHICAGO, NOVEMBER, 1964.

(2) ALL ELEVATIONS ARE REFERED TO NATIONAL GEODETIC VERTICAL DATUM, 1929 ADJUSTMENT.

Source: U. S. Army Corps of Engineers and SEWRPC.

stage may be higher than the "natural" stage as a result of the lateral constriction imposed on the stream by the dikes and floodwalls. This higher stage, together with an appropriate freeboard, must be used to establish the crest elevation of the dikes and floodwalls.

An advantage of dikes and floodwalls is that they can provide local protection quickly. Negative aspects of such facilities include high capital costs and the potential for increasing upstream flood stages, reducing the floodwater storage capacity of the stream and attendant floodlands and thereby increasing downstream discharges. These facilities could also have a negative aesthetic impact, and may engender a false sense of security with respect to flood dangers.

A typical set of containment facilities is shown in Figure 3.

Channel Modification and Enclosure: Channel modification may include one or more of the following changes to the natural stream channel, all designed to increase the capacity of that channel: straightening, and deepening and widening; placement of a concrete invert and partial sidewalls; and reconstruction of selected bridges and culverts as needed. In some instances, a completely new length of channel may be constructed. The stream channel may also be placed in a large covered conduit along or close to the alignment of the stream reach to convey floodwaters through an area in a manner which may substantially reduce overland flooding.

The function of channel modifications or enclosures is to provide a lower, hydraulically more efficient waterway through which a given flood discharge can be conveyed at a substantially lower stage relative to that which would exist under natural or prechannelized conditions. Key considerations in applying this measure include the availability of required right-of-way of sufficient width to accommodate the modified or relocated channel and the length of upstream and downstream natural channel reaches that must be modified to provide 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 can be quickly applied to local stream reaches. Such channels also have low maintenance costs. Negative features include a possible negative aesthetic impact and the potential, because of the loss of channel storage, to aggravate downstream problems by increasing downstream discharges and stages. Channelization incorporating concrete invert and sidewalls may have a harmful effect on fish and other biota and may result in the loss of the stream's existing and potential recreational use. These structures may have a high capital cost and may contribute to increased flood stages and channel degradation in natural downstream reaches.

Typical channel modifications are shown in Figure 4.

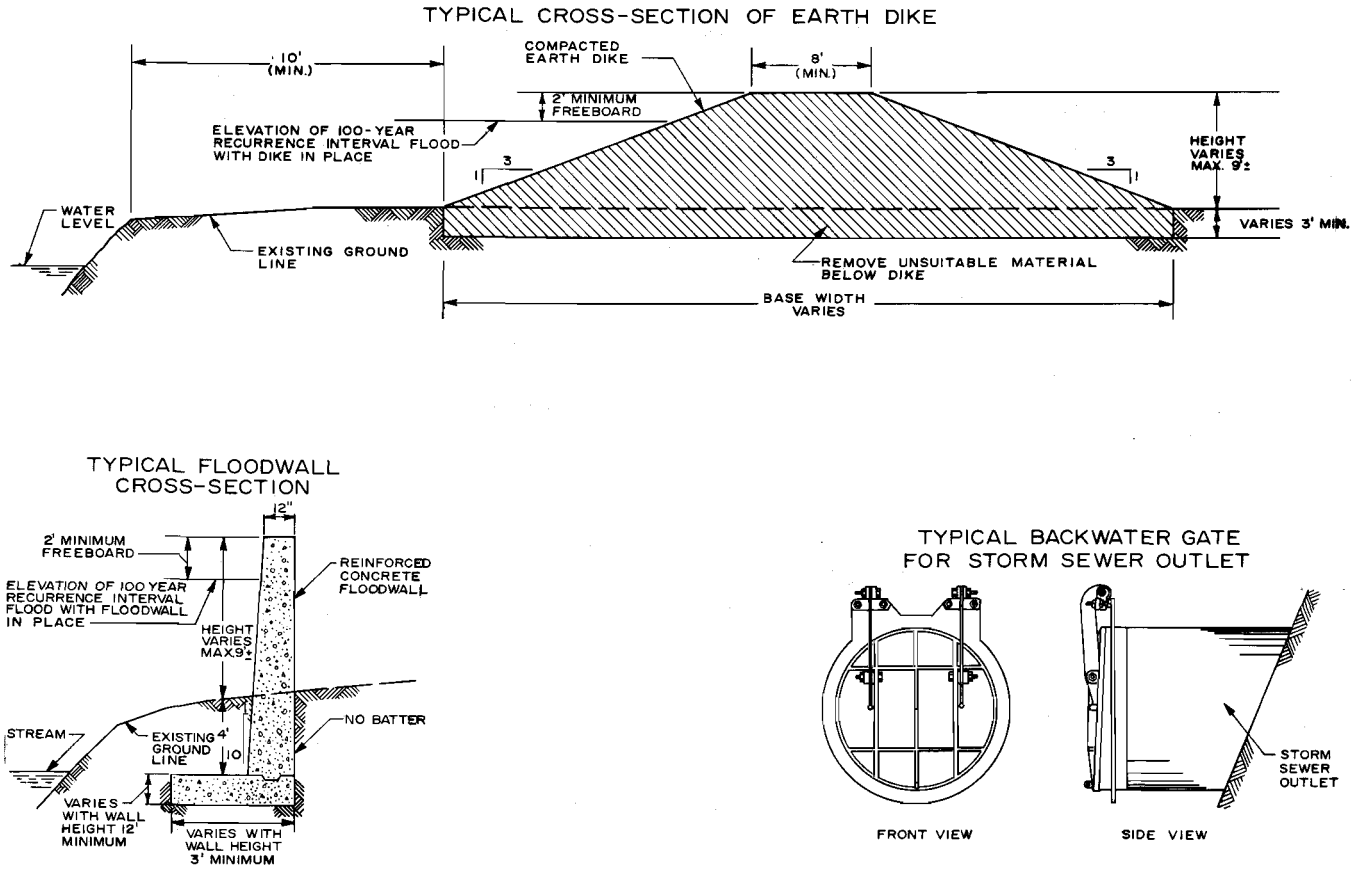
Bridge and Culvert Alteration or Replacement: Highway and railway bridges and culverts may significantly affect upstream flood stages and downstream flood stages and discharges and thereby aggravate existing flood problems or create such problems. Bridge and culvert alteration or replacement is intended to avoid or minimize the adverse hydrologic and hydraulic effects of existing bridges and culverts on flood flows and stages. This structural measure is normally most applicable in areas where the waterway crossings are relatively old and undersized. Although bridge and culvert modification usually entails increasing the waterway opening of the structures to increase their capacity, there are situations in which it may be desirable to maintain the waterway opening of the existing structure or to actually decrease that waterway opening in order to decrease downstream flood flows and stages.

Nonstructural Measures

Reservation of Floodlands for Recreational and Related Open Space Uses: There is a need in metropolitan areas for active and passive recreational and open space lands readily accessible to residents. Floodplains provide an ideal location for such lands both because recreational use frequently is compatible with the flood hazard and because other forms of intensive flood-damage-prone urban development are incompatible with the flood hazard. Recreational and related open space use of floodlands may be accomplished by several mechanisms, including public purchase or other acquisition in fee simple or purchase or other acquisition of easements. The principal advantage of this alternative is its definitive nature and legal incontestability. The key disadvantage is the cost. Land developers may be receptive to dedicating floodlands to public open space use since floodlands are usually not well suited to urban development, not only because of the flood hazard but also because

Figure 3

CONTAINMENT FACILITIES: TYPICAL EARTH DIKE, CONCRETE FLOODWALL, AND BACKWATER GATE



Source: Water Resources Research Institute and SEWRPC.

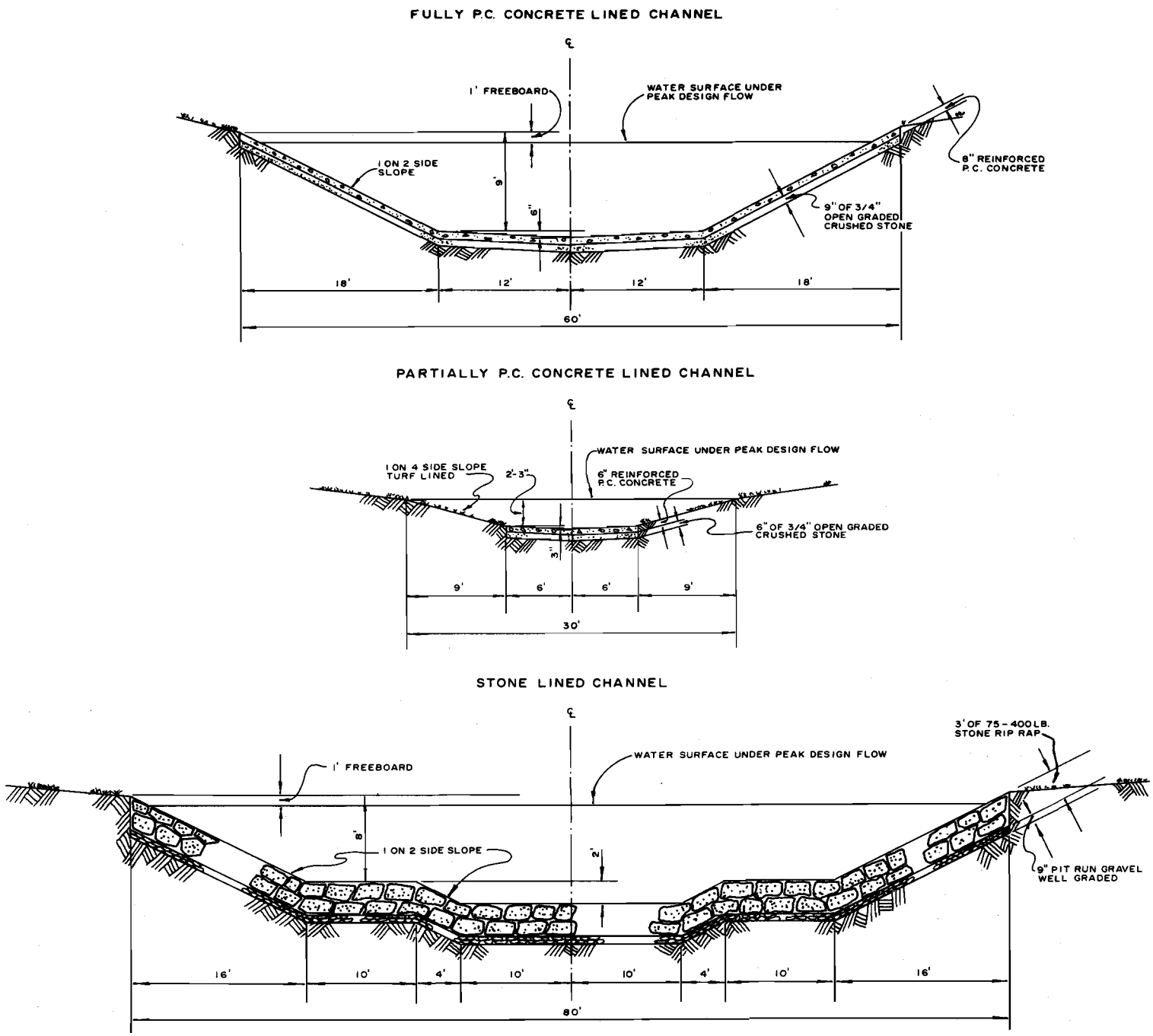
of soil and groundwater conditions and utility availability, since land subdivision regulations often require developers to provide a minimum amount of recreational land as a part of a proposed urban development, and since existing floodland regulations may limit the extent of floodland development. It should also be noted that the preservation of floodlands for recreation and open space uses may also have a favorable impact on the value of property in proximity to the riverine area.

Floodland Regulations: Floodland regulations take the form of, and often are incorporated into, zoning, land subdivision, sanitary, and building ordinances adopted by counties, cities, villages, and towns under police powers granted by the State Legislature. Such regulations are intended to achieve flood damage mitigation by controlling the manner in which new urban development is carried out in floodlands so as to assure that it is not flood damage prone and does not aggravate upstream and downstream flood problems. The principal advantage of floodland regulations is that they control the manner in which new development may occur, if at all, in riverine areas. The principal disadvantage is that they offer no relief from existing flood damage.

There is a potential downstream hydrologic problem associated with floodland regulations that employ a two-district floodway/floodland fringe approach as promoted by the State of Wisconsin and Federal Emergency Management Agency. Under this approach, filling and development of the floodland fringe area is permitted under specified conditions. Such filling and development may lead to a marked increase in downstream flood discharges and stages. The delineation of a floodway, by constricting the cross-sectional flow area, may also increase flood stages, thereby laterally extending the floodplain boundary and subjecting additional lands and structures to

Figure 4

CHANNEL MODIFICATION



Source: SEWRPC.

floodland regulation. This two-district approach, by permitting filling and development of the floodplain fringe area, may also destroy invaluable environmental amenities in the riverine area.

Control of Land Use Outside Floodlands: It is important to regulate the manner in which urban development occurs outside, as well as within, floodlands so as to minimize the hydrologic and hydraulic impacts on floodland areas receiving runoff from tributary watershed areas. The hydrologic and hydraulic interdependence between the land surface and the streamflow regimen of a watershed suggests that areawide land use planning is an essential part of effective flood control. It is important, therefore, that structural and non-

structural flood control measures be based upon an areawide land use plan, a plan which considers the hydrologic-hydraulic consequences of the location of future urban development, the amount of impervious surface in that development, and the manner in which stormwater runoff from new development is controlled.

Federal Flood Insurance: The federal government encourages the purchase of flood insurance by individual landowners to reduce the need for periodic federal disaster assistance. From the perspective of the owner of flood-prone residential, commercial, or industrial structures, federal flood insurance provides a means of distributing monetary flood losses in the form of an annual flood insurance premium. One of the requirements that must be met by a community before landowners can participate in the federal flood insurance program is that the community must enact land use controls which meet federal standards for floodland protection and development. A very close tie, therefore, exists between two of the nonstructural floodland measures—the federal flood insurance program and floodland regulations.

Lending Institution and Realtor Policies: Lending institutions and realtors have gradually become more aware of the flood hazards associated with properties located in floodland areas. The interest of lending institutions and realtors in the flood-prone status of property has been intensified by the federal flood insurance program, which requires the purchase of flood insurance for any structure within a flood hazard area when the purchaser seeks a mortgage through a federally supervised lending institution. Under state regulation, it is incumbent on real estate brokers, salesmen, or their agents to inform potential purchasers of property of any flood hazards which may exist. The purpose of this regulation is to reduce the unwitting acquisition or construction of flood-prone structures by providing information to prospective buyers.

Utility Extension Policies: Under state regulation, sanitary sewer service may not be extended into flood hazard areas to the extent that such areas are a part of an environmental corridor.[1] Local communities may supplement this regulation by policies which prevent the extension of sewers and other public utility services, such as water supply, into any flood-prone areas. Such policies discourage the development of flood-prone areas and help to avoid the need to construct flood control works.

Emergency Programs: The function of an emergency program is to minimize the damage and disruption associated with flooding through a coordinated preplanned action which is to be taken when a flood is impending or occurring. Such a program may include the installation of remote upstream sensors and alarms, preplanned road closures, evacuation of residents, and mobilization of portable pumping equipment to relieve the surcharge of sanitary sewers. In small watersheds the "flashy" nature of the hydrologic-hydraulic system may preclude, as a practical matter, the effective implementation of any warning system as a part of the emergency program.

Structure Floodproofing: Residential, commercial, and industrial structures located within or adjacent to floodlands are vulnerable to flood damage because of the variety of ways in which floodwaters can enter such structures. It is possible and

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[1] *An environmental corridor is defined as an elongated area in the landscape encompassing the best remaining natural resource features of an area, including its lakes and streams and associated floodlands and shorelands; its woodlands, wetlands, and wildlife habitat; areas of groundwater discharge and recharge; organic soils; and significant geological formations and physiographic features. By maintaining such corridors in essentially natural open uses—through appropriate floodland and conservancy zoning and through acquisition for public park and parkway purposes—groundwater and surface water quality will be protected and enhanced, soil erosion and sedimentation abated, air cleansed, wildlife population maintained, and important scientific and educational areas protected. Such corridors are generally well suited to outdoor recreational use, but poorly suited to intensive urban uses. The exclusion of such urban uses from the corridors will minimize costly flood damages and attendant hazards to public health and safety, avoid excessive infiltration of clear water into sanitary sewer systems, and avoid wet basements and failures of foundations for buildings and pavements. The maintenance of such environmental corridors in natural open uses will lend form and structure to urban development and provide a natural boundary to urban neighborhoods. In addition, such corridors provide excellent buffers between incompatible urban land uses, thus contributing to the aesthetic character and economic value of urban development and the stability of urban residential neighborhoods.*

generally practicable for individual owners to make adjustments to their structures and to employ certain measures or procedures which will significantly reduce potential flood damages. This approach is referred to as floodproofing.

Floodproofing techniques may be designed to prevent the entry of floodwaters into the structure or to ensure continuation of utility and other services during flood events, thereby protecting the structure contents in the event that floodwaters do by design or otherwise enter the building. Floodproofing measures should be applied only under the guidance of a registered professional engineer who has carefully inspected the building and contents, and has analyzed its structural integrity and evaluated the flood threat. A program of floodproofing could be initiated and supervised by the local community concerned.

Floodproofing measures may include the installation of backwater valves in sanitary sewer building connections, the operation of sump pumps to remove any floodwaters that enter the basement of a structure through foundation drains or other openings, the installation of waterproof seals at structural joints, the construction of earthen berms or masonry walls around the structure or cluster of structures, and the installation of glass block in basement window openings and flood shields over doorways or windows or other structure openings. Such measures may also include the elevation of electrical machinery and equipment above flood stage, and the elevation of existing structures to raise their first floors above flood stage.

The principal advantage of floodproofing is that it provides a means by which individual property owners can unilaterally take action to protect flood-prone structures against flood damage. A significant negative aspect of floodproofing is the possibility that it may be applied without adequate professional engineering guidance, thereby leading to possible major damage to the structure, as well as posing a threat to the health and safety of the owners, tenants, and users of the structure. Another negative attribute of floodproofing is the possibility that the technique will not be applied in a coordinated way throughout the entire flood-prone reach of the streams, thereby leaving a significant residual demand for flood relief. It should be noted that under current regulations, floodproofing will not remove the federal requirement for flood insurance.

Structure Removal: The removal of structures, in particular those structures having first floor elevations at or below the design flood stage, may constitute a cost-effective approach to flood damage control. This approach has the advantage of enhancing the opportunity to develop the aesthetic appearance and recreational potential of riverine areas by restoring floodlands to an essentially natural open use. A disadvantage of this alternative is the opposition likely to be encountered from some property owners even if offered an equitable price for the flood-damage-prone property. The removal of such structures may also result in a loss in tax base to the local civil division. The net cost to the community, however, may be considerably less than the amount of the taxes lost because of the compensating effect of other factors, including reduced costs of municipal services and of flood-related emergency services, and the likelihood that some of the evacuated residents will construct new residences within the civil division on previously undeveloped land, thereby adding to the tax base.

ELIGIBLE DRAINAGE AND FLOOD CONTROL IMPROVEMENTS

Historically, the Milwaukee Metropolitan Sewerage District has limited its participation in flood control works to channel modification and enclosure, with limited appurtenant dike and floodwall construction and bridge and culvert alteration or replacement. The District has not historically constructed storage or diversion facilities. The District also has not engaged in nonstructural flood control measures other than the limited publication of flood protection elevations for riverine properties along the estuary portion of the Milwaukee River. This emphasis on conveyance in the past flood control efforts of the District reflects the historic evolution of that flood control program in a period predating the development of more comprehensive approaches to flood damage abatement. The historic practices of the District should not, therefore, be regarded as a precedent constraining the use of present day state-of-the-art concepts. Rather, the District policy should be to consider as eligible all drainage and flood control measures and improvements which an adopted system plan has found to be the most cost-effective and environmentally sound measures for resolving a particular problem along a particular reach of a stream over which the District has assumed jurisdiction under this policy plan.

More specifically, to the extent that the District-adopted drainage and flood control system plan has found the measure concerned to be cost-effective, all forms of the following structural measures should be considered eligible for implementation by the District: storage; diversion; containment; channel modification and enclosure; and bridge, culvert, and dam alteration subject to the following conditions.

Storage facilities may include retention, as well as detention, reservoirs and subterranean-mined cavern facilities provided that they are located on or near a stream or watercourse over which the District has assumed jurisdiction pursuant to this policy plan, and provided further that the storage facility would either control the discharge affecting two or more downstream communities or would receive the discharge from two or more upstream communities or both. This exception is intended to preclude from District responsibility small decentralized storage facilities, the construction, maintenance, and operation of which are more properly the responsibility of the local units of government concerned, or of the developer, limiting the District's responsibilities to the construction, maintenance, and operation of centralized, on-channel, storage facilities and such larger decentralized storage facilities as may have multi-community impact.

The sole nonstructural measure considered eligible for implementation by the District should be structure removal, where this measure has been found in the system plan to be a more cost-effective and environmentally sound alternative than structural measures designed to abate flood damage problems. This policy is specifically intended to exclude from District responsibility the following nonstructural flood control measures: the reservation of floodlands for recreational and related open space uses; floodland use regulations; control of land uses outside the floodlands; flood insurance; lending institution policies; realtor policies; community utility extension policies; emergency programs; and structure floodproofing. All of the excluded nonstructural measures are clearly the responsibility of other units and agencies of government, including for the reservation of floodlands for recreational and open space uses, primarily Milwaukee County but also adjacent counties and local municipal units of government; for floodland use regulations within the District and related planning area, the local municipal units of government; for flood insurance, the individual property owner under federal regulation; for lending institution policies, the individual institution also under federal regulation; for realtor policies, the individual realtor under state regulation; for community utility extension policies, the local municipal units of government under state regulation; for emergency programs, county and state emergency government agencies; and for structure floodproofing, the individual property owners. The District will, however, as a matter of policy, encourage and support the units and agencies of government directly responsible for the pursuit of the nonstructural measures shown in the adopted comprehensive watershed plans and the District-adopted drainage and flood control system plan to be effective in preventing the exacerbation of existing problems and the creation of new flood problems.

The District would no longer issue flood regulatory elevations along the estuary portions of the Milwaukee, Menomonee, and Kinnickinnic Rivers, this function being superseded by the state-mandated local floodland zoning.

ELIGIBLE DRAINAGE AND FLOOD CONTROL IMPROVEMENT COMPONENTS

It should be the policy of the District that, for those structural and nonstructural drainage and flood control measures for which the District will assume jurisdiction under this policy plan, the costs of the following components will be eligible for District funding:

1. Aquisition of right-of-way for necessary constructed storage, diversion, containment, and channel modification and enclosure facilities. If county park and parkway lands, or if municipally owned lands, are required for the location of the structural drainage and flood control facilities, such lands should be provided by the County or municipality at no cost to the District.

2. Development of storage, diversion, containment, and channel modification and enclosure facilities, including necessary grading and construction of appurtenances, such as dams and outlet control structures; channel and reservoir linings; stormwater pumping stations; necessary erosion control measures; appropriate environmental restorative mea-

sures; and final landscaping, provided that the facilities were recommended as cost-effective in the District-adopted drainage and flood control system plan. The District, subsequent to the construction of needed drainage and flood control works, should be responsible for the proper operation and maintenance of such works. In the case of channels and reservoirs, the area of responsibility should extend from the channel or reservoir bottom to the hydraulic grade line of the 100-year recurrence interval flood.

3. Acquisition of flood-damage-prone sites and removal of buildings and other flood-damage-prone structures from flood hazard areas, provided that such removal was recommended as cost-effective in the District-adopted drainage and flood control system plan. Upon clearance of the floodlands, it is intended that the cleared land be conveyed to the appropriate county or local municipal unit of government for park and open space or other flood hazard-compatible use.

4. Necessary attendant legal, engineering, and administrative services.

The responsibility for, and funding of the costs of, the construction of new or replacement bridges or culverts carrying arterial, collector, and local streets and pedestrian ways and railways across channel or other drainage and flood control improvements or the removal of such bridges and culverts could be allocated in various ways. Alternatively, the cost of bridge and culvert replacement and removal could be assumed entirely by the District on the assumption that such replacement or removal was needed for drainage and flood control purposes. Conversely, such cost could be allocated to the units and agencies of government and private corporations responsible for the transportation facilities concerned on the assumption that the replacement was to facilitate the operation and maintenance of the transportation system; and, indeed, this has been the historic policy. The policy could also provide that the District assume responsibility for the cost of replacing only those bridges and culverts that must be replaced to provide either an adequate waterway opening or adequately deep foundations to accommodate the drainage and flood control works and attendant peak flows.

Bridges and culverts, however, all perform a dual function: to carry transportation facilities over waterways and to carry the waterways, and the peak flows of those waterways, under the transportation facilities without damage or obstruction to those facilities. Consequently, any bridge and culvert replacement will always have some transportation system benefit and some drainage and flood control benefit. Moreover, the determination of the allocation of costs between these two benefits may often be subjective.

After considering this matter, the Advisory Committee recommended that the Milwaukee Metropolitan Sewerage District pay for the removal of bridges and culverts if such removal is required for the construction by the District of drainage and flood control works; and that the cost of the replacement of such bridges and culverts be borne by the owner of such structures.

The relocation and reconstruction of public utilities, including sanitary sewers and water supply mains and power and communication cables, should, in accordance with historic practice, be the responsibility of the local unit of government or public utility corporation owning the utilities concerned. Similarly, the adjustment of local drainage channels, storm sewers, and other stormwater drainage facilities to accommodate the needed storage, diversion, containment, or channel modification and enclosure works should be the responsibility of the local municipality concerned.

With respect to the eligibility of flood control improvement components for District financing, the intent of the recommended District policy is for the District to bear the cost of the construction, maintenance, and operation of those components of needed major structural and nonstructural flood control measures which are directly related to the resolution of the flooding and drainage problems. The costs indirectly related to such problem resolution, including bridge and culvert replacement, utility adjustments, and local stormwater drainage facility adjustments, should be borne by the state, county, and local units of government and by the private railway and utility corporations responsible for the bridges and culverts, and for the utility and local drainage facilities involved.

Chapter IV

PRIORITY FOR DRAINAGE AND FLOOD CONTROL IMPROVEMENTS

INTRODUCTION

One of the specific purposes of the District drainage and flood control policy planning program is the identification of the method to be used by the District to establish priorities for the construction of otherwise eligible drainage and flood control improvements within the District and environs. Because rarely, if ever, are sufficient public monies available to construct simultaneously all of the public works facilities which may be needed in a functional area, such as drainage and flood control, it becomes necessary to establish a program of construction projects arranged in order of priority. Desirably, that order would provide the greatest return on the public funds invested in the projects over time.

The establishment of priorities for public works construction is an issue which has received considerable attention in relation to the development of municipal capital improvement programs. Criteria advanced for prioritization of projects within such programs have included, among others: the provision of essential public services; the abatement of hazards to public health and safety; the facilitation of economic development; the reduction of operating and maintenance costs; and compliance with the law. Various methods for applying these criteria in capital improvement programming have been advanced, some of which are entirely qualitative, while others are more or less quantitative. All involve value judgments, although the quantitative approaches tend to discipline the application of the value judgments. Because value judgments may be expected to continue to be involved, any quantitative method for establishing priorities should provide for the application of certain overriding criteria through which such value judgments can be explicitly exercised.

In dealing with a single system of public works, such as drainage and flood control facilities, the establishment of a priority order among potential projects can probably best be achieved through economic analysis and selection. All decisions concerning monetary expenditures, public or private, are based on an evaluation, objective or subjective, of benefits and costs. This is not to imply that a formal economic analysis is made before every such decision. The process of decision-making itself, however, consists of an evaluation as to whether or not the benefits to be received will be worth the costs to be incurred. Benefits are not necessarily accountable in monetary terms, but the very act of spending money—or resources—for an intangible benefit implies that the benefit is perceived to be worth at least the cost incurred.

In addition, consideration should be given to possible alternative benefits that could be received for alternative expenditures within the limits of the available resources. Alternative benefits are compared, and the project which is considered to give the greatest value for the costs entailed selected. One alternative that should always be considered is the benefit which would be received from investment in the money market. This benefit is expressed in the prevailing interest rates.

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

It is then a goal of good public administration that every public expenditure return to the public a value at least equal to the amount proposed to be expended for a project plus the interest income foregone from the ever-present alternative of private investment. Accordingly, benefit-cost analysis is increasingly being used to select from among alternatives the most economically efficient means of resolving a problem—or of reaching an objective. Agencies utilizing this method in planning and engineering include the U. S. Army Corps of Engineers and the Wisconsin Department of Transportation, as well as the Southeastern Wisconsin Regional Planning Commission. The method is recommended by such national agencies as the American Association of Highway and Transpor-

tation Officials, and is usually one of the major methods set forth in textbooks on engineering economics. Benefit-cost analysis can also be adapted to provide a basis for prioritizing projects, all intended to attain the same objectives. Thus, benefit-cost analysis, together with certain overriding considerations, is herein recommended as the method to be used by the District for establishing a construction priority order among otherwise eligible drainage and flood control improvements.

Variations on the means by which benefit-cost analyses are applied in planning and engineering work are possible, including application of the method in a manner which considers the difference between benefits and costs; and in a manner which differentiates between major and minor projects. For the purpose of the prioritization of the District drainage and flood control projects, however, it is recommended that the method be applied in its simplest and most direct form. This not only maintains simplicity and thereby promotes public understanding, but recognizes that maximization of benefits minus costs will in some cases be insufficient in and of itself for the final prioritization of proposed projects. Other factors, including the amount of public funds available, or potentially available, and public attitudes toward, and understanding of, a particular improvement proposal must also be considered in prioritizing projects if the political and financial feasibility of the program is to be assured.

BENEFIT-COST ANALYSIS

The benefit-cost analysis method of evaluating government investment 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 costs. The monetary value of benefits is defined as the amount of money which an individual would pay for that benefit if given the market choice of purchase. Monetary costs are defined as the total value of the resources used in the construction of the project.

Benefits should exceed costs in order for a project to be justified, but this criterion alone is not sufficient to justify the investment. Although a project may have a benefit-cost ratio greater than one, the ratio may be less than the benefit-cost of an alternative project which would accomplish identical objectives. Therefore, in order to assure that public funds are invested most profitably, alternative plans or projects should be investigated and analyzed. Such investigations and analyses are properly conducted at the systems planning level and, for flood control projects within the District and environs, have indeed been carried out under the Commission watershed studies. The benefits considered in the investigations and analyses under the watershed studies included, among others, flood control, outdoor recreation, and enhancement of property values. Costs considered included land acquisition, construction, operation, and maintenance, and income foregone as a result of land use regulation.

The benefits and often the costs of drainage and flood control projects accrue over long periods of time. Moreover, each project 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 recurrent, expenditures over a long period of time 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 applied. A dollar benefit or a dollar cost at some time in the future has a value less than a dollar at present. The variation of the value of benefits and costs with respect to time is expressed through the mathematics of compound interest. Use of an interest rate also incorporates consideration of the ever-present possibility of private investment as an alternative. The Regional Planning Commission in its work has used an interest rate of 6 percent in the economic evaluation of drainage and flood control projects as fairly representative of the opportunity cost of the money to an average taxpayer, who is generally a small investor and whose return is thereby constrained.

The benefit-cost analysis must also be based on a specified number of years, usually equal to the physical or economic life of the project. Drainage and flood control improvement will often continue to furnish benefits for an indefinite period of time, particularly land use control and public park elements. Accordingly, the Regional Planning Commission has selected 50 years as the period of economic analysis for drainage and flood control works. Benefits accrued after 50 years discounted to the present at 6 percent are very small.

PROJECT BENEFITS

The benefits from a drainage and flood control project can be classified as tangible—that is, measurable in monetary terms—and as intangible. Tangible benefits include flood damage reduction, enhancement of property values, and that part of outdoor recreation to which a monetary value can be assigned. Intangible benefits include aesthetic factors and such benefits as improved efficiencies in public utilities that have monetary values, but values that cannot be practically calculated. The specific benefits of water quality improvements were considered to be intangible in the sense that these benefits are difficult to measure, although very real since a high level of recreational use of surface waters is possible only if applicable water quality standards are met.[1]

USE OF BENEFIT-COST ANALYSIS IN PROJECT PRIORITIZATION

The accepted rule for economic efficiency is to select the set of improvement projects having the greatest excess of benefits over costs—that is, the maximum net present value. In situations where there is a budgetary constraint, the net present value of the potential projects can be maximized by selecting the combination of projects that have maximum present value but in total do not violate the budgetary constraint. For a number of projects, benefit-cost ratios can be defined with maintenance and operating costs and residual, or salvage, value in the numerator as follows:

$$B/C = \frac{PV(\triangle U) - PV(\triangle M) + PV(\triangle R)}{PV\ (\triangle I)}$$

where: B/C = the benefit-cost ratio

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[1] *More specifically, flood damage is defined as the physical deterioration or destruction caused by floodwaters. Flood loss refers to the net effect of flood damages on the economy and is usually expressed in monetary terms. All losses resulting from a flood can be broadly classified as direct, indirect, depreciation, and intangible. Reduction of flood loss by flood protection measures creates benefits equal to the damages protected against.*

Direct losses are defined as the monetary costs entailed in restoring flood-damaged property to preflood condition. This includes the cost of restoring flood-damaged residential, commercial, and industrial properties and the value of farm crops destroyed by flooding.

Indirect losses are defined as the monetary costs of flood-fighting and floodproofing, and of flood-caused loss of wages, sales, and production. Increased costs of carrying on normal operations during periods of flood disruption, and increased costs of transportation because of flood-caused detours, are also defined as indirect losses.

Depreciation losses are defined as the reduction in the value of real property when the risk of flooding becomes known. Property values after a flood are reduced by the amount of money which will have to be expended for flood repairs. Accordingly, depreciation losses should be equal to the probable direct losses from future floods. In the Regional Planning Commission approach to flood control planning, the direct flood losses, rather than the depreciation losses, are used in the economic analyses.

Intangible losses are defined as losses that cannot be measured in monetary terms. Intangible losses include loss of life, health hazard, interruption of schooling, loss of police and fire protection, and mental aggravation. Although these losses cannot be measured in monetary terms, they often constitute the most severe flood damage experienced by the public, monetary costs notwithstanding.

Flood damages may also be classified into public sector and private sector losses. Direct public sector losses include road and bridge repairs, basement pumping, and flood clean-up operations. Indirect public sector losses include highway traffic rerouting and control and relief and health services. In the Commission flood control planning work, road-user detour costs are calculated on the basis of traffic volume, detour length, time of closures, and average per-mile vehicle costs over the normal routes and over the detour routes. Direct private sector losses include damage to residential, commercial, and industrial properties and to agricultural crops, with such damages being related to the type of building or structure involved, the value of the structures and contents, and the depths and durations of inundation. Damages to structures include, among others, damages to electrical, heating, and ventilating equipment; ceilings, walls, floors and fittings; carpeting; furniture and appliances; and other contents.

$PV(\Delta U)$ = the present value of benefits relative to the do nothing alternative; these benefits are measured in terms of the monetary value of the direct and indirect flood damages avoided by the project;

$PV(\Delta M)$ = the present value of maintenance and operating costs relative to the do nothing alternative;

$PV(\Delta R)$ = the present value of the project residual, or salvage, value relative to the do nothing alternative; and

$PV(\Delta I)$ = the present value of the project capital cost relative to the do nothing alternative

The rationale for deducting maintenance and operating costs from benefits in the foregoing equation follows from the stated objective of maximizing the present value of the excess of discounted benefits over discounted costs per unit of investment. Residual value belongs in the numerator in this case because it can be considered equivalent to a positive future cash flow or benefit.

To use the foregoing equation for ranking independent improvements, the project with the highest benefit-cost ratio is selected first, and other projects—always with the next highest benefit-cost ratio—are added to the list until all projects are accounted for. Based upon consideration of the total cost of the program and estimates of the available funding for the program, a five-year capital improvements program can then be developed. This program should be reviewed annually, at which time the first year of the program would be proposed for inclusion in the District annual budget, and an additional year would be added to the end of the program—thus always maintaining a five-year program—until all of the needed drainage and flood control improvements are in place.

OVERRIDING CONSIDERATIONS

Certain overriding considerations must be met before applying benefit-cost analyses. Each project to be considered must have been shown at the systems level of planning to be technically feasible and economically and environmentally sound. The determination of technical feasibility should be based upon analyses, preferably hydrologic and hydraulic simulation model studies that clearly indicate that the proposed project will achieve the reductions in peak flood flows or peak flood stages, or both, that are necessary to abate the flood damages concerned without exacerbating such problems either upstream or downstream of the proposed project. The project should be shown to be economically sound by benefit-cost analysis. While such analysis applied in the classic manner would require that the benefit-cost ratio of a project be greater than one, it must be recognized that other objectives, such as providing adequate outlets for municipal stormwater sewers or abating public health and safety hazards resulting from the backup of sanitary sewers surcharged by floodwaters into basements of buildings, may make it politically desirable to construct a project having a benefit-cost ratio of less than one. In such cases, it should always be demonstrated, however, that the project, while having a benefit-cost ratio of less than one, has the highest benefit-cost ratio of the feasible alternatives. The project must have been shown at the systems level of planning to be environmentally sound by explicitly considering potential impacts on surface- and groundwater quality and existing and potential fish and wildlife habitats and populations, among others. The project must qualify for all legally required regulatory agency approvals.

Only if a project meets the foregoing overriding considerations should it be considered for prioritization utilizing the benefit-cost analysis herein recommended.

Once the projects have been prioritized on the basis of the benefit-cost analysis, two additional overriding criteria may increase the order of priority of a given project. First would be evidence of a foreseeable danger to human life. Second would be evidence that the timing of the project must be changed in order to coordinate its construction with the construction of other major public works, such as highways, sanitary sewerage systems, or water supply facilities.

Chapter V

SUMMARY

INTRODUCTION

The Milwaukee Metropolitan Sewerage District is charged by Section 66.89 of the Wisconsin Statutes with the function and duty of planning, designing, constructing, maintaining, and operating a sewerage system for the collection, transmission, and disposal of all sewage and drainage generated within its service area. Specifically, that function and duty includes the provision and management of a system of facilities for the collection, transmission, and disposal of stormwater, as well as sanitary sewage. The District is accordingly authorized to plan, design, construct, maintain, and operate storm sewers and other facilities and structures for the collection and transmission of stormwater and, subject to certain reviews and approvals by state and federal regulatory agencies, is authorized to improve watercourses within the District by deepening, widening, or other changes needed to carry off surface or drainage waters. The District is also authorized to make such improvements outside the geographic limits of the District on any watercourses that flow out of the District, and may divert stormwater from surface watercourses into drains, conduits, and storm sewers. Sound public administration, as well as good planning and engineering practice, dictate that these broad responsibilities for stormwater management be carried out within explicit policy guidelines set forth by the governing body of the District, as well as within the context of a comprehensive stormwater drainage and flood control system plan consistent with those policies.

Recognizing the need for both a policy plan and a system plan that could be used to guide the development over time of drainage and flood control facilities within the greater Milwaukee area, the Milwaukee Metropolitan Sewerage District on January 25, 1985, requested that the Southeastern Wisconsin Regional Planning Commission prepare, in cooperation with the District, a comprehensive stormwater drainage and flood control plan. That plan was to consist of two elements—a policy plan and a system plan.

The policy plan is to identify those streams and watercourses for which the District, as an areawide agency, should assume jurisdiction[1]; identify the types of improvements for which the District should assume responsibility; and set forth the manner in which improvement costs are to be shared between the District and benefited local municipalities. The policy plan should also provide a basis for prioritizing and scheduling the needed drainage and flood control improvements to be constructed by the District.

The system plan is to identify the type, general location, and horizontal and vertical alignment of needed drainage and flood control facilities. To this end, the system plan will recommend the approximate elevation, size, grade, and capacity of channels and appurtenant bridge waterway openings, major storm sewers, detention and retention basins, pumping stations, and other appurtenances of areawide significance and such data on flood stages under existing and planned conditions as may be required for the District to issue sound flood protection elevations. The system plan will be in sufficient depth to provide a sound basis for local flood control planning and design, as well as for proceeding with final construction engineering of the recommended watercourse and major drainage projects recommended to be constructed by the District. The system plan will identify the costs and benefits of the recommended improvements and identify an order of priority and schedule for their construction over time, constituting, in effect, a capital improvements program for areawide drainage and flood control works within the District and service areas.

This report documents the policy plan element of the overall drainage and flood control plan for the greater Milwaukee area.

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[1] *It is recognized that, given the State Statutes governing the operation of the District, the term "jurisdiction" may have certain legal implications. Within the context of this policy plan, however, the term is defined to mean those streams and watercourses for which the District is recommended to act as the primary management agency with respect to the construction and maintenance of needed drainage and flood control works.*

The Geographic Planning Unit

The geographic area identified for drainage and flood control policy and system planning purposes in the greater Milwaukee area under this study is shown on Map 3, Chapter I, of this report. This area includes the Milwaukee Metropolitan Sewerage District; the balance of lands in Milwaukee County not currently in the District—namely, the City of South Milwaukee and the southern portions of the Cities of Franklin and Oak Creek; and the existing and proposed District service areas in Ozaukee, Racine, Washington, and Waukesha Counties lying easterly of the subcontinental divide as that divide is approximated by the District service area boundary through the Village of Menomonee Falls and the City of Brookfield, and as that divide is actually located in the Cities of Muskego and New Berlin. The geographic planning area is about 324 square miles in extent and includes all of the Kinnickinnic and Oak Creek watersheds; all of the area along the Lake Michigan shoreline directly tributary to the lake; and portions of the Menomonee, Milwaukee, and Root River watersheds. There are 37 perennial streams within the planning area having a total length of 176.4 linear miles. There are also within the planning area an undetermined number of intermittent streams or watercourses having an undetermined total length. The very nature of these intermittent streams and watercourses is such that definitive identification and delineation are difficult, as such streams and watercourse would include very small topographic swales with insignificant drainage areas.

Staff and Committee Structure

This policy plan was prepared by the staffs of the Regional Planning Commission and Milwaukee Metropolitan Sewerage District working under the guidance of an Advisory Committee created for this purpose. The full membership of this Advisory Committee, which includes representatives of local municipalities, the County, the Wisconsin Department of Natural Resources, the District, and the Regional Planning Commission, as well as citizen members, is set forth on the inside front cover of this report.

JURISDICTIONAL CLASSIFICATION

The Advisory Committee determined that the perennial stream network of the planning area should constitute the universe of streams to be considered. The Committee then applied the following four agreed-upon jurisdictional classification criteria to these streams to establish the recommended jurisdiction of the District for streams and watercourses for drainage and flood control matters:

1. The nature and extent of the known flood hazard by major stream reach.

2. The multi-community nature of the stream or stream reach.

3. The location and continuity of existing stream channel improvements constructed by the District in relationship to potential downstream effects.

4. Commitments by the District to local communities concerning jurisdiction over specific streams or watercourses for drainage and flood control purposes.

More specifically, the Advisory Committee recommended that the Milwaukee Metropolitan Sewerage District jurisdiction for perennial streams for the resolution of drainage and flood control problems should—after the application of certain overriding considerations[2]—include all perennial streams which meet at least one of the following three criteria:

1. Streams within the District for which the District has completed channel improvements.

2. Streams within the District with significant monetary flood damage risk.

3. Streams within the District having a tributary drainage area in more than one community.

[2] *The overriding considerations set forth by the Committee were: 1) the estuary reaches of the Kinnickinnic, Menomonee, and Milwaukee Rivers should be excluded from District jurisdiction, since these reaches are more properly the responsibility of the state and federal levels of government; and 2) major stream reaches having 50 percent or more of their tributary drainage area outside the study area should be excluded from District jurisdiction. Through the application of these overriding considerations, 2.4 miles of the Kinnickinnic River estuary, 1.8 miles of the Menomonee River estuary, and 3.4 miles of the Milwaukee River estuary were recommended to be excluded from District jurisdiction. Similarly, 20.2 miles of the main stem of the Milwaukee River—the remainder of the Milwaukee River in the study area outside the estuary area—and 4.8 miles of the Root River were recommended to be excluded from District jurisdiction.*

In addition, the Advisory Committee recommended that the Milwaukee Metropolitan Sewerage District jurisdiction for the resolution of drainage and flood control problems include intermittent streams which meet any two of the above three criteria.

The application of the overriding considerations and three criteria to perennial streams within the District resulted, as summarized in Table 15 and shown on Map 16, in a total of 103.3 miles of perennial streams, or 58.6 percent of the total miles of perennial streams in the study area, being recommended for District jurisdiction. In addition, 8.3 miles of intermittent streams were recommended for District jurisdiction.

ELIGIBLE DRAINAGE AND FLOOD CONTROL IMPROVEMENTS

Historically, the Milwaukee Metropolitan Sewerage District has limited its participation in flood control works to channel modification and enclosure, with limited appurtenant dike and floodwall construction and bridge and culvert alteration or replacement. The District had not constructed storage or diversion facilities or engaged in non-flood-control structures other than the limited publication of flood protection elevations for riverine properties along the estuary of the Milwaukee River. This emphasis on conveyance in past flood control efforts of the District reflects the historic evolution of that flood control program in a period predating the development of more comprehensive approaches to flood damage abatement. The Advisory Committee recommended that the historic practices of the District not be regarded as a precedent, constraining the use of present day state-of-the-art concepts. Rather, the Advisory Committee recommended that the District policy plan consider as eligible all drainage and flood control measures and improvements which an adopted system plan has found to be the most cost-effective and environmentally sound measures for resolving a particular problem along a particular reach of stream over which the District has assumed jurisdiction.

More specifically, to the extent that the District-adopted drainage and flood control system plan has found the measures concerned to be cost-effective, all forms of the following structural measures should be considered eligible for implementation by the District: storage; diversion; containment; channel modification and enclosure, including rights-of-way for such measures; and bridge, culvert, and dam alteration, provided only that the District responsibilities be limited to the construction, maintenance, and operation of centralized on-channel storage facilities and such larger decentralized storage facilities as may have multi-community impact.

The sole nonstructural measure that should be considered eligible for implementation by the District is structure removal where this measure has been found in the system plan to be more cost-effective and environmentally sound than structural measures. The District would no longer issue flood regulatory elevations along the estuary portions of the Milwaukee, Menomonee, and Kinnickinnic Rivers, this publication being superseded by the state-mandated local floodland zoning.

It should be the policy of the District that, for those structural and nonstructural drainage and flood control measures for which the District has assumed jurisdiction, the following components will be eligible for District funding:

1. Acquisition of right-of-way for necessary constructed storage, diversion, containment, and channel modification and enclosure facilities. If county park and parkway lands, or if municipally owned lands, are required for the location of the structural drainage and flood control facilities, such lands should be provided by the County or municipality at no cost to the District.

2. Development of storage, diversion, containment, and channel modification and enclosure facilities, including necessary grading and construction of appurtenances, such as dams and outlet control structures, channel and reservoir linings, stormwater pumping stations, necessary erosion control measures, appropriate environmental restorative measures, final landscaping, and, subsequent to the construction of such measures, their proper operational maintenance.

3. Acquisition of flood-damage-prone sites and removal of buildings and other flood-damage-prone structures from flood hazard areas. Upon clearance of the floodlands, it is intended that the cleared land be conveyed to the appropriate county or local municipal unit of government for park and open space use or other flood hazard-compatible uses.

4. Necessary legal, engineering, and administrative services.

It is recommended that the policy of the District be to pay for the removal of any bridge or culvert if such removal is required for the construction by the District of drainage and flood control works. The cost of the replacement of such bridges or culverts, however, should be borne entirely by the owner of such facilities.

The relocation and reconstruction of public utilities, including sanitary sewers and water supply mains and power and communication cables, should be the responsibility of the local unit of government or public utility corporation owning the utilities concerned. Similarly, the adjustment of local drainage channels, storm sewers, and other stormwater drainage facilities to accommodate needed storage, diversion, containment, or channel modification or enclosure should be the responsibility of the local municipality concerned.

PRIORITY FOR DRAINAGE AND FLOOD CONTROL IMPROVEMENTS

It is recommended that the District establish priorities for the construction of otherwise eligible drainage and flood control improvements within the District on the basis of the benefit-cost ratios of the projects concerned as determined in the system plan. Certain overriding considerations must be met before applying the benefit-cost analysis to the prioritization of the drainage and flood control projects. Each project to be considered must have been shown at the systems level of planning to be technically feasible and economically and environmentally sound. Two additional criteria may increase the order of priority of a given project as determined by the benefit-cost analysis. The first would be evidence of a foreseeable danger to human life. The second would be evidence that the timing of the project must be changed in order to coordinate its construction with the construction of other major public works, such as highways, sanitary sewerage facilities, or water supply facilities.

CONCLUSION

The policy plan for drainage and flood control works set forth in this report provides the basis for the development of a system plan and plan implementation program that will resolve the areawide, multi-community, drainage and flood control problems of the greater Milwaukee area in the most cost-effective manner possible, and will provide for a fair and equitable distribution of the costs entailed between the District and the local municipalities concerned.

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