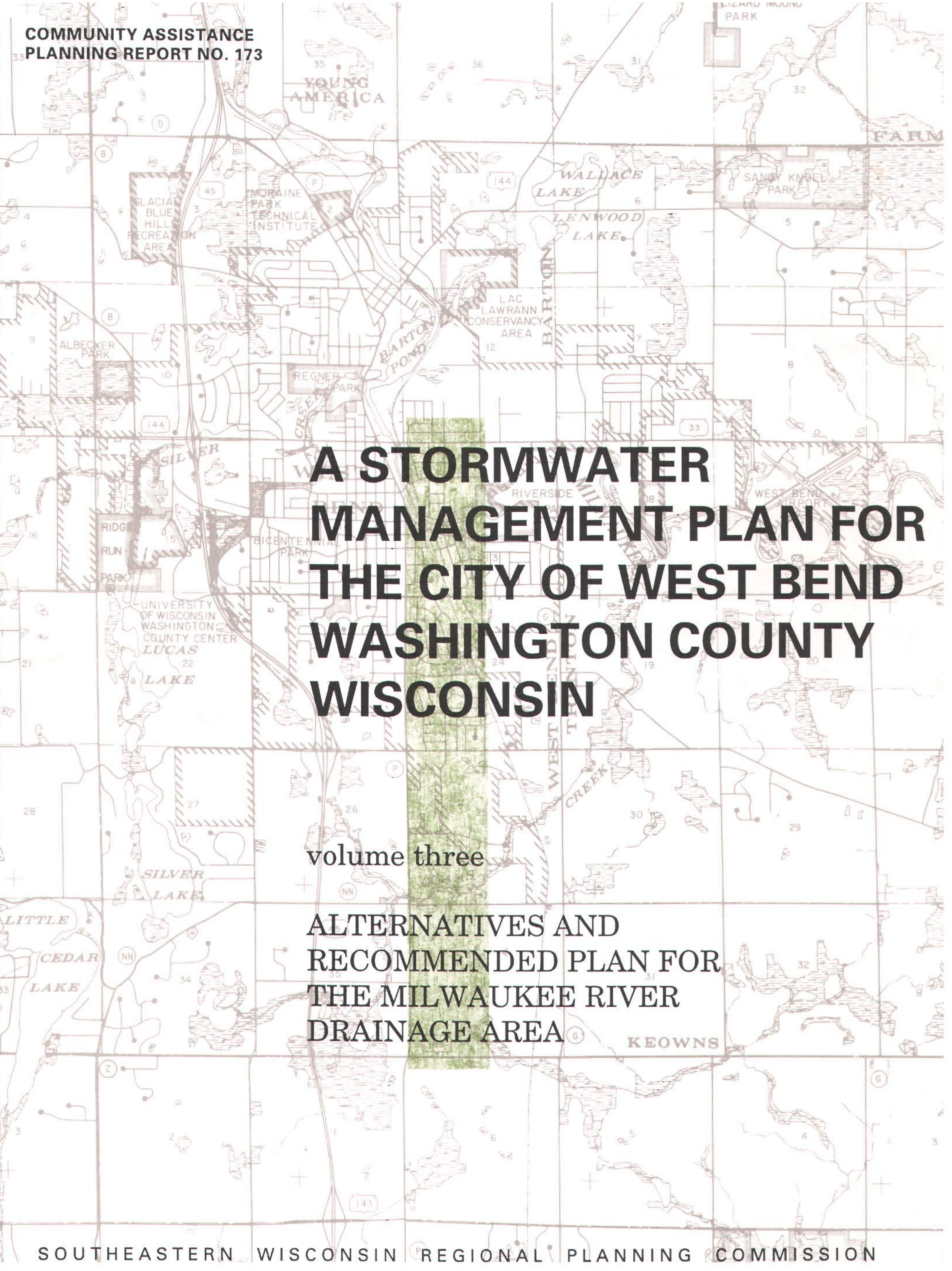
COMMUNITY ASSISTANCE
PLANNING REPORT NO. 173



A STORMWATER MANAGEMENT PLAN FOR THE CITY OF WEST BEND WASHINGTON COUNTY WISCONSIN

volume three

ALTERNATIVES AND RECOMMENDED PLAN FOR THE MILWAUKEE RIVER DRAINAGE AREA

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Special acknowledgement is due Ms. Judith A. Neu, Stormwater Management Engineer, and Mr. Mark A. Piotrowicz, Planner, for their contributions to the preparation of this report.

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Special acknowledgement is due Mr. Michael G. Hahn and Mr. Ronald J. Printz, SEWRPC Principal Engineers, and Ms. Najoua Ksontini, SEWRPC Engineer, *for their contributions to this report.*

COMMUNITY ASSISTANCE PLANNING REPORT
NUMBER 173

A STORMWATER MANAGEMENT PLAN FOR THE CITY OF WEST BEND

CITY OF WEST BEND
WASHINGTON COUNTY, WISCONSIN

Volume Three

ALTERNATIVES AND RECOMMENDED PLAN FOR THE MILWAUKEE RIVER DRAINAGE AREA

Prepared by the

Southeastern Wisconsin Regional Planning Commission
P. O. Box 1607
Old Courthouse
916 N. East Avenue
Waukesha, Wisconsin 53187-1607

June 1995

Inside Region	$5.00
Outside Region	$10.00

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June 6, 1995

Mayor, City Council, and
City Plan Commission
c/o City Clerk
City of West Bend
100 N. Sixth Avenue
West Bend, Wisconsin 53095

Ladies and Gentlemen:

In January 1985, the City of West Bend requested that the Southeastern Wisconsin Regional Planning Commission assist the City in the preparation of a stormwater management plan for the City of West Bend and environs. This volume is the third in a series of four volumes, which together present the major findings and recommendations of the resulting stormwater management planning program. The first volume set forth the basic principles and concepts underlying the planning effort, presented existing and forecast resident population levels and land use within the study area, described the existing stormwater drainage system, and identified general stormwater management problems. The first volume also described the various components of a typical stormwater management system and presented a set of stormwater management objectives, standards, and design criteria for use in plan design, test, and evaluations.

The second volume presented the findings of an evaluation of the existing stormwater management system serving that portion of the planned urban service area of the City of West Bend lying within the Silver Creek subwatershed, described and evaluated alternative stormwater management plans designed to serve that subwatershed through the design year 2010, and recommended a stormwater management system plan for the subwatershed.

This volume pertains to that portion of the planned urban service area of the City lying within the Milwaukee River drainage area and presents a recommended stormwater management system plan for that subwatershed. The final volume will present information and recommendations for the Quaas Creek subwatershed.

The information presented herein is consistent with regional, as well as local, land use development, water quality management, and floodland management objectives and is intended to serve, along with the other volumes, as a guide to City officials in making sound decisions, over time, concerning the development of stormwater management facilities in the City of West Bend.

The Regional Planning Commission is appreciative of the assistance offered by City officials and staff in the preparation of this report. The Commission staff stands ready to assist the City in the adoption and implementation of the plan over time.

Sincerely,

Kurt W. Bauer
Executive Director

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Chapter I

INTRODUCTION

This volume is the third in a series of four volumes which together present the major findings and recommendations of a stormwater management planning program for the City of West Bend and environs. The first volume sets forth the basic principles and concepts underlying the planning effort, presents forecasts of anticipated future land use within the study area, describes the existing stormwater drainage system, and identifies generally existing stormwater management problems. The first volume also describes the various components of a typical stormwater management system and presents the stormwater management objectives, standards, and design criteria applied in the synthesis of the stormwater management plan for the City of West Bend.

The second volume presents the findings of an inventory and evaluation of the existing stormwater management system serving that portion of the planned urban service area of the City of West Bend which lies within the Silver Creek subwatershed, describes and evaluates alternative stormwater management plans designed to serve that subwatershed through the design year 2010, and recommends a stormwater management plan for the subwatershed.

This, the third volume, addresses that portion of the planned urban service area of the City which lies within designated areas draining to the Milwaukee River and presents information similar to that provided for the Silver Creek subwatershed in the second volume of this report. The fourth and final volume presents information and recommendations for the Quaas Creek subwatershed.

STUDY AREA

The study area is shown on Map 1. The Milwaukee River drainage area stormwater management study area includes the entire Wingate Creek subwatershed plus 57 additional hydrologic units designated MR-A through MR-BE. The portions of the study area for which stormwater management needs were not investigated in detail are: 1) areas which are internally drained and lie outside the planned urban service area or which lie inside the urban service area and are almost completely contained within a primary environmental corridor where no urban development is planned, or 2) areas which lie predominantly outside the planned urban service area and are not tributary to a major stream within the urban service area.

The water quality management element of this plan was designed to be consistent with the regional water quality management plan[1] prepared by the Regional Planning Commission and with the priority watershed plan prepared for the East and West Branches of the Milwaukee River by the State of Wisconsin and the County Land Conservation Departments.[2] Therefore, the same areas studied under the priority watershed study were included under this plan. Map 1 also delineates additional areas which were not included under the priority watershed study, but which were considered in the water quality management and stormwater drainage elements of this plan.

The stormwater management alternatives are designed to serve the Milwaukee River drainage area through the design year 2010. Planned year 2010 land use conditions are based on the recommended land use plan prepared by the

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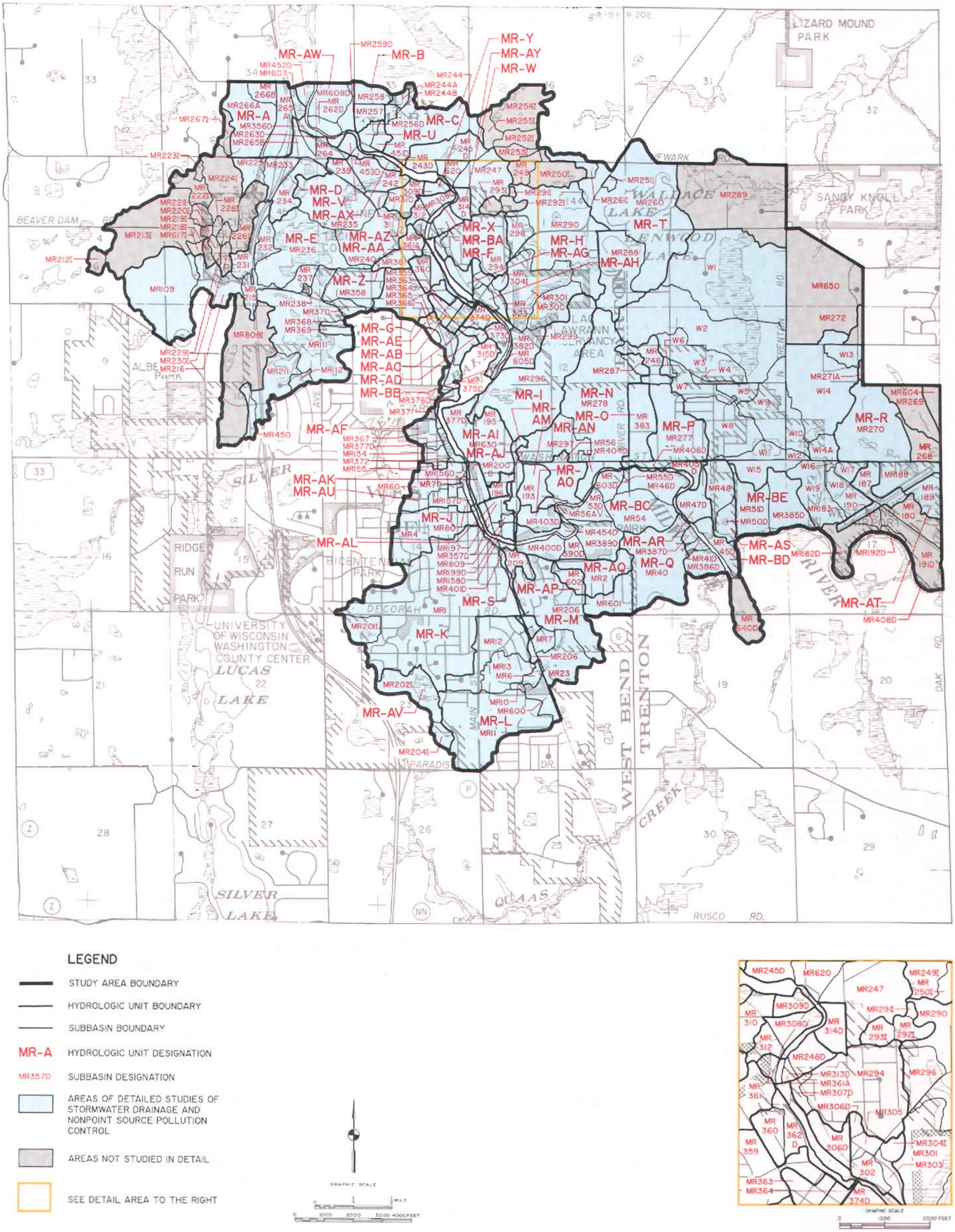
[1] *SEWRPC Planning Report No. 30, A Regional Water Quality Management Plan for Southeastern Wisconsin: 2000, Volume One, September 1978; Volume Two, February 1979; Volume Three, June 1979.*

[2] *Wisconsin Department of Natural Resources; Wisconsin Department of Agriculture, Trade and Consumer Protection; and the Dodge, Fond du Lac, Ozaukee, Sheboygan, and Washington County Land Conservation Departments, A Nonpoint Source Control Plan for the East and West Branches of the Milwaukee River Priority Watershed Project, Publication WR-255-90, February 1989.*

Map 1

MILWAUKEE RIVER SUBWATERSHED STUDY AREA



Source: SEWRPC.

Regional Planning Commission for the City of West Bend.[3]

ANALYSIS OF ALTERNATIVE PLANS

On the basis of experience in the preparation of the stormwater management plans for the Silver Creek and Wingate Creek subwatersheds, the City's and Commission's staffs agreed, at an interagency staff meeting held on November 13, 1991, on a set of stormwater management components to be incorporated into the basic alternatives to be considered. It was agreed that, in those hydrologic units which are anticipated to experience significant urban development over the approximately 20-year planning period, a basic alternative would be developed which utilized centralized detention storage and storm sewer conveyance facilities except in low-density residential and certain industrial park areas, where the use of roadside swale conveyance facilities would also be considered. Experience has shown that such a basic alternative would often be the most cost-effective means of substantially meeting the standards and objectives established for the planning effort in Volume One of this report, while recognizing the City's policies and preferences regarding the stormwater conveyance system. Additional alternatives were investigated when the specific characteristics of a hydrologic unit dictated consideration of such alternatives. In areas which are developed under existing conditions, the alternative developed may deviate somewhat from the basic alternative set forth above because of constraints or opportunities imposed by the existing development.

REVIEW OF PLAN COMPONENTS FOR COMPLIANCE WITH CHAPTER NR 103 OF THE WISCONSIN ADMINISTRATIVE CODE

Chapter NR 103 of the Wisconsin Administrative Code, which became effective on August 1, 1991, establishes water quality standards for wetlands. The rules set forth in Chapter NR 103 consist of two parts: 1) a set of standards intended to protect water quality-related functions of wetlands including sediment and pollution control, stormwater and floodwater storage, hydrologic cycle maintenance, shoreline erosion protection, habitat protection for aquatic organisms and other wildlife species, and recreational uses, and 2) implementation procedures for application of the water quality standards. The Wisconsin Department of Natural Resources (DNR) is responsible for the review of proposed projects for compliance with Chapter NR 103.

The plan set forth in this report is intended to meet the multiple objectives of controlling nonpoint source pollution, protecting primary environmental corridors and wetlands, and providing adequate stormwater drainage and flood control facilities to meet the needs of existing and new development. Those objectives are generally consistent with the intent of the standards set forth in Chapter NR 103; however, fully meeting each of the objectives may not be possible in all instances because the objectives may conflict. In such cases, it may be most desirable for a certain objective to be met only partially in order to insure that other equally important objectives can be met fully.

In general, the recommendations of this stormwater management plan are intended to preserve or enhance the quality of receiving streams and wetlands wherever practicable through the control of frequently occurring flows and through the control of nonpoint source pollution. In some instances, the provisions of such controls may involve locating a stormwater management facility in a wetland. In those cases, the proposed facility must be evaluated for conformance with the requirements of Chapter NR 103.

A project would not be in compliance with the provisions of Chapter NR 103 if it is not surface water- or wetland-dependent, meaning that it does not necessarily require "location in or adjacent to surface waters or wetlands to fulfill its basic purpose," and if a practicable alternative to the project exists.[4] Under a practicable

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[3] *SEWRPC Community Assistance Planning Report No. 167, A Land Use Plan for the City of West Bend: 2010, July 1992.*

[4] *DNR staff members have determined that wet detention basins for control of nonpoint source pollution are not surface water- or wetland-dependent and would, therefore, not be in compliance with Chapter NR 103 if practicable alternatives exist which "will not adversely impact wetlands and will not result in other significant adverse environmental consequences."*

alternatives analysis, the proposed project would be compared to the practicable alternatives considering relative monetary costs, logistical limitations, technological limitations, and other pertinent positive or negative aspects of the alternatives. If there is an alternative to the project which is practicable, will not adversely impact wetlands, and will not have other significant adverse environmental consequences, then the alternative would be selected.

If, following the practicable alternatives analysis, no suitable alternative is identified, an assessment of the impacts of the project on the functional values of the wetland must be made. That assessment should provide details of the impacts on the wetland relative to the categories set forth in the standards and listed above. Those impacts would then be considered by the DNR in making a determination that the requirements of Chapter NR 103 are satisfied.

The detailed permit application procedure set forth above would be initiated following the planning stage, at the time a given project is to be implemented. For the purposes of the stormwater management plan documented in this report, a practicable alternatives analysis was provided in each instance where a component of the preliminary recommended plan could result in wetland disturbance. If the analysis indicated that an alternative to the component included in the preliminary recommendation could be provided without significantly compromising the overall plan objectives, that alternative was then selected. If no such alternative were judged to be practicable, the preliminary recommendation was maintained and a general assessment of the impact of the recommendation on the functional values of the wetland was made. That assessment was based in part on determinations by Commission staff biologists of the existing functional value of each affected wetland and the potential for enhancement or degradation of the wetland.

ORGANIZATION OF VOLUME THREE

Following this introductory chapter, the second chapter of this volume presents the findings of the study of the Wingate Creek subwatershed. It includes the evaluation of the existing stormwater management system; the preparation, test, and evaluation of alternative stormwater management system plans; a recommended stormwater management system plan; and estimates of the cost of the recommended plan. The third chapter presents similar information for the remaining hydrologic units, where applicable. The fourth presents water quality management plan elements, dealing specifically with the control of nonpoint source pollution from each of the areas for which stormwater management system plans were prepared. Chapter V presents auxiliary plan recommendations regarding preservation of natural resources and open spaces, revisions to the City's floodplain map, and maintenance of stormwater management facilities. Chapter VI deals with implementation of the plan and includes a prioritization of projects. The seventh and final chapter presents a summary of the recommended plan.

The design of the recommended plan was based upon careful consideration of many factors; primary emphasis, however, was placed on the degree to which the recommended stormwater management objectives and supporting standards are satisfied. Most important among the considerations were those relating to cost, to the ability of the system components to accommodate flows resulting from the design storm events without exacerbating downstream drainage and flooding problems, and to the ability of the system components to abate nonpoint source pollution.

Chapter II

WINGATE CREEK SUBWATERSHED

INTRODUCTION

This chapter presents the findings and recommendations of the stormwater management planning program for the City of West Bend as it relates to the Wingate Creek subwatershed. The chapter is divided into three sections: 1) an inventory and evaluation of the existing stormwater management system serving the Wingate Creek subwatershed, 2) a description and evaluation of alternative stormwater management plans designed to serve the subwatershed through the design year 2010, and 3) a recommended stormwater management system plan for the subwatershed.

EVALUATION OF THE EXISTING STORMWATER MANAGEMENT SYSTEM

In order to characterize the existing stormwater management system, the components of that system must be definitively described. Such a description permits the hydraulic capacities of the existing conveyance and storage facilities to be calculated, along with the required capacities for the design storms under planned future and existing land use development conditions in the tributary catchment areas. Those system components which are unable to accommodate the runoff expected from the design storms under either existing or future land use conditions, or both, are thus identified. The inadequate components can then be addressed in the design of alternative stormwater management system plans.

The 1.65-square-mile[1] Wingate Creek subwatershed was divided, for analytical purposes, into 31 subbasins, as shown on Map 2. The existing stormwater drainage systems are comprised primarily of roadway curbs and gutters, storm sewer inlets, storm sewers, roadside swales, and open channels and associated culverts, together with streams to which the outlets of the engineered and constructed system components discharge. The existing stormwater management systems are described in Chapter II of Volume One of this report.

The hydraulic capacity of such conveyance facilities as storm sewers, roadside swales, culverts, and open channels is determined by the shape and dimensions of the cross-section of the facility, by the facility's composition and lining, by its elevation and gradient, and by surface roughness as represented by Manning's "n" value. The methods used to determine the hydraulic capacity of the system components are described in Chapter IV of Volume One of this report. The capacities of storm sewers and open channels and culverts in the minor stormwater management system and of selected watercourses of the major stormwater management system were calculated as part of this evaluation. It was assumed that the backyard and sideyard drainage swales and the storm sewer inlets would have adequate capacity to convey to the receiving conveyance facilities of the minor system the stormwater flows generated by storms up to and including the 10-year recurrence interval event, except in cases where specific problems had been reported by the City to indicate to the contrary. In those cases further analyses were required.

Peak rates of stormwater runoff, as determined by the hydrologic and hydraulic characteristics of each catchment area, were estimated utilizing the methods described in Chapter IV of Volume One of this report. Peak rates of flow were also estimated for catchment areas within subbasins in order to determine the hydraulic loadings, as appropriate, on each segment of the storm sewer. Where these stormwater flows exceed the capacities of the conveyance facilities, surface ponding, flooding, and surcharging of upstream and downstream drainage facilities may be expected to occur.

In identifying problems in the existing system, consideration was given to the potential impact

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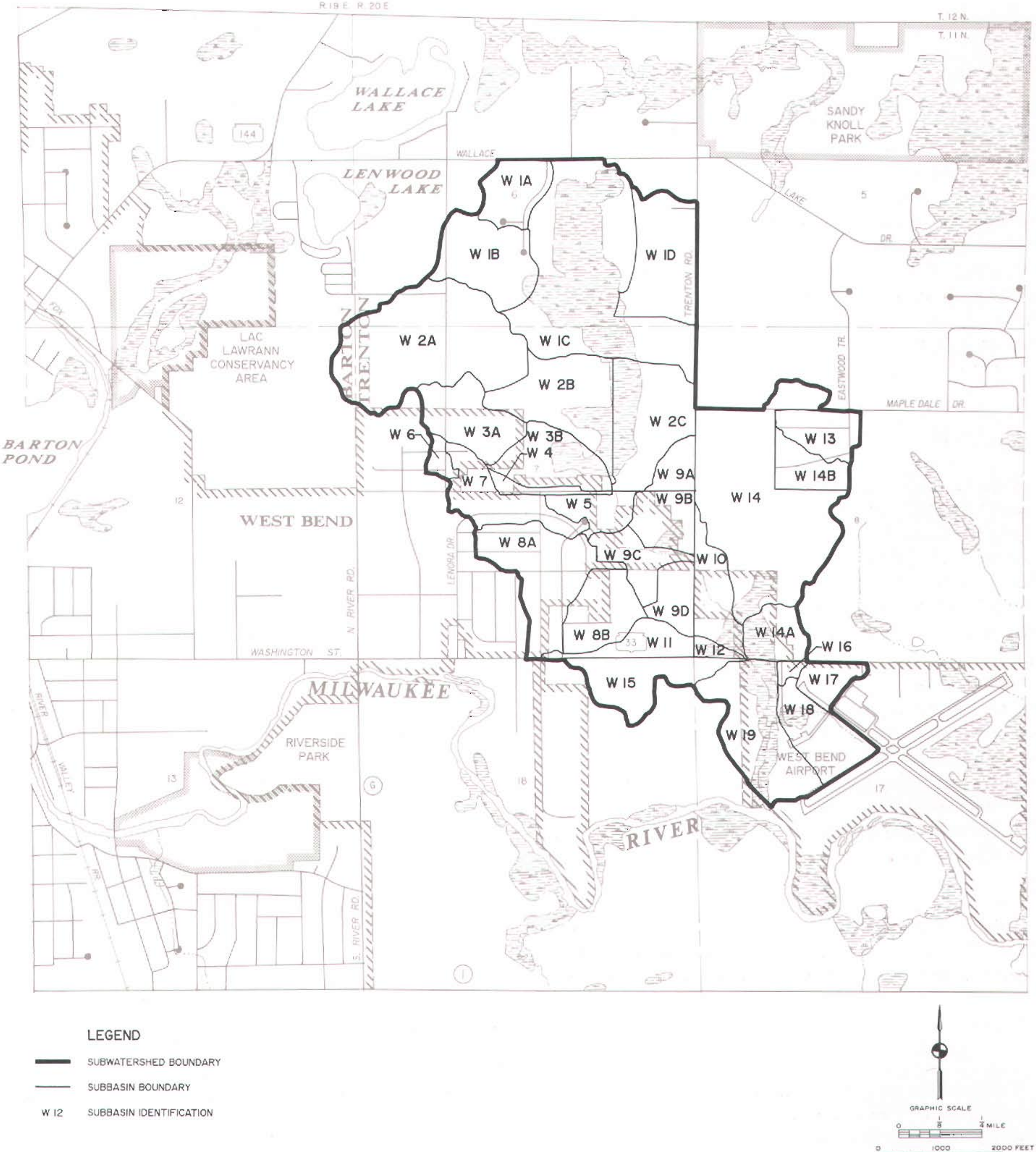
[1] *This drainage area reflects the delineation of the Wingate Creek subwatershed on large-scale topographic maps prepared in 1990 and 1991. This drainage area represents a refinement of that documented in Volume One of this report. That volume was published before the preparation of the new topographic maps.*

Map 2

SUBBASINS WITHIN THE WINGATE CREEK SUBWATERSHED



Source: SEWRPC.

of excessive flows. In some cases, problems were not created even though the capacity of the system component was exceeded as, for example, in the case of the attendant inundation of areas in which no flood damage-prone buildings, transportation facilities, or other improvements were located, and in the case where Standard No. 3 of Objective No. 1 as set forth in Chapter IV of Volume One, relating to acceptable levels of street flooding during a 10-year recurrence interval event, was satisfied.

Because of the generally rural character of the Wingate Creek subwatershed, few problems were found with the existing drainage system. Insufficient capacities in the minor conveyance system were identified at three locations under both existing and planned development conditions. These locations were: 1) the storm sewer in subbasin W7 along Wellington Drive east of Clearview Drive, 2) the storm sewer in subbasin W8A along Deerfield Drive between Clearview Drive and Sandy Acre Drive, and 3) the storm sewer in subbasin W8A discharging from Deerfield Drive to the Wingate Creek channel. The locations of these three problem areas are shown on Maps 3 through 5. No capacity problems were identified for the major conveyance systems. No structural damages were identified as associated with flooding along Wingate Creek.

ALTERNATIVE STORMWATER DRAINAGE PLANS

Utilizing the alternative stormwater management approaches which were described in Chapter III of Volume Two of this report, the following four alternative stormwater management plans were developed for the Wingate Creek subwatershed: 1) a storm sewer conveyance plan, 2) a storm sewer-roadside swale conveyance plan, 3) a storm sewer conveyance plan with centralized detention, and 4) a storm sewer-roadside swale conveyance plan with centralized detention.

During the alternative plan development and evaluation stage, components of the minor drainage system, such as storm sewers and off-channel detention facilities, were considered, as were such components of the major drainage system as major engineered drainage channels, natural watercourses, and on-channel detention facilities. In areas with existing or planned urban street patterns, the alternative plans included a complete system of minor system components. In areas planned to be developed for urban use but for which no street layout had been established, only certain key components of the minor system such as trunk storm sewers, important open drainage channels, and centralized detention facilities could be explicitly considered. Smaller collector storm sewers, culverts, curbs and gutters, and inlets could be considered only implicitly through the simulation modeling. Nonpoint source pollution abatement measures were considered only in a general manner in the development and evaluation of the alternative system plans. However, these components, together with the major system, were specifically considered in the design and evaluation of the recommended plan. Each alternative proposes preservation of natural wetlands and floodplains for storage purposes.

Alternative Plan No. 1: Storm Sewer Conveyance

The storm sewer conveyance alternative plan involves primarily the provision of new storm sewers and engineered open channels to abate existing stormwater runoff problems and to serve planned new urban development effectively. Map 3 shows the approximate location and alignment of new storm sewers and engineered open channels proposed under the alternative. Table 1 presents the salient characteristics and estimated costs of the new storm sewers and channels comprising this alternative plan. The total estimated capital cost of this alternative plan is $3,413,000. The estimated annual operation and maintenance would be $8,200.

The storm sewer conveyance alternative includes 18,350 lineal feet of new storm sewers in areas of planned development, ranging from 12-inch circular pipe to 68-inch by 43-inch horizontal elliptical pipe. As part of the construction of the proposed new storm sewer in subbasin W9D, it was assumed that an existing sag in the Trenton Road profile south of the Wingate Creek crossing would be elevated in order to provide adequate cover for the storm sewer. Elimination of this sag will prevent the overtopping of Trenton Road during major flood events and consequent potentially raising upstream flood stages. Therefore, this alternative plan includes the replacement of the Trenton Road culvert with two eight-foot-wide by four-foot-high reinforced concrete box culverts. With the addition of those culverts, upstream 100-year recur-

Table 1

COMPONENTS AND COSTS OF STORMWATER DRAINAGE ALTERNATIVE NO. 1: STORM SEWER CONVEYANCE IN THE WINGATE CREEK SUBWATERSHED

Subbasin Designation	Project and Component Description[a]	Estimated Cost	
		Capital	Annual Operation and Maintenance[b]
W1A	No new stormwater management measures considered	- -	- -
W1B	Northern portion of Wingate Creek subwatershed		
	1. 260 feet of 15-inch storm sewer	$ 10,000	$ 100
	2. 372 feet of 21-inch storm sewer	19,000	100
	3. 402 feet of 24-inch storm sewer	25,000	200
	4. 176 feet of 38-inch x 24-inch HE storm sewer	16,000	100
	5. 368 feet of double 38-inch x 24-inch HE storm sewer	68,000	100
	6. Construct 720-foot long grass-lined channel at storm sewer outlet	11,000	300
	7. Engineering, administration, and contingencies	52,000	0
	Subtotal	$ 201,000	$ 900
W1C	No new stormwater management measures considered	- -	- -
W1D	Northern portion of Wingate Creek subwatershed		
	1. 663 feet of 38-inch x 24-inch HE storm sewer	$ 61,000	$ 200
	2. 650 feet of double 38-inch x 24-inch HE storm sewer	120,000	500
	3. 1,250 feet of double 45-inch x 29-inch HE storm sewer	275,000	500
	4. Deepen and reconstruct 2,535 feet of Wingate Creek channel	31,000	1,100[c]
	5. Engineering, administration, and contingencies	169,000	0
	Subtotal	$ 656,000	$2,300
W2A	Northern portion of Wingate Creek subwatershed		
	1. 183 feet of 15-inch storm sewer	$ 7,000	$ 100
	2. 707 feet of 24-inch storm sewer	43,000	300
	3. 908 feet of 36-inch storm sewer	89,000	200
	4. 564 feet of 53-inch x 34-inch HE storm sewer	78,000	100
	5. 748 feet of 60-inch x 38-inch HE storm sewer	125,000	100
	6. Engineering, administration, and contingencies	120,000	0
	Subtotal	$ 462,000	$ 800
W2B	Northern portion of Wingate Creek subwatershed		
	1. 327 feet of 60-inch x 38-inch HE storm sewer	$ 54,000	$ 100
	2. 476 feet of 68-inch x 43-inch HE storm sewer	91,000	100
	3. Construct 1,370-foot-long, grass-lined channel from storm sewer outlet to existing drainage channel	46,000	600
	4. Engineering, administration, and contingencies	67,000	0
	Subtotal	$ 258,000	$ 800
W2C	No new stormwater management measures considered	- -	- -
W3A	Western portion of Wingate Creek subwatershed		
	1. 216 feet of 1.5-foot-deep drainage swale	$ 1,000	$ 100
	2. 860 feet of 2.0-foot-deep drainage swale	6,000	300
	3. Engineering, administration, and contingencies	2,000	0
	Subtotal	$ 9,000	$ 400
W3B	Western portion of Wingate Creek subwatershed		
	1. 630 feet of 36-inch storm sewer	$ 62,000	$ 100
	2. 796 feet of 42-inch storm sewer	93,000	100
	3. Construct 114-foot-long, grass-lined channel at storm sewer outlet	2,000	100
	4. Engineering, administration, and contingencies	55,000	0
	Subtotal	$ 212,000	$ 300

Table 1 (continued)

Subbasin Designation	Project and Component Description[a]	Estimated Cost	
		Capital	Annual Operation and Maintenance[b]
W4, W5, W6	No new stormwater management measures considered	- -	- -
W7	Western portion of Wingate Creek subwatershed		
	1. Replace 643 feet of 24-inch storm sewer in Wellington Drive with 44-inch x 27-inch RCPA storm sewer	$ 99,000	$ -100
	2. Replace 665 feet of 27-inch storm sewer in Wellington Drive and Wingate Park with 44-inch x 27-inch RCPA storm sewer	102,000	-100
	3. Engineering, administration, and contingencies	71,000	0
	Subtotal	$ 272,000	$ -200
W8A	Western portion of Wingate Creek subwatershed		
	1. Replace 135 feet of 50-inch x 31-inch CMPA storm sewer in Deerfield Drive with 58-inch x 36-inch RCPA storm sewer	$ 32,000	$ 0
	2. Replace 259 feet of 42-inch storm sewer in Deerfield Drive with 60-inch x 38-inch HE storm sewer	60,000	0
	3. Engineering, administration, and contingencies	32,000	0
	Subtotal	$ 124,000	$ 0
W8B	Central portion of Wingate Creek subwatershed		
	1. 193 feet of 18-inch storm sewer	$ 9,000	$ 100
	2. 119 feet of 24-inch storm sewer	7,000	100
	3. 177 feet of 27-inch storm sewer	12,000	100
	4. 381 feet of 30-inch storm sewer	30,000	100
	5. Engineering, administration, and contingencies	20,000	0
	Subtotal	$ 78,000	$ 400
W9A	Central portion of Wingate Creek subwatershed		
	1. 330 feet of 12-inch storm sewer	$ 11,000	$ 100
	2. 365 feet of 18-inch storm sewer	16,000	100
	3. Engineering, administration, and contingencies	10,000	0
	Subtotal	$ 37,000	$ 200
W9B	Central portion of Wingate Creek subwatershed		
	1. 45 feet of 18-inch storm sewer	$ 2,000	$ 100
	2. 474 feet of 21-inch storm sewer	25,000	200
	3. 302 feet of 24-inch storm sewer	18,000	100
	4. 309 feet of 30-inch storm sewer	24,000	100
	5. Engineering, administration, and contingencies	24,000	0
	Subtotal	$ 93,000	$ 500
W9C	No new stormwater management measures considered	- -	- -
W9D	Central portion of Wingate Creek subwatershed		
	1. 175 feet of 15-inch storm sewer	$ 7,000	$ 100
	2. 302 feet of 38-inch x 24-inch HE storm sewer	28,000	100
	3. 546 feet of 45-inch x 29-inch HE storm sewer	60,000	100
	4. Replace existing 72-inch x 44-inch CMPA under Trenton Road at Wingate Creek with double 8-foot x 4-foot reinforced concrete box culvert	55,000	0
	5. Engineering, administration, and contingencies	52,000	0
	Subtotal	$ 202,000	$ 300
W10	No new stormwater management measures considered	- -	- -

Table 1 (continued)

Subbasin Designation	Project and Component Description[a]	Estimated Cost	
		Capital	Annual Operation and Maintenance[b]
W11	Southern portion of Wingate Creek subwatershed		
	1. 380 feet of 18-inch storm sewer	$ 17,000	$ 100
	2. 310 feet of 24-inch storm sewer	19,000	100
	3. 335 feet of 45-inch x 29-inch HE storm sewer	37,000	100
	4. Construct 120-foot-long grass-lined channel at storm sewer outlet	1,000	100
	5. Engineering, administration, and contingencies	26,000	0
	Subtotal	$ 100,000	$ 400
W12, W13	No new stormwater management measures considered	- -	- -
W14	Eastern portion of Wingate Creek subwatershed		
	1. 381 feet of 30-inch storm sewer	$ 30,000	$ 200
	2. 440 feet of 36-inch storm sewer	43,000	100
	3. 663 feet of 42-inch storm sewer	78,000	100
	4. Deepen 232 feet of existing open channel downstream of storm sewer outlet	6,000	100
	5. Engineering, administration, and contingencies	55,000	0
	Subtotal	$ 212,000	$ 500
W14A, W14B	No new stormwater management measures considered	- -	- -
W15	Southern portion of Wingate Creek subwatershed		
	1. 537 feet of 30-inch storm sewer	$ 42,000	$ 200
	2. 1,215 feet of 36-inch storm sewer	119,000	200
	3. 890 feet of 53-inch x 34-inch HE storm sewer	123,000	200
	4. Engineering, administration, and contingencies	99,000	0
	Subtotal	$ 383,000	$ 600
W16, W17, W18, W19	No new stormwater management measures considered	- -	- -
- -	Total	$3,413,000[d]	$8,200

NOTE: The following abbreviations have been used:

CMPA	Corrugated metal pipe arch
HE	Horizontal elliptical
RCPA	Reinforced concrete pipe arch

[a] *All new and replacement storm sewers are concrete pipe.*

[b] *Costs were noted to be zero when the project proposed replacement of a component having similar operation and maintenance cost. Negative costs were noted when the replacement component was estimated to have a lower operation and maintenance cost than that of the existing facility.*

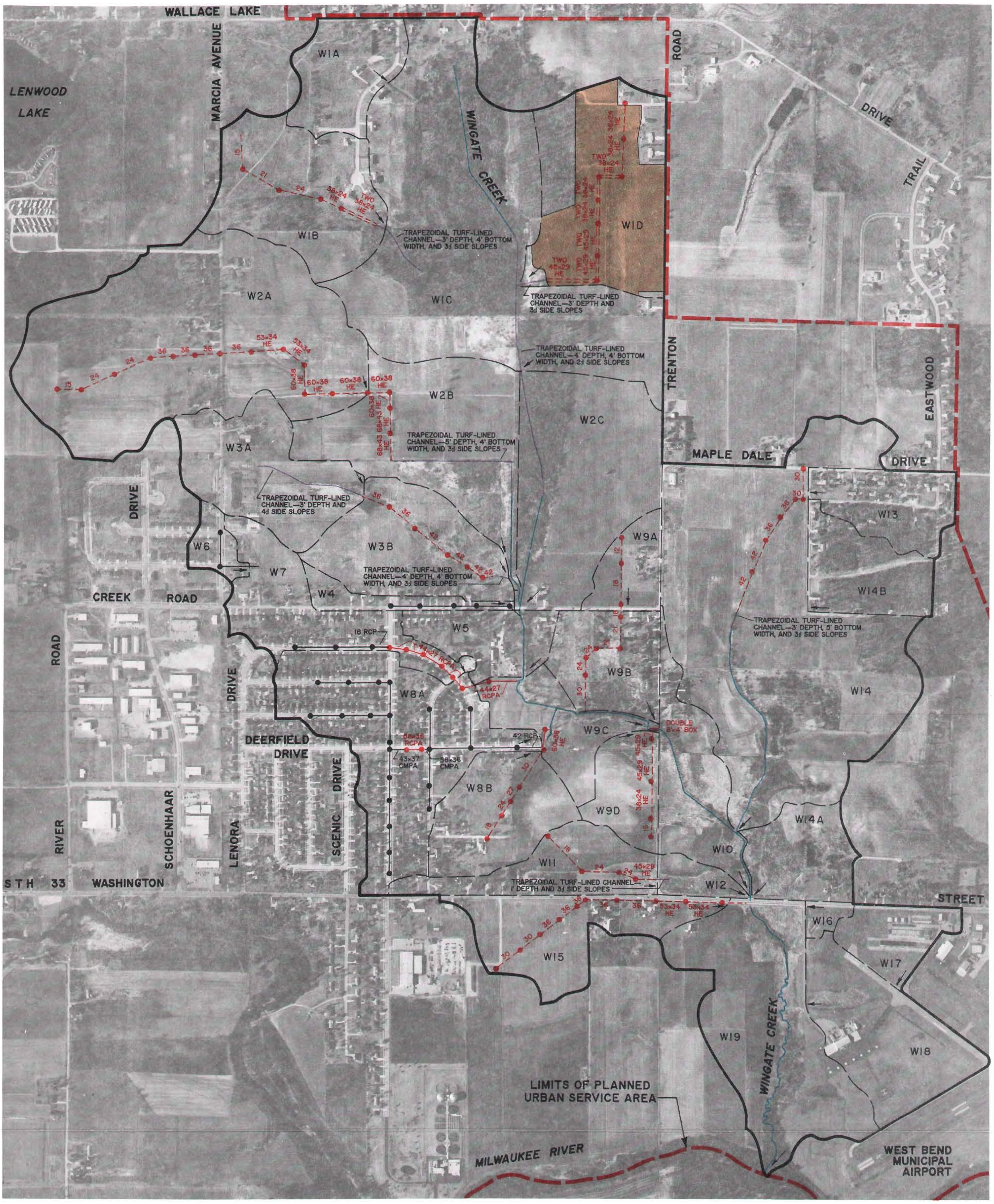
[c] *Maintenance of channel assumed to consist mainly of sediment removal required to ensure an adequate outlet for the proposed storm sewer.*

[d] *Includes $114,000 cost of providing riprap along Wingate Creek channel to protect against erosion due to increased streamflow.*

Source: SEWRPC.

Map 3

ALTERNATIVE PLAN NO 1: STORM SEWER CONVEYANCE FOR STORMWATER MANAGEMENT IN THE WINGATE CREEK SUBWATERSHED



LEGEND

▬	SUBWATERSHED BOUNDARY
— —	SUBBASIN BOUNDARY
W7	SUBBASIN IDENTIFICATION
●	EXISTING MANHOLE OR CATCH BASIN
58x36	EXISTING STORM SEWER TO BE RETAINED (SIZE IN INCHES)
—	EXISTING OPEN CHANNEL
●	PROPOSED MANHOLE
68x43	PROPOSED STORM SEWER OR CULVERT (SIZE IN INCHES)
27	PROPOSED REPLACEMENT STORM SEWER OR CULVERT (SIZE IN INCHES)
—	PROPOSED OPEN CHANNEL
▨	AREA REQUIRING AN AVERAGE OF ABOUT 2 FEET OF FILL IN ORDER TO BE DEVELOPED. THIS IS TO MINIMIZE THE REQUIRED CHANNEL DEEPENING ALONG WINGATE CREEK AT THIS LOCATION
→	SUBBASIN OUTLET
HE	HORIZONTAL ELLIPTICAL REINFORCED CONCRETE PIPE
RCPA	REINFORCED CONCRETE PIPE ARCH
CMPA	CORRUGATED METAL PIPE ARCH

NOTE: PIPES ARE CONSTRUCTED OF REINFORCED CONCRETE UNLESS DESIGNATED AS ABOVE

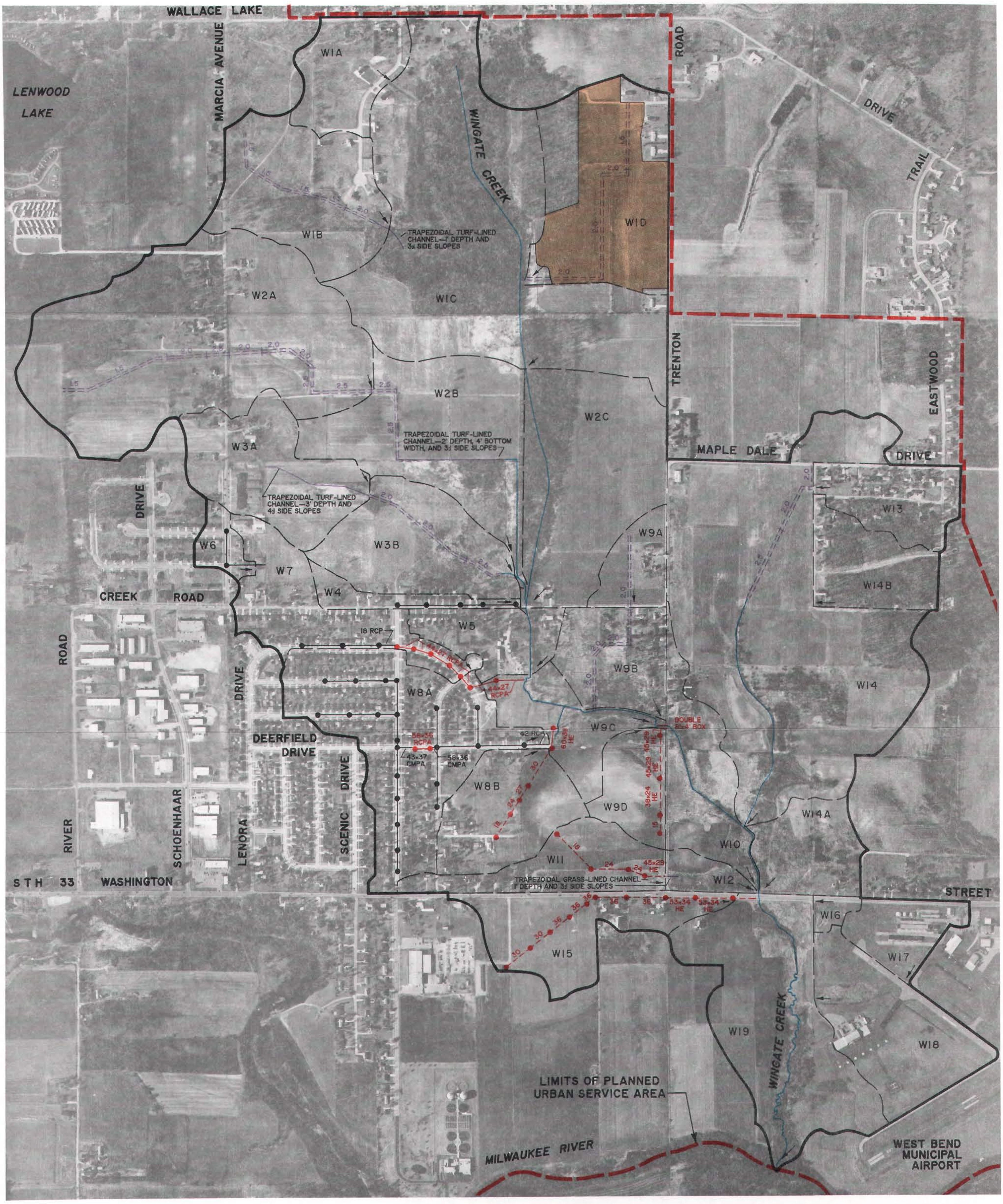
EXISTING SEWER SIZES ARE GENERALLY SHOWN ONLY FOR SEWERS WITH IDENTIFIED EXISTING OR POTENTIAL CAPACITY PROBLEMS AND FOR SEWER SEGMENTS IMMEDIATELY UPSTREAM OF SUCH PROBLEM SECTIONS

THE COST OF ALTERNATIVE PLAN ASSUMES THE PLACEMENT OF RIPRAP ALONG THE WINGATE CREEK CHANNEL TO CONTROL EROSION DUE TO THE INCREASE IN THE MAGNITUDE OF DISCHARGE UNDER FREQUENT STORM EVENTS

Source: SEWRPC.

Map 4

ALTERNATIVE PLAN NO. 2: STORM SEWER-ROADSIDE SWALE CONVEYANCE FOR STORMWATER MANAGEMENT IN THE WINGATE CREEK SUBWATERSHED



LEGEND

—	SUBWATERSHED BOUNDARY
— —	SUBBASIN BOUNDARY
W7	SUBBASIN IDENTIFICATION
●	EXISTING MANHOLE OR CATCH BASIN
58×36	EXISTING STORM SEWER TO BE RETAINED (SIZE IN INCHES)
—	EXISTING OPEN CHANNEL
●	PROPOSED MANHOLE
68×43	PROPOSED STORM SEWER OR CULVERT (SIZE IN INCHES)
27	PROPOSED REPLACEMENT STORM SEWER OR CULVERT (SIZE IN INCHES)
—	PROPOSED OPEN CHANNEL
2.5	PROPOSED ROADSIDE SWALE (DEPTH IN FEET)
🟧	AREA REQUIRING AN AVERAGE OF ABOUT 1 FOOT OF FILL IN ORDER TO BE DEVELOPED. THIS IS TO ELIMINATE THE NEED FOR CHANNEL DEEPENING ALONG WINGATE CREEK AT THIS LOCATION
→	SUBBASIN OUTLET
HE	HORIZONTAL ELLIPTICAL REINFORCED CONCRETE PIPE
RCPA	REINFORCED CONCRETE PIPE ARCH
CMPA	CORRUGATED METAL PIPE ARCH

NOTE: PIPES ARE CONSTRUCTED OF REINFORCED CONCRETE UNLESS DESIGNATED AS ABOVE

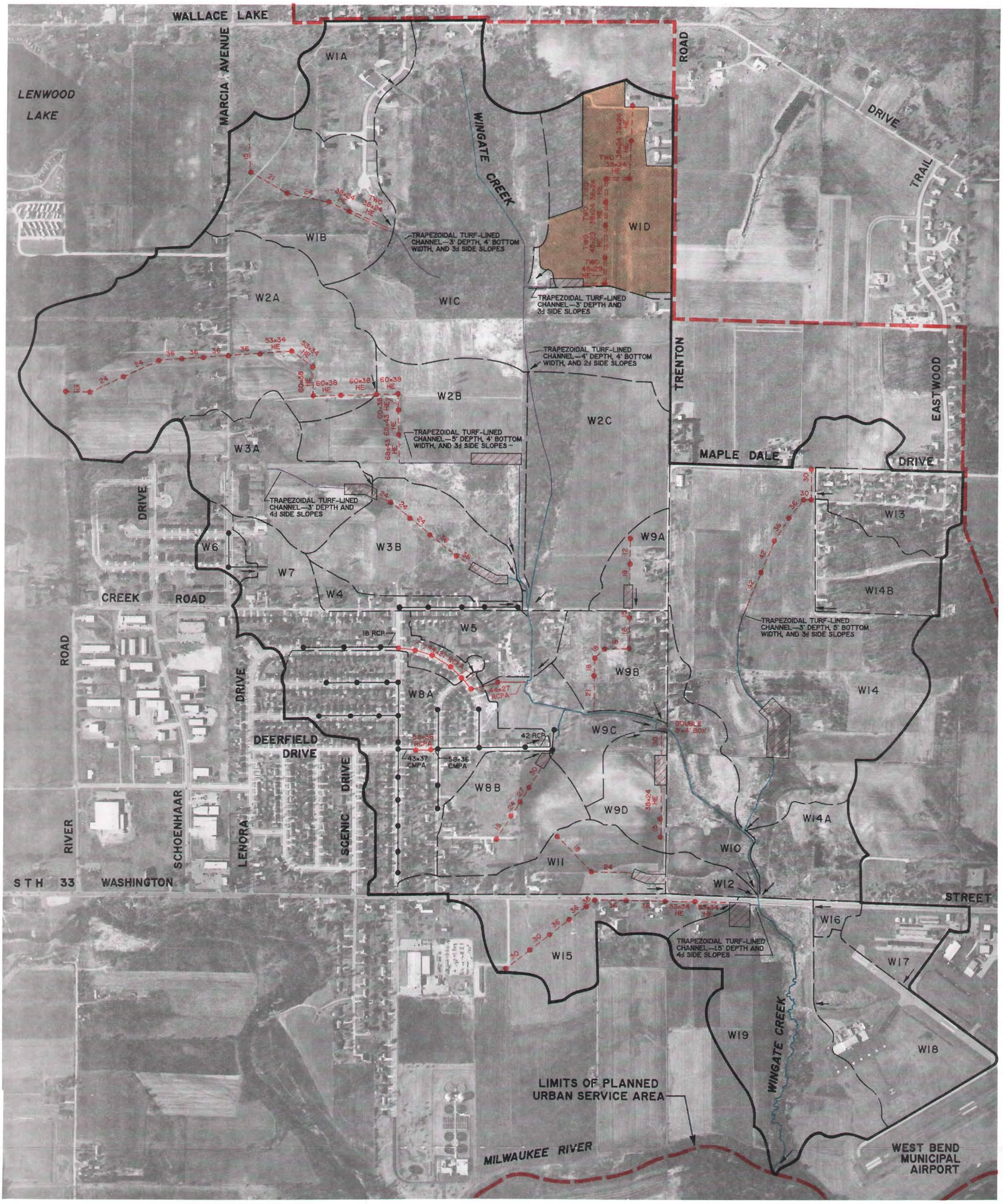
EXISTING SEWER SIZES ARE GENERALLY SHOWN ONLY FOR SEWERS WITH IDENTIFIED EXISTING OR POTENTIAL CAPACITY PROBLEMS AND FOR SEWER SEGMENTS IMMEDIATELY UPSTREAM OF SUCH PROBLEM SECTIONS

THE COST OF ALTERNATIVE PLAN ASSUMES THE PLACEMENT OF RIPRAP ALONG THE WINGATE CREEK CHANNEL TO CONTROL EROSION DUE TO THE INCREASE IN THE MAGNITUDE OF DISCHARGE UNDER FREQUENT STORM EVENTS

Source: SEWRPC.

Map 5

ALTERNATIVE PLAN NO. 3: STORM SEWER CONVEYANCE WITH CENTRALIZED DETENTION FOR STORMWATER MANAGEMENT IN THE WINGATE CREEK SUBWATERSHED



LEGEND

▬	SUBWATERSHED BOUNDARY
— —	SUBBASIN BOUNDARY
W7	SUBBASIN IDENTIFICATION
●	EXISTING MANHOLE OR CATCH BASIN
58x36	EXISTING STORM SEWER TO BE RETAINED (SIZE IN INCHES)
—	EXISTING OPEN CHANNEL
●	PROPOSED MANHOLE
68x43	PROPOSED STORM SEWER OR CULVERT (SIZE IN INCHES)
27	PROPOSED REPLACEMENT STORM SEWER OR CULVERT (SIZE IN INCHES)
—	PROPOSED OPEN CHANNEL
▨	PROPOSED DETENTION BASIN
🟧	AREA REQUIRING AN AVERAGE OF ABOUT 2 FEET OF FILL IN ORDER TO BE DEVELOPED. THIS IS TO MINIMIZE THE REQUIRED CHANNEL DEEPENING ALONG WINGATE CREEK AT THIS LOCATION
→	SUBBASIN OUTLET
HE	HORIZONTAL ELLIPTICAL REINFORCED CONCRETE PIPE
RCPA	REINFORCED CONCRETE PIPE ARCH
CMPA	CORRUGATED METAL PIPE ARCH
NOTE:	PIPES ARE CONSTRUCTED OF REINFORCED CONCRETE UNLESS DESIGNATED AS ABOVE EXISTING SEWER SIZES ARE GENERALLY SHOWN ONLY FOR SEWERS WITH IDENTIFIED EXISTING OR POTENTIAL CAPACITY PROBLEMS AND FOR SEWER SEGMENTS IMMEDIATELY UPSTREAM OF SUCH PROBLEM SECTIONS

GRAPHIC SCALE
0 200 400 800 FEET
DATE OF PHOTOGRAPHY: MARCH 1990

Source: SEWRPC.

rence interval flood stages would not be increased under planned land use and channel conditions. The alternative also includes 1,700 lineal feet of replacement storm sewer in areas of existing development, ranging from 44-inch by 27-inch reinforced concrete pipe arch to 66-inch by 38-inch horizontal elliptical pipe.

A total of about 3,630 lineal feet of new grass-lined open channels would be provided at the outlets of storm sewers. Also, about 2,525 lineal feet of the Wingate Creek channel would be deepened between river miles 1.60 and 2.08 in order to provide an adequate outlet for the proposed storm sewer in subbasin W1D. Proper measures should be taken to ensure restoration of in-stream habitat lost to this deepening. It should also be noted that, in order to place the proposed storm sewer at the highest possible elevation and thereby minimize the required channel deepening, it was assumed that all areas of new development in subbasin W1D would be filled an average of about two feet. Finally, this alternative plan includes the placement of riprap along the Wingate Creek channel in order to control erosion from the higher streamflows expected. The actual location of the riprap should be determined on a site-specific basis which would identify those areas of greatest need.

Under the storm sewer conveyance alternative plan, abatement of pollutants from nonpoint sources could be achieved through the installation of parking lot infiltration devices, along with certain public works activities. The frequency of street sweeping during spring and fall would be increased. Leaf and yard waste collection during fall would be increased. The City would continue enforcement of its construction site erosion ordinance. Public education programs would be developed to encourage good urban "housekeeping" practices and to promote the acceptance and understanding of the proposed abatement measures and the importance of water quality protection.

Alternative Plan No. 2: Storm Sewer-Roadside Swale Conveyance

The storm sewer-roadside swale conveyance alternative plan involves primarily the provision of new storm sewers, roadside swales, and engineered open channels to abate existing stormwater runoff problems and to serve planned new urban development effectively. Map 4 shows the approximate location and alignment of new storm sewers, roadside swales, and engineered open channels proposed under this alternative. Table 2 presents the salient characteristics and estimated cost of the new storm sewers, roadside swales, and channels. This alternative plan has an estimated capital cost of $1,512,000 and an estimated annual operation and maintenance cost of $12,500.

This alternative plan includes 12,790 lineal feet of roadside swales in areas of planned single-family residential development. The standard City of West Bend rural roadway cross-section, as shown in Figure 2 in Chapter III in Volume One of this report, was assumed for all roadside swales. It should be noted that, in order to place the roadside swale in subbasin W1D at the highest possible elevation and thereby eliminate the need to deepen the Wingate Creek channel, it was assumed that all areas of new development in subbasin W1D would be filled an average of about one foot.

The alternative calls for 5,500 lineal feet of new storm sewers in areas of planned development and 1,700 lineal feet of replacement storm sewers in areas of existing development. The new storm sewer ranges from 12-inch circular pipe to 53-inch by 34-inch horizontal elliptical pipe, while the replacement sewer ranges from 44-inch by 27-inch reinforced concrete pipe arch to 60-inch by 38-inch horizontal elliptical pipe. As under the first alternative, as part of the construction of the proposed new storm sewer in subbasin W9D, it was assumed that the existing sag in the Trenton Road profile south of the Wingate Creek crossing would be elevated in order to provide adequate cover. To avoid raising upstream flood stages, the Trenton Road culvert would be replaced with two eight-foot-wide by four-foot-high reinforced concrete box culverts.

Some 2,520 lineal feet of new grass-lined open channels would be provided at the outlets of storm sewers. Finally, this alternative calls for the placement of riprap along the Wingate Creek channel to control erosion from the higher streamflows expected. The location and extent of the riprap should be determined on a site-specific basis which identifies those areas of greatest need.

Under the storm sewer-roadside swale conveyance alternative plan, abatement of pollutants from nonpoint sources would be achieved through the filtering effects of the grass swales,

Table 2

COMPONENTS AND COSTS OF STORMWATER DRAINAGE ALTERNATIVE NO. 2: STORM SEWER-ROADSIDE SWALE CONVEYANCE IN THE WINGATE CREEK SUBWATERSHED

Subbasin Designation	Project and Component Description[a]	Estimated Cost	
		Capital	Annual Operation and Maintenance[b]
W1A	No new stormwater management measures considered	- -	- -
W1B	Northern portion of Wingate Creek subwatershed		
	1. 1,209 feet of 1.5-foot-deep roadside swale with driveway culverts	$ 10,000	$ 1,000
	2. 368 feet of 2.0-foot-deep roadside swale with driveway culverts	5,000	300
	3. Construct 320-foot-long grass-lined channel at swale outlet	2,000	100
	4. Engineering, administration, and contingencies	6,000	0
	Subtotal	$ 23,000	$ 1,400
W1C	No new stormwater management measures considered	- -	- -
W1D	Northern portion of Wingate Creek subwatershed		
	1. 663 feet of 1.5-foot-deep roadside swale with driveway culverts	$ 5,000	$ 600
	2. 1,900 feet of 2.0-foot-deep roadside swale with driveway culverts	27,000	1,500
	3. Engineering, administration, and contingencies	11,000	0
	Subtotal	$ 43,000	$ 2,100
W2A	Northern portion of Wingate Creek subwatershed		
	1. 890 feet of 1.5-foot-deep roadside swale with driveway culverts	$ 7,000	$ 800
	2. 1,241 feet of 2.0-foot-deep roadside swale with driveway culverts	17,000	1,000
	3. 979 feet of 2.5-foot-deep roadside swale with driveway culverts	18,000	800
	4. Engineering, administration, and contingencies	15,000	0
	Subtotal	$ 57,000	$ 2,600
W2B	Northern portion of Wingate Creek subwatershed		
	1. 803 feet of 2.5-foot-deep roadside swale with driveway culverts	$ 15,000	$ 700
	2. Construct 1,010-foot-long, grass-lined channel from swale outlet to existing drainage channel	8,000	400
	3. Engineering, administration, and contingencies	8,000	0
	Subtotal	$ 31,000	$ 1,100
W2C	No new stormwater management measures considered	- -	- -
W3A	Western portion of Wingate Creek subwatershed		
	1. 216 feet of 1.5-foot-deep drainage swale	$ 1,000	$ 100
	2. 860 feet of 2.0-foot-deep drainage swale	6,000	300
	3. Engineering, administration, and contingencies	2,000	0
	Subtotal	$ 9,000	$ 400
W3B	Western portion of Wingate Creek subwatershed		
	1. 977 feet of 2.0-foot-deep roadside swale with driveway culverts	$ 14,000	$ 800
	2. 448 feet of 2.5-foot-deep roadside swale with driveway culverts	8,000	400
	3. Engineering, administration, and contingencies	7,000	0
	Subtotal	$ 29,000	$ 1,200
W4, W5, W6	No new stormwater management measures considered	- -	- -

Table 2 (continued)

Subbasin Designation	Project and Component Description[a]	Estimated Cost	
		Capital	Annual Operation and Maintenance[b]
W7	Western portion of Wingate Creek subwatershed		
	1. Replace 643 feet of 24-inch storm sewer in Wellington Drive with 44-inch x 27-inch RCPA storm sewer	$ 99,000	$ -100
	2. Replace 665 feet of 27-inch storm sewer in Wellington Drive and Wingate Park with 44-inch x 27-inch RCPA storm sewer	102,000	-100
	3. Engineering, administration, and contingencies	71,000	0
	Subtotal	$ 272,000	$ -200
W8A	Western portion of Wingate Creek subwatershed		
	1. Replace 135 feet of 50-inch x 31-inch CMPA storm sewer in Deerfield Drive with 58-inch x 36-inch RCPA storm sewer	$ 32,000	$ 0
	2. Replace 259 feet of 42-inch storm sewer in Deerfield Drive with 60-inch x 38-inch HE storm sewer	60,000	0
	3. Engineering, administration, and contingencies	32,000	0
	Subtotal	$ 124,000	$ 0
W8B	Central portion of Wingate Creek subwatershed		
	1. 193 feet of 18-inch storm sewer	$ 9,000	$ 100
	2. 119 feet of 24-inch storm sewer	7,000	100
	3. 177 feet of 27-inch storm sewer	12,000	100
	4. 381 feet of 30-inch storm sewer	30,000	100
	5. Engineering, administration, and contingencies	20,000	0
	Subtotal	$ 78,000	$ 400
W9A	Central portion of Wingate Creek subwatershed		
	1. 695 feet of 1.5-foot-deep roadside swale with driveway culverts	$ 6,000	$ 600
	2. Engineering, administration, and contingencies	2,000	0
	Subtotal	$ 8,000	$ 600
W9B	Central portion of Wingate Creek subwatershed		
	1. 1,130 feet of 2.0-foot-deep roadside swale with driveway culverts	$ 8,000	$ 500
	2. Engineering, administration, and contingencies	3,000	0
	Subtotal	$ 11,000	$ 500
W9C	No new stormwater management measures considered	- -	- -
W9D	Central portion of Wingate Creek subwatershed		
	1. 175 feet of 15-inch storm sewer	$ 7,000	$ 100
	2. 302 feet of 38-inch x 24-inch HE storm sewer	28,000	100
	3. 546 feet of 45-inch x 29-inch HE storm sewer	60,000	100
	4. Replace existing 72-inch x 44-inch CMPA under Trenton Road at Wingate Creek with double 8-foot x 4-foot reinforced concrete box culvert	55,000	0
	5. Engineering, administration, and contingencies	52,000	0
	Subtotal	$ 202,000	$ 300
W10	No new stormwater management measures considered	- -	- -

Table 2 (continued)

Subbasin Designation	Project and Component Description[a]	Estimated Cost	
		Capital	Annual Operation and Maintenance[b]
W11	Southern portion of Wingate Creek subwatershed		
	1. 380 feet of 18-inch storm sewer	$ 17,000	$ 100
	2. 310 feet of 24-inch storm sewer	19,000	100
	3. 335 feet of 45-inch x 29-inch HE storm sewer	37,000	100
	4. Construct 120-foot-long grass-lined channel at storm sewer outlet	1,000	100
	5. Engineering, administration, and contingencies	26,000	0
	Subtotal	$ 100,000	$ 400
W12, W13	No new stormwater management measures considered	- -	- -
W14	Eastern portion of Wingate Creek subwatershed		
	1. 821 feet of 2.0-foot-deep roadside swale with driveway culverts	$ 9,000	$ 500
	2. 663 feet of 2.5-foot-deep roadside swale with driveway culverts	12,000	600
	3. Engineering, administration, and contingencies	7,000	0
	Subtotal	$ 28,000	$ 1,100
W14A, W14B	No new stormwater management measures considered	- -	- -
W15	Southern portion of Wingate Creek subwatershed		
	1. 537 feet of 30-inch storm sewer	$ 42,000	$ 200
	2. 1,215 feet of 36-inch storm sewer	119,000	200
	3. 890 feet of 53-inch x 34-inch HE storm sewer	123,000	200
	4. Engineering, administration, and contingencies	99,000	0
	Subtotal	$ 383,000	$ 600
W16, W17, W18, W19	No new stormwater management measures considered	- -	- -
- -	Total	$1,512,000[c]	$12,500

NOTE: The following abbreviations have been used:

CMPA	Corrugated metal pipe arch
HE	Horizontal elliptical
RCPA	Reinforced concrete pipe arch

[a] *All new and replacement storm sewers are concrete pipe.*

[b] *Costs were noted to be zero when the project proposed replacement of a component having similar operation and maintenance cost. Negative costs were noted when the replacement component was estimated to have a lower operation and maintenance cost than that of the existing facility.*

[c] *Includes $114,000 cost of providing riprap along Wingate Creek channel to protect against erosion due to increased streamflow.*

Source: SEWRPC.

the installation of parking lot infiltration devices, and certain public works activities. The frequency of street sweeping during spring and fall would be increased. Leaf and yard waste collection during fall would be increased. The City would continue enforcement of its construction site erosion ordinance. Public education programs would be developed to encourage good urban "housekeeping" practices and to promote the acceptance and understanding of the proposed abatement measures and the importance of water quality protection. Chiefly because of the effects of the roadside swales, the overall level of nonpoint source pollution reduction under this alternative would be greater than under Alternative Plan No. 1, storm sewer conveyance.

Alternative Plan No. 3: Storm Sewer Conveyance with Centralized Detention

The storm sewer conveyance with centralized detention alternative plan is essentially the same as the storm sewer conveyance plan with the exception that it would provide for the construction of 10 new detention basins, as shown on Map 5. Since no flooding of existing structures is expected along Wingate Creek, the proposed detention basins are provided to limit more frequent flows to existing levels and to reduce the size of selected minor system components where feasible. These basins were sized to limit the planned land use two-year recurrence interval outflow from each basin to that experienced under existing development conditions. The purpose of limiting the magnitude of the more frequent storm events is to help reduce the amount of streambank erosion and attendant sedimentation associated with these events. Table 3 presents the salient characteristics and estimated costs of the new storm sewers, channels, and detention basins comprising this plan. The estimated capital cost of this alternative is $3,599,000 and the annual operation and maintenance cost is $41,700.

The 10 new detention basins called for under this alternative would have surface areas ranging from 0.2 acres to 2.3 acres and corresponding surcharge storage volumes ranging from 0.2 acre-feet to 2.7 acre-feet under two-year recurrence interval runoff conditions.

This alternative also includes the construction of 16,300 lineal feet of new storm sewers in areas of planned development, ranging from 12-inch circular pipe to 68-inch by 43-inch horizontal elliptical pipe. As under the preceding alternatives, the existing sag in the Trenton Road profile south of the Wingate Creek crossing would be elevated and the Trenton Road culvert would be replaced with two eight-foot-wide by four-foot-high reinforced concrete box culverts in order to avoid increasing the 100-year recurrence interval flood stage. The alternative also includes 1,440 lineal feet of replacement storm sewer in areas of existing development, ranging from 44-inch by 27-inch to 58-inch by 36-inch reinforced concrete pipe arch.

A total of about 2,690 lineal feet of new grass-lined open channels would be provided at the outlets of storm sewers. Also, about 2,535 lineal feet of the Wingate Creek channel would be deepened between river miles 1.60 and 2.08 in order to provide an adequate outlet for the proposed storm sewer in subbasin W1D. Proper measures should be taken to ensure restoration of in-stream habitat lost due to this deepening. It should also be noted that, in order to place the proposed storm sewer at the highest possible elevation and thereby minimize the required channel deepening, it was assumed that all areas of new development in subbasin W1D would be filled an average of about two feet.

For purposes of comparing stormwater drainage alternatives, the new detention facilities were sized as dry basins with no permanent pool for abatement of nonpoint source pollutant loadings. The basins could be enlarged into wet basins which would be effective in removing nonpoint source pollutant loadings, primarily through sedimentation of particulate pollutants and the biological uptake of nutrients. Additional nonpoint source pollution reduction could be achieved through the control of construction site erosion, through the installation of parking lot infiltration devices, and by implementation of a public education program. Assuming the basins were expanded into wet basins, this alternative plan would achieve a greater level of abatement of nonpoint source pollutants than that achieved by either of the two purely conveyance alternative plans described above.

Alternative Plan No. 4: Storm Sewer-Roadside Swale Conveyance with Centralized Detention

Upon review of the features, benefits, and costs of the three alternative plans mentioned above, consideration was given to a fourth alternative which would incorporate both the benefits of the centralized detention basins and the lower capital cost of the roadside swales. This alterna-

Table 3

COMPONENTS AND COSTS OF STORMWATER DRAINAGE ALTERNATIVE NO. 3: STORM SEWER CONVEYANCE WITH CENTRALIZED DETENTION IN THE WINGATE CREEK SUBWATERSHED

Subbasin Designation	Project and Component Description[a]	Estimated Cost	
		Capital	Annual Operation and Maintenance[b]
W1A	No new stormwater management measures considered	- -	- -
W1B	Northern portion of Wingate Creek subwatershed		
	1. 260 feet of 15-inch storm sewer	$ 10,000	$ 100
	2. 372 feet of 21-inch storm sewer	19,000	100
	3. 402 feet of 24-inch storm sewer	25,000	200
	4. 176 feet of 38-inch x 24-inch HE storm sewer	16,000	100
	5. 368 feet of double 38-inch x 24-inch HE storm sewer	68,000	100
	6. Construct 720-foot long grass-lined channel at storm sewer outlet	11,000	300
	7. Engineering, administration, and contingencies	52,000	0
	Subtotal	$ 201,000	$ 900
W1C	No new stormwater management measures considered	- -	- -
W1D	Northern portion of Wingate Creek subwatershed		
	1. 663 feet of 38-inch x 24-inch HE storm sewer	$ 61,000	$ 200
	2. 650 feet of double 38-inch x 24-inch HE storm sewer	120,000	500
	3. 740 feet of double 45-inch x 29-inch HE storm sewer	163,000	300
	4. Deepen and reconstruct 2,535 feet of Wingate Creek channel	31,000	1,100[c]
	5. Construct 210-foot-long grass-lined channel at detention basin outlet	3,000	100
	6. Construct a 1.8-acre-foot detention basin	58,000	3,400
	7. Engineering, administration, and contingencies	153,000	0
	Subtotal	$ 589,000	$ 5,600
W2A	Northern portion of Wingate Creek subwatershed		
	1. 183 feet of 15-inch storm sewer	$ 7,000	$ 100
	2. 707 feet of 24-inch storm sewer	43,000	300
	3. 908 feet of 36-inch storm sewer	89,000	200
	4. 564 feet of 53-inch x 34-inch HE storm sewer	78,000	100
	5. 748 feet of 60-inch x 38-inch HE storm sewer	125,000	100
	6. Engineering, administration, and contingencies	120,000	0
	Subtotal	$ 462,000	$ 800
W2B	Northern portion of Wingate Creek subwatershed		
	1. 327 feet of 60-inch x 38-inch HE storm sewer	$ 54,000	$ 100
	2. 476 feet of 68-inch x 43-inch HE storm sewer	91,000	100
	3. Construct 890-foot-long, grass-lined channel from storm sewer outlet	32,000	400
	4. Construct a 4.5-acre-foot detention basin	88,000	4,700
	5. Engineering, administration, and contingencies	92,000	0
	Subtotal	$ 357,000	$ 5,300
W2C	No new stormwater management measures considered	- -	- -
W3A	Western portion of Wingate Creek subwatershed		
	1. 216 feet of 1.5-foot-deep drainage swale	$ 1,000	$ 100
	2. 540 feet of 2.0-foot-deep drainage swale	4,000	200
	3. Construct a 1.1-acre-foot detention basin	53,000	2,800
	4. Engineering, administration, and contingencies	20,000	0
	Subtotal	$ 78,000	$ 3,100
W3B	Western portion of Wingate Creek subwatershed		
	1. 630 feet of 24-inch storm sewer	$ 39,000	$ 200
	2. 494 feet of 36-inch storm sewer	48,000	100
	3. Construct a 2.5-acre-foot detention basin	67,000	3,600
	4. Engineering, administration, and contingencies	54,000	0
	Subtotal	$ 208,000	$ 3,900

Table 3 (continued)

Subbasin Designation	Project and Component Description[a]	Estimated Cost	
		Capital	Annual Operation and Maintenance[b]
W4, W5, W6	No new stormwater management measures considered	- -	- -
W7	Western portion of Wingate Creek subwatershed		
	1. Replace 643 feet of 24-inch storm sewer in Wellington Drive with 44-inch x 27-inch RCPA storm sewer	$ 99,000	$ -100
	2. Replace 665 feet of 27-inch storm sewer in Wellington Drive and Wingate Park with 44-inch x 27-inch RCPA storm sewer	102,000	-100
	3. Engineering, administration, and contingencies	71,000	0
	Subtotal	$ 272,000	$ -200
W8A	Western portion of Wingate Creek subwatershed		
	1. Replace 135 feet of 50-inch x 31-inch CMPA storm sewer in Deerfield Drive with 58-inch x 36-inch RCPA storm sewer	$ 32,000	$ 0
	2. Engineering, administration, and contingencies	10,000	0
	Subtotal	$ 42,000	$ 0
W8B	Central portion of Wingate Creek subwatershed		
	1. 193 feet of 18-inch storm sewer	$ 9,000	$ 100
	2. 119 feet of 24-inch storm sewer	7,000	100
	3. 177 feet of 27-inch storm sewer	12,000	100
	4. 231 feet of 30-inch storm sewer	18,000	100
	5. Construct a 0.9-acre-foot detention basin	49,000	2,700
	6. Engineering, administration, and contingencies	33,000	0
	Subtotal	$ 128,000	$ 3,100
W9A	Central portion of Wingate Creek subwatershed		
	1. 330 feet of 12-inch storm sewer	$ 11,000	$ 100
	2. 175 feet of 18-inch storm sewer	8,000	100
	3. Construct a 0.4-acre-foot detention basin	25,000	1,300
	4. Engineering, administration, and contingencies	16,000	0
	Subtotal	$ 60,000	$ 1,500
W9B	Central portion of Wingate Creek subwatershed		
	1. 55 feet of 15-inch storm sewer	$ 2,000	$ 100
	2. 776 feet of 18-inch storm sewer	36,000	300
	3. 309 feet of 21-inch storm sewer	16,000	100
	4. Engineering, administration, and contingencies	19,000	0
	Subtotal	$ 73,000	$ 500
W9C	No new stormwater management measures considered	- -	- -
W9D	Central portion of Wingate Creek subwatershed		
	1. 175 feet of 15-inch storm sewer	$ 7,000	$ 100
	2. 368 feet of 38-inch x 24-inch HE storm sewer	34,000	100
	3. 220 feet of 30-inch storm sewer	17,000	100
	4. Construct a 1.4-acre-foot detention basin	56,000	3,100
	5. Replace existing 72-inch x 44-inch CMPA under Trenton Road at Wingate Creek with double 8-foot x 4-foot reinforced concrete box culvert	55,000	0
	6. Engineering, administration, and contingencies	59,000	0
	Subtotal	$ 228,000	$ 3,400
W10	No new stormwater management measures considered	- -	- -

Table 3 (continued)

Subbasin Designation	Project and Component Description[a]	Estimated Cost	
		Capital	Annual Operation and Maintenance[b]
W11	Southern portion of Wingate Creek subwatershed		
	1. 380 feet of 18-inch storm sewer	$ 17,000	$ 100
	2. 325 feet of 24-inch storm sewer	20,000	100
	3. Construct a 1.4-acre-foot detention basin	58,000	3,100
	4. Engineering, administration, and contingencies	33,000	0
	Subtotal	$ 128,000	$ 3,300
W12, W13	No new stormwater management measures considered	- -	- -
W14	Eastern portion of Wingate Creek subwatershed		
	1. 381 feet of 30-inch storm sewer	$ 30,000	$ 200
	2. 440 feet of 36-inch storm sewer	43,000	100
	3. 663 feet of 42-inch storm sewer	78,000	100
	4. Deepen 232 feet of existing open channel downstream of storm sewer outlet	6,000	100
	5. Construct a 4.6-acre-foot detention basin	90,000	4,800
	6. Engineering, administration, and contingencies	86,000	0
	Subtotal	$ 333,000	$ 5,300
W14A, W14B	No new stormwater management measures considered	- -	- -
W15	Southern portion of Wingate Creek subwatershed		
	1. 537 feet of 30-inch storm sewer	$ 42,000	$ 200
	2. 1,215 feet of 36-inch storm sewer	119,000	200
	3. 560 feet of 53-inch x 34-inch HE storm sewer	78,000	100
	4. Construct a 3.9-acre-foot detention basin	86,000	4,600
	5. Construct a 100-foot-long grass-lined channel at detention basin outlet	1,000	100
	6. Engineering, administration, and contingencies	114,000	0
	Subtotal	$ 440,000	$ 5,200
W16, W17, W18, W19	No new stormwater management measures considered	- -	- -
- -	Total	$3,599,000	$41,700

NOTE: The following abbreviations have been used:

CMPA	Corrugated metal pipe arch
HE	Horizontal elliptical
RCPA	Reinforced concrete pipe arch

[a] *All new and replacement storm sewers are concrete pipe.*

[b] *Costs were noted to be zero when the project proposed replacement of a component having similar operation and maintenance cost. Negative costs were noted when the replacement component was estimated to have a lesser operation and maintenance cost than the cost of the existing facility.*

[c] *Maintenance of channel assumed to consist mainly of sediment removal required to ensure an adequate outlet for the proposed storm sewer.*

Source: SEWRPC.

tive plan represents a combination of the components of Alternative Plans No. 2 and 3, as shown on Maps 4 and 5.

Under this alternative plan, 10 new stormwater detention basins would be constructed as called for in the storm sewer conveyance plan with centralized detention. In addition, about 4,505 lineal feet of new storm sewer would be constructed and about 1,440 lineal feet of existing storm sewer would be replaced. Also, about 12,660 lineal feet of roadside swales and about 845 lineal feet of open channel would be constructed. Finally, the existing Trenton Road culvert at Wingate Creek would be replaced with a double eight-foot-wide by four-foot-high reinforced concrete box culvert.

The estimated capital cost of this alternative plan is $1,966,000. The estimated annual operation and maintenance cost would be $45,200. In addition to the detention basins, nonpoint source pollution reduction would be achieved through the control of construction site erosion, through the installation of parking lot infiltration devices, and by implementation of a public education program. Assuming the stormwater detention basins were expanded to wet basins, this alternative would achieve the greatest level of abatement of nonpoint source pollutants of the four alternative plans presented.

Evaluation of Alternative Stormwater Drainage Plans

The foregoing information provides a basis for a comparative evaluation of the four alternative stormwater drainage plans. Each alternative was designed to resolve the identified existing drainage problems and to serve anticipated future development within the subwatershed. Also, each alternative preserves primary environmental corridor lands, including associated floodlands and wetlands, in essentially natural, open uses. Thus, the principal criteria for the comparative evaluation were reduced to cost, nonpoint source pollutant removal effectiveness, impacts on flood flows and stages, and environmental impacts associated with modification of the Wingate Creek channel. For each subbasin in the subwatershed, Table 4 compares the capital costs, the annual operation and maintenance costs, and the present value of the cost of each alternative. A comparison of the ability of each alternative plan to meet the recommended stormwater management objectives and supporting standards is provided in Table 5 for those objectives and standards which differ in level of achievement between the plans. The advantages and disadvantages of each alternative are discussed below.

The storm sewer conveyance alternative plan relies on storm sewers and open channels to convey stormwater runoff to receiving surface watercourses in the Wingate Creek subwatershed. This plan has the second highest capital cost of the four alternatives considered, but also the lowest annual operation and maintenance cost. The advantages of this plan, in addition to the low operation and maintenance costs, are that the proposed system would be readily implementable and would probably be more acceptable to local officials and citizens. Importantly, few health and safety hazards or aesthetic nuisances would be created. The disadvantages of this plan are the high capital cost, the fact that downstream discharges would be highest of the four alternative plans, the need for deepening of the Wingate Creek channel to accommodate a proposed storm sewer outfall, the lowest level of nonpoint source pollution removal of the four alternative plans, and the lack of any multipurpose-use benefits.

Under the combination storm sewer-roadside swale conveyance alternative plan, storm sewers, roadside swales, and open channels would convey runoff to receiving surface waters. This plan has the lowest capital cost of the four alternatives considered, as well as the second lowest operation and maintenance cost. The advantages of this alternative, in addition to the low capital and operation and maintenance costs, are that the downstream discharges would be slightly lower, about 15 percent, than under the storm sewer conveyance alternative and a higher level of nonpoint source pollutant removal would be obtained over the storm sewer conveyance alternative. The disadvantages of this alternative plan are the fact that downstream discharges would still be higher than under the detention storage alternatives, a relatively low level of nonpoint source pollutant abatement would be achieved because of the location of roadside swales only in areas of residential development where pollutant loadings would be low, and the lack of any multipurpose-use benefits. In addition, officials of the City of West Bend have indicated that the use of roadside swales in the City would generally be unacceptable except in areas of low-

Table 4

ESTIMATED COSTS OF THE ALTERNATIVE STORMWATER DRAINAGE PLANS FOR THE WINGATE CREEK SUBWATERSHED UNDER PLAN YEAR LAND USE CONDITIONS

Subbasin Designation	Alternative No. 1 Storm Sewer Conveyance			Alternative No. 2 Storm Sewer-Roadside Swale Conveyance		
	Capital	Annual Operation and Maintenance	Present Value[a]	Capital	Annual Operation and Maintenance	Present Value[a]
W1A[b]	$ - -	$ - -	$ - -	$ - -	$ - -	$ - -
W1B	201,000	900	215,000	23,000	1,400	45,000
W1C[b]	- -	- -	- -	- -	- -	- -
W1D	656,000	2,300	692,000	43,000	2,100	76,000
W2A	462,000	800	475,000	57,000	2,600	98,000
W2B	258,000	800	271,000	31,000	1,100	48,000
W2C[b]	- -	- -	- -	- -	- -	- -
W3A	9,000	400	15,000	9,000	400	15,000
W3B	212,000	300	218,000	29,000	1,200	48,000
W4[b]	- -	- -	- -	- -	- -	- -
W5[b]	- -	- -	- -	- -	- -	- -
W6[b]	- -	- -	- -	- -	- -	- -
W7	272,000	-200	269,000	272,000	-200	269,000
W8A	124,000	0	124,000	124,000	0	124,000
W8B	78,000	400	84,000	78,000	400	84,000
W9A	37,000	200	40,000	8,000	600	17,000
W9B	93,000	500	101,000	11,000	500	19,000
W9C[b]	- -	- -	- -	- -	- -	- -
W9D	202,000	300	207,000	202,000	300	207,000
W10[b]	- -	- -	- -	- -	- -	- -
W11	100,000	400	106,000	100,000	400	106,000
W12[b]	- -	- -	- -	- -	- -	- -
W13[b]	- -	- -	- -	- -	- -	- -
W14	212,000	500	202,000	28,000	1,100	45,000
W14A[b]	- -	- -	- -	- -	- -	- -
W14B[b]	- -	- -	- -	- -	- -	- -
W15	383,000	600	392,000	383,000	600	392,000
W16[b]	- -	- -	- -	- -	- -	- -
W17[b]	- -	- -	- -	- -	- -	- -
W18[b]	- -	- -	- -	- -	- -	- -
W19[b]	- -	- -	- -	- -	- -	- -
Total	$3,413,000	$8,200	$3,544,000	$1,512,000	$12,500	$1,709,000

density residential or industrial development. Future residential development in the Wingate Creek subwatershed is envisioned to consist of medium-density development or denser.

The storm sewer conveyance with centralized detention alternative plan provides for the construction of 10 centralized detention basins, as well as storm sewers and open channels to convey stormwater runoff to the basins or receiving waters. This plan has the highest capital cost and the second highest operation and maintenance cost of the four alternative plans considered. The capital cost and total present cost of this alternative, while the highest of the alternatives evaluated, are only about 5 percent and 20 percent higher, respectively, than the storm sewer alternative. The advantages of this plan are the level of reduction of both peak rates of discharge and downstream pollutant loadings, a reduction in the required size of some conveyance components due to the detention basins, and consistency with the City's policy of providing storm sewer conveyance in urban areas. The disadvantages of this alternative include the high capital cost and

Table 4 (continued)

Subbasin Designation	Alternative No. 3 Storm Sewer Conveyance with Centralized Detention			Alternative No. 4 Storm Sewer-Roadside Swale Conveyance with Centralized Detention		
	Capital	Annual Operation and Maintenance	Present Value[a]	Capital	Annual Operation and Maintenance	Present Value[a]
W1A[b]	$ - -	$ - -	$ - -	$ - -	$ - -	$ - -
W1B	201,000	900	215,000	23,000	1,400	45,000
W1C[b]	- -	- -	- -	- -	- -	- -
W1D	589,000	5,600	677,000	112,000	5,100	192,000
W2A	462,000	800	475,000	57,000	2,600	98,000
W2B	357,000	5,300	440,000	145,000	5,600	233,000
W2C[b]	- -	- -	- -	- -	- -	- -
W3A	78,000	3,100	127,000	78,000	3,100	127,000
W3B	208,000	3,900	269,000	113,000	4,500	184,000
W4[b]	- -	- -	- -	- -	- -	- -
W5[b]	- -	- -	- -	- -	- -	- -
W6[b]	- -	- -	- -	- -	- -	269,000
W7	272,000	-200	269,000	272,000	-200	42,000
W8A	42,000	0	42,000	42,000	0	177,000
W8B	128,000	3,100	177,000	128,000	3,100	67,000
W9A	60,000	1,500	84,000	40,000	1,700	19,000
W9B	73,000	500	81,000	11,000	500	- -
W9C[b]	- -	- -	- -	- -	- -	282,000
W9D	228,000	3,400	282,000	228,000	3,400	- -
W10[b]	- -	- -	- -	- -	- -	180,000
W11	128,000	3,300	180,000	128,000	3,300	- -
W12[b]	- -	- -	- -	- -	- -	- -
W13[b]	- -	- -	- -	- -	- -	242,000
W14	333,000	5,300	417,000	149,000	5,900	- -
W14A[b]	- -	- -	- -	- -	- -	- -
W14B[b]	- -	- -	- -	- -	- -	522,000
W15	440,000	5,200	522,000	440,000	5,200	- -
W16[b]	- -	- -	- -	- -	- -	- -
W17[b]	- -	- -	- -	- -	- -	- -
W18[b]	- -	- -	- -	- -	- -	- -
W19[b]	- -	- -	- -	- -	- -	- -
Total	$3,599,000	$41,700	$4,257,000	$1,966,000	$45,200	$2,679,000

[a] *Present value computations assume a 50-year life and 6 percent annual interest.*

[b] *No new stormwater management measures considered.*

Source: SEWRPC.

operation and maintenance costs, the need to deepen the Wingate Creek channel to accommodate a proposed storm sewer outfall, and increased land area required for the proposed detention facilities.

The storm sewer-roadside swale conveyance with centralized detention alternative plan also provides for the construction of 10 detention basins, storm sewers, roadside swales, and open channels to convey stormwater runoff to the basins or receiving waters. This plan has the second lowest capital cost of the four alternative plans considered, but also the highest operation and maintenance cost. The advantages of this plan, in addition to the low capital cost, are that it would provide the highest level of reduction in both rates of discharge and downstream pollut-

Table 5

ABILITY OF THE STORMWATER MANAGEMENT ALTERNATIVE PLANS TO MEET THE RECOMMENDED STORMWATER MANAGEMENT OBJECTIVES AND SUPPORTING STANDARDS

Stormwater Management Objective[a]	Supporting Standards	Alternative No. 1 Storm Sewer Conveyance	Alternative No. 2 Storm Sewer-Roadside Swale Conveyance	Alternative No. 3 Storm Sewer Conveyance with Centralized Detention	Alternative No. 4 Storm Sewer-Roadside Swale Conveyance with Centralized Detention
The development of a stormwater management system which will abate nonpoint source water pollution and help achieve the recommended water use objectives and supporting water quality standards for suface water bodies	1. Stormwater management and flood control facilities should not impede the achievement of existing water use objectives and supporting water quality standards for lakes, streams, and wetlands, nor degrade existing habitat conditions for fish and aquatic life	Can be partially met through provision of onsite controls for nonpoint source pollutants	Can be partially met through provision of onsite controls in addition to pollutant loading reductions resulting from infiltration and filtering in swales	Can be met through provision of onsite controls in addition to detention basins, which reduce downstream peak discharges	Can be met through provision of onsite controls in addition to detention basins, which reduce downstream peak discharges and infiltration and filtering in swales
	2. Stormwater drainage and flood control facilities should be designed to minimize adverse impacts on wetlands	Can be partially met with addition of grassed flow strips, infiltration trenches, or wet detention basins	Can be partially met through provision of grassed swales and addition of grassed flow strips, infiltration trenches, or wet detention basins	Can be met through provision of detention basins controlling peak discharges from frequent storm events and addition of grassed flow strips, infiltration trenches, or wet detention basins	Can be met through detention basins controlling peak discharges from frequent storm events, grassed swales, and addition of grassed flow strips, infiltration trenches, or wet detention basins
The development of a stormwater management system which will efficiently and effectively meet all the other stated objectives at the lowest practicable cost	1. The sum of stormwater management system capital investment and operation and maintenance costs should be minimized	Not met; this alternative has the second highest total present value	Met; this alternative has the lowest total present value	Not met; this alternative has the highest total present value	Not met; this alternative has the second lowest total present value
	2. To the maximum extent practicable, the location and alignment of new storm sewers and engineered channels and storage facilities should coincide with existing public rights-of-way to minimize land acquisition or easement costs	Can be met	Can be met	Partially met; the proposed detention basins would be located on property which is currently privately owned	Partially met; the proposed detention basins would be located on property which is currently privately owned
	3. Stormwater storage facilities, consisting of retention facilities and of both centralized and onsite detention facilities, should, where hydraulically feasible and economically sound, be considered as a means of reducing the size and resultant costs of the requird stormwater conveyance facilities immediately downstream of these storage sites	Not met; by design, stormwater storage facilities were not included in this alternative	Not met; by design, stormwater storage facilities were not included in this alternative	Met	Partially met; provision of detention basin with smaller downstream conveyance facility is not economically sound compared to provision of larger conveyance facility alone

[a] *The stormwater management objectives and supporting standards are set forth in Table 14 of Volume One of this report. This table compares only those objectives and supporting standards which differed in the degree to which they are met by the alternatives.*

Source: SEWRPC.

ant loadings of the four alternatives and a reduction in the size of some conveyance components. In addition to the high operation and maintenance cost, the disadvantages of this alternative are the increased land area required for the proposed detention facilities and the fact that City officials have expressed a desire for storm sewer conveyance in all urban areas except those with low-density residential or industrial development.

PLAN RECOMMENDATIONS

Recommended Stormwater Drainage Plan Element

On the basis of a comparative evaluation of the alternative plans considered, a combination of the storm sewer conveyance with centralized detention alternative plan and the roadside swale alternative plan is recommended for adoption in the Wingate Creek subwatershed. This recommended plan has a lower capital cost than either the storm sewer conveyance or the storm sewer with centralized detention alternative. The present worth cost of the recommended plan is also less than that of the storm sewer conveyance with centralized detention alternative and the storm sewer conveyance alternative. The recommended plan also eliminates the need to lower the channel of Wingate Creek. This plan provides a high level of reduction in nonpoint source pollution and in the magnitude of discharge from more frequent storm events while remaining consistent with the City's policy concerning the provision of storm sewers in urban areas. The minor and major system components of this recommended plan are set forth in Table 6. The recommended stormwater drainage plan is summarized in graphic form on Map 6.

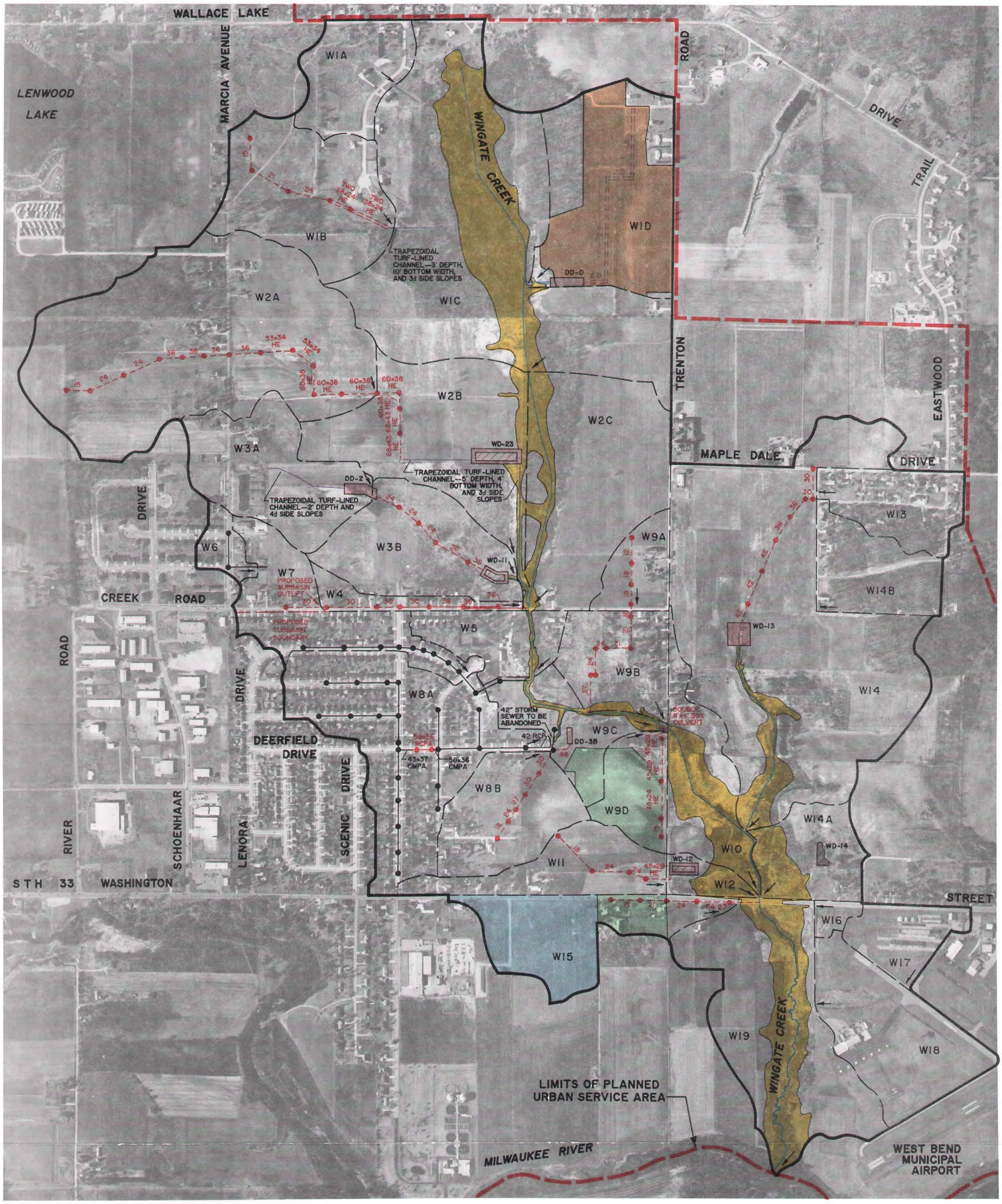
The recommended plan components presented in Table 6 and shown on Map 6 reflect certain refinements and revisions to the original alternative plans set forth in the previous section of this chapter. These refinements are based upon further review and analysis of the initially selected alternative following review of the alternatives by City staff during a May 29, 1992, interagency staff meeting attended by members of the Commission and City staffs. The refinements and revisions include the relocation of three detention basins, the elimination of three detention basins, the westward extension of an existing storm sewer in Creek Road, and the relocation of one open channel and one storm sewer.

Proposed detention basin DD3B was relocated from the south side of Deerfield Drive, on land proposed for residential development, to the north side of Deerfield Drive, on land proposed to remain in open-space use. For similar reasons, detention basin WD12 was relocated from the west side of Trenton Road, on land proposed for commercial development, to the east side of Trenton Road, on land proposed to remain in open-space use. Detention basin WD13 was originally sited in a wetland. As a result of further analyses described in Appendix A of this volume, that basin has been relocated about 1,200 feet further north, outside the wetland and primary environmental corridor. The size of that basin has also been reduced from 4.6 acre-feet to 2.8 acre-feet. Detention basins DD4 and DD4A have been eliminated because it was found that these basins did not contribute significantly to a reduction in flows along Wingate Creek nor serve to significantly reduce the size of downstream stormwater conveyance facilities. Detention basin DD7A was also eliminated, on the basis of comments made by City staff at the May 29, 1992, meeting. At that meeting, City staff indicated that future development within subbasin W15 would probably result in regrading much of the land so that it would drain south, directly to the Milwaukee River, rather than north and east towards Wingate Creek, as it currently does. If this regrading were to occur, subbasin W15 would be reduced in area by about 21 acres, or about 72 percent. Since basin DD7A would serve a much smaller area than previously envisioned and would accordingly have a much smaller impact on reducing Wingate Creek flows, it was eliminated from the final recommended plan.

City staff indicated that the existing storm sewer in Creek Road would be extended westward. That storm sewer extension would result in the interception and redirection of stormwater runoff from subbasin W6 and that portion of subbasin W7 north of Creek Road. That runoff currently crosses Creek Road to the south, where it eventually enters an existing storm sewer in subbasin W7. Because of the additional drainage area and attendant runoff, the existing Creek Road storm sewer will need to be replaced. However, because of the reduction in tributary area, none of the existing storm sewer components in subbasin W7 would need to be replaced. As originally designed, the open channel which is intended to provide an outlet for the proposed storm sewers in subbasin W1B would extend through a wetland. In order to avoid potential adverse impacts on that wetland, the channel has been relocated to the north, outside the wetland. Also, the storm sewers proposed for subbasin W9B would extend partially through a wetland. In order to avoid any potential adverse impacts, a segment of storm sewer about 600 feet in length was relocated westward to avoid that encroachment.

Map 6

RECOMMENDED SYSTEM PLAN FOR STORMWATER MANAGEMENT FOR THE WINGATE CREEK SUBWATERSHED



LEGEND

▬	SUBWATERSHED BOUNDARY
— —	SUBBASIN BOUNDARY
W7	SUBBASIN IDENTIFICATION
→	SUBBASIN OUTLET
●	EXISTING MANHOLE OR CATCH BASIN
58x36	EXISTING STORM SEWER TO BE RETAINED (SIZE IN INCHES)
—	EXISTING OPEN CHANNEL
●	PROPOSED MANHOLE
68x43	PROPOSED STORM SEWER OR CULVERT (SIZE IN INCHES)
30	PROPOSED REPLACEMENT STORM SEWER DESIGNED FOR 10-YEAR STORM (SIZE IN INCHES)
36	PROPOSED REPLACEMENT STORM SEWER DESIGNED FOR 100-YEAR STORM (SIZE IN INCHES)
—	PROPOSED OPEN CHANNEL
2.5	PROPOSED ROADSIDE SWALE (DEPTH IN FEET)
WD-11 ▨	PERMANENT POND AREA OF PROPOSED WET DETENTION BASIN AND DESIGNATION
WD-12 ▨	PROPOSED DUAL-PURPOSE DETENTION BASIN AND DESIGNATION
DD-2 🟥	PROPOSED DRY DETENTION BASIN AND DESIGNATION
🟧	AREA REQUIRING AN AVERAGE OF 1 FOOT OF FILL IN ORDER TO BE DEVELOPED. THIS IS TO ELIMINATE THE NEED FOR CHANNEL DEEPENING ALONG WINGATE CREEK AT THIS LOCATION
🟦	AREA ASSUMED TO BE REGRADED TO DRAIN SOUTH TO HYDROLOGIC UNIT MR-BE
🟨	100-YEAR RECURRENCE INTERVAL FLOOD INUNDATION AREA UNDER PLANNED LAND USE AND PLANNED DRAINAGE CONDITIONS
🟩	AREA TRIBUTARY TO STREET TO BE SWEPT 11 TIMES IN SPRING AND 11 TIMES IN FALL
HE	HORIZONTAL ELLIPTICAL REINFORCED CONCRETE PIPE
RCPA	REINFORCED CONCRETE PIPE ARCH
CMPA	CORRUGATED METAL PIPE ARCH

NOTE: PIPES ARE CONSTRUCTED OF REINFORCED CONCRETE UNLESS DESIGNATED AS ABOVE

EXISTING STORM SEWERS ARE GENERALLY SHOWN ONLY FOR SEWERS WITH IDENTIFIED EXISTING OR POTENTIAL CAPACITY PROBLEMS AND FOR SEWER SEGMENTS IMMEDIATELY UPSTREAM OF SUCH PROBLEM SECTIONS

GRAPHIC SCALE
0 200 400 800 FEET
DATE OF PHOTOGRAPHY: MARCH 1990

Source: SEWRPC.

Table 6

COMPOSITION AND COST OF THE MINOR AND MAJOR COMPONENTS OF THE RECOMMENDED STORMWATER DRAINAGE PLAN FOR THE WINGATE CREEK SUBWATERSHED

Subbasin Designation	Project and Component Description[a]	Estimated Cost	
		Capital	Annual Operation and Maintenance[b]
W1A	No new stormwater management measures recommended	- -	- -
W1B	Northern portion of Wingate Creek subwatershed		
	1. 260 feet of 15-inch storm sewer	$ 10,000	$ 100
	2. 372 feet of 21-inch storm sewer	19,000	100
	3. 402 feet of 24-inch storm sewer	25,000	200
	4. 544 feet of double 38-inch x 24-inch HE storm sewer	100,000	400
	5. Construct 465-foot-long grass-lined channel at stormsewer outlet	9,000	200
	6. Engineering, administration and contingencies	57,000	0
	Subtotal	$ 220,000	$ 1,000
W1C	No new stormwater management measures recommended	- -	- -
W1D	Northern portion of Wingate Creek subwatershed		
	1. 663 feet of 1.5-foot-deep roadside swale with driveway culverts	$ 5,000	$ 600
	2. 1,390 feet of 2.0-foot-deep roadside swale with driveway culverts	20,000	1,100
	3. Construct a 1.3 acre-foot detention basin	50,000	2,700
	4. Engineering, administration, and contingencies	26,000	0
	Subtotal	$ 101,000	$ 4,400
W2A	Northern portion of Wingate Creek subwatershed		
	1. 183 feet of 15-inch storm sewer	$ 7,000	$ 100
	2. 707 feet of 24-inch storm sewer	43,000	300
	3. 908 feet of 36-inch storm sewer	89,000	200
	4. 564 feet of 53-inch x 34-inch HE storm sewer	78,000	100
	5. 748 feet of 60-inch x 38-inch HE storm sewer	125,000	100
	6. Engineering, administration, and contingencies	120,000	0
	Subtotal	$ 462,000	$ 800
W2B	Northern portion of Wingate Creek subwatershed		
	1. 327 feet of 60-inch x 38-inch HE storm sewer	$ 54,000	$ 100
	2. 476 feet of 68-inch x 43-inch HE storm sewer	91,000	100
	3. Construct 880-foot-long grass-lined channel from storm sewer outlet	32,000	400
	4. Construct a 4.5 acre-foot detention basin	57,000[c]	800[c]
	5. Engineering, administration, and contingencies	82,000	0
	Subtotal	$ 316,000	$ 1,400
W2C	No new stormwater management measures recommended	- -	- -
W3A	Western portion of Wingate Creek subwatershed		
	1. 216 feet of 1.5-foot-deep drainage swale	$ 1,000	$ 100
	2. 540 feet of 2.0-foot-deep drainage swale	4,000	200
	3. Construct a 1.1 acre-foot detention basin	53,000	2,800
	4. Engineering, administration, and contingencies	20,000	0
	Subtotal	$ 78,000	$ 3,100
W3B	Western portion of Wingate Creek subwatershed		
	1. 630 feet of 24-inch storm sewer	$ 39,000	$ 200
	2. 494 feet of 36-inch storm sewer	48,000	100
	3. Construct a 2.5 acre-foot detention basin	27,000[c]	600[c]
	4. Engineering, administration, and contingencies	40,000	0
	Subtotal	$ 154,000	$ 900

Table 6 (continued)

Subbasin Designation	Project and Component Description[a]	Estimated Cost	
		Capital	Annual Operation and Maintenance[b]
W4	Western portion of Wingate Creek subwatershed		
	1. 727 feet of 30-inch storm sewer in Creek Road	$ 57,000	$ 300
	2. Replace 265 feet of 21-inch storm sewer in Creek Road with 30-inch storm sewer	29,000	0
	3. Replace 928 feet of 27-inch storm sewer in Creek Road with 36-inch storm sewer	133,000	-200
	4. Engineering, administration, and contingencies	77,000	0
	Subtotal	$ 296,000	$ 100
W5, W6	No new stormwater management measures recommended	- -	- -
W7	Western portion of Wingate Creek subwatershed		
	1. 325 feet of 30-inch storm sewer in Creek Road	$ 25,000	$ 100
	2. Engineering, administration, and contingencies	9,000	0
	Subtotal	$ 34,000	$ 100
W8A	Western portion of Wingate Creek subwatershed		
	1. Replace 135 feet of 50-inch x 31-inch CMPA storm sewer in Deerfield Drive with 58-inch x 36-inch RCPA storm sewer	$ 32,000	$ 0
	2. Engineering, administration, and contingencies	10,000	0
	Subtotal	$ 42,000	$ 0
W8B	Central portion of Wingate Creek subwatershed		
	1. 193 feet of 18-inch storm sewer	$ 9,000	$ 100
	2. 119 feet of 24-inch storm sewer	7,000	50
	3. 177 feet of 27-inch storm sewer	12,000	100
	4. 390 feet of 30-inch storm sewer	31,000	100
	5. 200 feet of 48-inch storm sewer	28,000	50
	6. Construct a 0.8 acre-foot detention basin	49,000	2,700
	7. Engineering, administration, and contingencies	47,000	0
	Subtotal	$ 183,000	$ 3,100
W9A	Central portion of Wingate Creek subwatershed		
	1. 330 feet of 12-inch storm sewer	$ 11,000	$ 100
	2. 365 feet of 18-inch storm sewer	17,000	200
	3. Engineering, administration, and contingencies	9,000	0
	Subtotal	$ 37,000	$ 300
W9B	Central portion of Wingate Creek subwatershed		
	1. 45 feet of 18-inch storm sewer	$ 2,000	$ 100
	2. 560 feet of 21-inch storm sewer	29,000	200
	3. 440 feet of 24-inch storm sewer	27,000	100
	4. 320 feet of 27-inch storm sewer	22,000	100
	5. Engineering, administration, and contingencies	28,000	0
	Subtotal	$ 108,000	$ 500
W9C	No new stormwater management measures recommended	- -	- -
W9D	Central portion of Wingate Creek subwatershed		
	1. 175 feet of 15-inch storm sewer	$ 7,000	$ 100
	2. 302 feet of 38-inch x 24-inch HE storm sewer	28,000	100
	3. 546 feet of 45-inch x 29-inch HE storm sewer	60,000	100
	4. Replace existing 72-inch x 44-inch CMPA under Trenton Road at Wingate Creek with double 8-foot x 4-foot reinforced concrete box culvert	55,000	0
	5. Engineering, administration, and contingencies	52,000	0
	Subtotal	$ 202,000	$ 300

Table 6 (continued)

Subbasin Designation	Project and Component Description[a]	Estimated Cost	
		Capital	Annual Operation and Maintenance[b]
W10	No new stormwater management measures recommended	- -	- -
W11	Southern portion of Wingate Creek subwatershed		
	1. 380 feet of 18-inch storm sewer	$ 17,000	$ 100
	2. 310 feet of 24-inch storm sewer	19,000	100
	3. 335 feet of 45-inch x 29-inch HE storm sewer	37,000	100
	4. Engineering, administration, and contingencies	26,000	0
	Subtotal	$ 99,000	$ 300
W12	Southern portion of Wingate Creek subwatershed		
	1. Construct a 1.5 acre-foot detention basin	$ 14,000[c]	$ 300[c]
	2. Engineering, administration, and contingencies	5,000	0
	Subtotal	$ 19,000	$ 300
W13	No new stormwater management measures recommended	- -	- -
W14	Eastern portion of Wingate Creek subwatershed		
	1. 381 feet of 30-inch storm sewer	$ 30,000	$ 100
	2. 440 feet of 36-inch storm sewer	43,000	100
	3. 840 feet of 42-inch storm sewer	98,000	200
	4. Construct a 2.8 acre-foot detention basin	69,000	3,800
	5. Engineering, administration, and contingencies	84,000	0
	Subtotal	$ 324,000	$ 4,200
W14A, W14B	No new stormwater management measures recommended	- -	- -
W15	Southern portion of Wingate Creek subwatershed		
	1. 515 feet of 21-inch storm sewer	$ 27,000	$ 200
	2. 510 feet of 24-inch storm sewer	31,000	200
	3. 340 feet of 27-inch storm sewer	23,000	100
	4. Engineering, administration, and contingencies	29,000	0
	Subtotal	$ 110,000	$ 500
W16, W17, W18, W19	No new stormwater management measures recommended	- -	- -
- -	Total	$2,785,000	$21,300

NOTE: The following abbreviations have been used:

CMPA	Corrugated metal pipe arch
HE	Horizontal elliptical
RCPA	Reinforced concrete pipe arch

[a] *All new and replacement storm sewers are concrete pipe.*

[b] *Costs were noted to be zero when the project proposed replacement of a component having similar operation and maintenance costs. Negative costs were noted when the replacement component was estimated to have a lesser operation and maintenance cost than the cost of the existing facility.*

[c] *This basin is recommended to have a permanent pool for water quality purposes as set forth in Chapter IV of this volume. The costs shown in this table represent only the incremental cost of providing the additional storage required for flow attenuation under the stormwater drainage element of the plan. Costs for construction of the wet basin portion have been assigned to the water quality element of the plan.*

Source: SEWRPC.

Finally, the recommended plan calls for the provision of roadside swales in place of storm sewers for stormwater conveyance in subbasin W1D. Utilization of roadside swales, as opposed to storm sewers, would be less costly and would eliminate the need to deepen about 2,500 feet of the Wingate Creek channel, a deepening required to provide an adequate outlet for the storm sewers. The subject reach of Wingate Creek is located in a wetland complex. The required channel deepening of up to 3.5 feet could have a significant adverse impact on this wetland and disturb the existing in-stream habitat. Because of the potential adverse environmental impacts, implementation of the storm sewer alternative for subbasin W1D is considered unlikely. It is felt that these concerns are substantial enough to justify the use of roadside swales at this location, even though proposed development is envisioned to be at a higher density than that for which the City normally allows the use of such swales. In order to maintain consistency in the City policy regarding the use of roadside swales, it may be necessary for the City Plan Commission to rezone this area to provide for low- or suburban-density development.

The minor stormwater management system includes conveyance and centralized detention system components. The conveyance components have been designed to convey flows for storm events up to and including the 10-year recurrence interval storm, while the centralized detention components have been sized to limit outflows from a two-year recurrence interval storm to existing development conditions and, where feasible, to provide some reduction in the size of downstream components of the minor drainage system. The conveyance components include roadside swales, storm sewers and related inlets, manholes, outfalls, and open channels. The centralized detention components include surface detention basins and ponds with associated facility inlets and outlets.

The major stormwater management system includes conveyance components that have been designed to accommodate flows from a 100-year recurrence interval storm. Conveyance components include street cross-sections, major open channel drainageways, and receiving watercourses. The major stormwater management system consists of those minor stormwater management system components necessary to meet drainage requirements, together with certain components recommended to offset adverse impacts of the recommended minor system facilities on downstream flood flows. The major system of the recommended stormwater drainage plan element utilizes the existing natural floodwater storage along Wingate Creek to the maximum extent practicable.

The recommended stormwater drainage plan element envisions that the full street cross-section will be utilized to convey flows in excess of those generated by a 10-year recurrence interval storm event and up to the flows generated by a 100-year recurrence interval storm event. As already noted, in areas with existing urban street patterns, or in areas where street patterns are available, the capacity of the streets to convey the stormwater was calculated and evaluated. In other areas it was assumed that street patterns and grades would be developed to be compatible with stormwater drainage needs. Recommended typical street cross-sections for arterial, collector, and minor land access streets are provided in Chapter III of Volume One of this report.

About 26 percent of the Wingate Creek subwatershed was in urban land uses in 1985, the remainder was in open, agricultural, woodland, and wetland uses. The plan design was based upon the City of West Bend land use plan[2] which provided for about 78 percent of the subwatershed to be in urban uses. Storm sewer capacity problems identified within the subwatershed are indicated by replacement sewers on Map 6. No damages to existing structures were identified due to flooding during a 100-year recurrence interval event along Wingate Creek under either existing or planned development conditions.

To accommodate anticipated runoff conditions within the entire subwatershed, the recommended plan proposes the construction of 15,900 lineal feet of new storm sewers ranging in size from 12-inch-diameter circular pipe to 68-inch by 43-inch horizontal elliptical pipe, the construction of 1,330 lineal feet of replacement storm sewers ranging in size from 30-inch-diameter

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[2] *SEWRPC Community Assistance Planning Report No. 167, A Land Use Plan for the City of West Bend: 2010, July 1992*

Table 7

HYDROLOGIC AND HYDRAULIC CHARACTERISTICS OF RECOMMENDED DETENTION BASINS IN THE WINGATE CREEK SUBWATERSHED

Basin Designation	Permanent Pond Area (acres)	Permanent Pond Volume (acre-feet)	Incremental Pond Volume for Control of a Two-Year Storm[a] (acre-feet)	Total Pond Volume for Control of a Two-Year Storm (acre-feet)	Peak Outflow from Detention Basin During a Two-Year Storm (cfs)	Incremental Pond Volume During a 100-Year Storm[a,b] (acre-feet)	Total Pond Volume During a 100-Year Storm (acre-feet)	Peak Outflow from Detention Basin During a 100-Year Storm (cfs)
WD11	0.6	2.9	1.2	4.1	1	2.5	5.4	44
WD12	0.3	1.3	0.9	2.2	1	1.5	2.8	27
WD13	- -[c]	- -[c]	1.8	1.8	6	2.8	2.8	93
WD23	1.1	5.6	3.2	8.8	5	4.5	10.1	96
DD0	- -	- -	0.9	0.9	1	1.3	1.3	23
DD2	- -	- -	0.6	0.6	1	1.1	1.1	20
DD3B	- -	- -	0.6	0.6	40	0.8	0.8	175

[a] *Incremental volume above the permanent pond volume.*

[b] *Although not required for control of a 100-year storm, some flow reduction benefits would be realized through basin construction. Also, basins have been sized to ensure that adjacent lands which are proposed for development are not flooded during a 100-year storm event.*

[c] *Permanent pond eliminated under final recommended plan.*

Source: SEWRPC.

circular pipe to 58-inch by 36-inch reinforced concrete pipe arch, the construction of 2,100 feet of turf-lined channel at storm sewer outfalls, and the construction of about 2,050 feet of roadside swales. The plan assumes that new urban development in subbasin W1D would be placed on an average of about one foot of fill in order to provide an adequate outlet for the proposed roadside swales. As already noted, the plan also envisions that about 21 acres from subbasin W15 will eventually be regraded so as to drain directly to the Milwaukee River, as shown on Map 6. In addition, the recommended plan proposes the construction of seven detention basins with attendant inlet and outlet structures. These basins would range in area from 0.2 acre to 1.3 acres. Hydraulic and hydrologic characteristics of the recommended detention basins are given in Table 7. The plan also recommends the replacement of the existing Trenton Road culvert over Wingate Creek with a double eight-foot-wide by four-foot-high box culvert and the removal of the existing roadway sag extending about 550 feet south of this crossing. The removal of this sag is required to accommodate a proposed storm sewer in Trenton Road. The location, configuration, and horizontal and vertical alignment of the street system required to support future urban development should be carefully laid out to provide the necessary major drainage system conveyance capacity.

The evaluation of nonpoint source pollution abatement measures for the entire Milwaukee River study area, which is presented in Chapter IV of this volume, indicated a need to utilize three of these recommended stormwater detention basins for dual purposes, with a permanent pool for the abatement of nonpoint source pollution in addition to the surcharge storage volume recommended under the drainage element. These three basins are indicated on Map 6.

Stormwater Drainage System Costs

The capital cost of the recommended stormwater drainage system plan is estimated to be $2,785,000. The annual operation and maintenance cost increase of the recommended plan is estimated to be $21,300. The total present worth of the recommended plan is estimated to be $3,121,000, assuming a 50-year project life and an annual interest rate of 6 percent. These costs are all expressed in 1991 dollars.

The recommended plan costs are based upon planned development of the Wingate Creek subwatershed and includes neither the cost of minimum-diameter collector sewers, roadside swale collectors, and road culverts that may be required to drain collector and land access roadways, the alignment of which has not yet been determined, nor the cost of roadway sections in newly developing areas that have been designated to function as a component of the major drainage system. The cost of minimum size collectors in 1991 dollars would be approximately $7,000 per acre of area served.

The costs presented above reflect only the stormwater drainage plan element and do not include costs for nonpoint source pollutant abatement measures. Costs for the entire stormwater management system plan, including those for nonpoint source pollution abatement measures, are presented in Chapter VII of this volume, which deals with implementation of the plan.

Integration of Stormwater Drainage and Water Quality Management Plan Elements

The recommended water quality management plan element for control of nonpoint source pollution in the entire Milwaukee River study area is described separately in Chapter IV of this volume. That chapter sets forth the components and costs of alternative plans, evaluates the alternatives on the basis of how well they meet the objectives and supporting standards presented in Volume One of this report, and selects a recommended plan. The water quality control facilities and measures recommended for the Wingate Creek subwatershed were integrated into the recommended stormwater drainage plan element, following their quantitative analysis in the overall framework of the Milwaukee River study area. The recommended stormwater management plan as presented on Map 6 includes both the drainage facilities described in this chapter and the water quality facilities described in Chapter IV.

Chapter III

ALTERNATIVES AND RECOMMENDED PLAN FOR THE MILWAUKEE RIVER DRAINAGE AREA OUTSIDE THE WINGATE CREEK SUBWATERSHED

INTRODUCTION

This chapter presents the findings and recommendations of the stormwater management planning program for the City of West Bend as it relates to areas of the Milwaukee River drainage area outside the Wingate Creek subwatershed. This chapter is divided into 57 sections, one for each hydrologic unit to be studied.[1] Each section includes, as applicable: 1) an evaluation of the stormwater management system serving the hydrologic unit, 2) a description and evaluation of alternative stormwater management plans to serve the hydrologic unit through the design year 2010, and 3) a recommended stormwater management system plan for the hydrologic unit.

The general stormwater drainage alternatives which were considered for hydrologic units in the Milwaukee River study area are: 1) storm sewer conveyance, 2) storm sewer conveyance with centralized detention, 3) storm sewer and open channel conveyance, 4) storm sewer and open channel conveyance with centralized detention, 5) storm sewer conveyance with decentralized detention, 6) open channel conveyance, and 7) open channel conveyance with centralized detention. Consistent with City development policies and standards, roadside swale and open channel drainage facilities were generally utilized only in areas of industrial parks and low-density residential development or in areas where drainage is provided by an existing stream system which can be utilized to provide conveyance and storage of stormwater runoff.

INTEGRATION OF STORMWATER DRAINAGE AND WATER QUALITY MANAGEMENT PLAN ELEMENTS

The recommended water quality management plan element for control of nonpoint source pollution in the entire Milwaukee River study area is described separately in Chapter IV of this volume. That chapter sets forth the components and costs of the recommended water quality management plan and evaluates the recommended plan on the basis of how well it meets the objectives and supporting standards presented in Volume One of this report. The water quality management facilities and measures recommended for each hydrologic unit were initially quantitatively analyzed for both the Wingate Creek study area and the Milwaukee River study area to meet the pollution reduction goals set forth in Chapter IV of this volume. These facilities and measures were then integrated with the recommended stormwater drainage plan element as described in this chapter for the Milwaukee River watershed study area and in Chapter II for the Wingate Creek study area.

Certain components of the water quality management plan element, such as wet detention basins, are directly interrelated with conveyance and detention facilities considered for stormwater drainage purposes. Other water quality components such as street sweeping and infiltration of runoff from frequent storms may be expected to have a minimal impact on the size and location of stormwater drainage facilities. The detention basins which were recommended in Chapter IV of this volume for the control of nonpoint source pollution were evaluated to assess their function as dual-purpose facilities in the management of nonpoint sources of pollution as well as in the management of the quantity of stormwater runoff. Those basins were incorporated as dual-purpose facilities in the recommended plan where such incorporation was found to be applicable and cost effective when compared to other alternatives. The recommended stormwater management plan as presented on Map 14 includes both the drainage facilities described in this chapter and the water quality management facilities described in Chapter IV of this volume.

STORMWATER DRAINAGE SYSTEM COSTS

The recommended plan costs presented in the following sections of this chapter are based upon planned development of each hydrologic unit.

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[1] *A hydrologic unit is a grouping of subbasins directly tributary to the Milwaukee River.*

The costs do not include minimum-diameter collector sewers, roadside swale collectors, and road culverts that may be required to drain collector and land access roadways in areas of future development. The cost of minimum-size collectors would be approximately $7,000 per acre of area served.

The base unit cost data used to develop the cost estimates for the alternative and recommended plans are presented in Chapter IV and in Appendix A of Volume One of this report.

EVALUATION OF ALTERNATIVE STORMWATER MANAGEMENT PLANS AND SELECTION OF THE RECOMMENDED PLAN FOR EACH HYDROLOGIC UNIT

The following sections of this report describe the components of the alternative and recommended plans for each hydrologic unit. Table 8 sets forth a comparison of the total capital, annual operation and maintenance, and present value costs of the alternative plans developed for each hydrologic unit. Because the individual hydrologic units are generally hydrologically and hydraulically independent of each other, the analysis of alternatives and selection of a recommended plan can be made separately for each unit. When more than one alternative was developed for a hydrologic unit, separate detailed component and cost tables are presented for each alternative. When only one plan was developed for a hydrologic unit, the detailed components and costs of that plan are presented in recommended plan summary Table 9, which is an aggregation of the individual recommendations for each unit.

Hydrologic Unit MR-A

Evaluation of the Stormwater Management System: Hydrologic Unit MR-A is a 0.22-square-mile area located along the Milwaukee River, as shown on Map 1 in Chapter I of this volume. Under existing land use conditions, about 13 percent of the hydrologic unit is developed in urban land uses, primarily freeway, industrial, and low-density residential uses. Under planned land use conditions, the hydrologic unit would be about 67 percent developed for urban use, predominantly industrial. The remaining 33 percent would be devoted to agricultural uses. The existing stormwater management system consists of roadside swales and culverts. There are no identified intermittent or perennial streams within the hydrologic unit. Runoff from the unit discharges through a culvert under USH 45 to a wetland in the floodplain of the Milwaukee River. Owing to the relatively low development density of the hydrologic unit under existing conditions, there are no known existing, significant stormwater drainage problems in the unit.

Alternative Stormwater Drainage Plans: Because planned development in the hydrologic unit is anticipated to be primarily industrial, storm sewer drainage facilities would be provided as urban development proceeds in the unit. The recommended water quality management plan presented in Chapter IV of this volume calls for the provision of wet detention basin WD9 near the outlet of the hydrologic unit, but outside any mapped wetlands. Thus, on the basis of planned industrial development and the recommendation for the provision of wet detention, the only stormwater management option which was considered was storm sewer conveyance with centralized detention.

Recommended Stormwater Management Plan: The recommended plan calls for the provision of 2,830 lineal feet of new storm sewers to serve planned development. The reinforced concrete pipe sewers range in diameter from 18 to 42 inches. It would be necessary for detention basin WD9 to have a permanent pond elevation of about 927 feet National Geodetic Vertical Datum, 1929 adjustment, (NGVD) if runoff from the freeway is to be collected as proposed. Construction of the permanent pond at that elevation would create usable storage volume above the pond elevation which would be effective in reducing peak flood flows.

The provision of adequate storm sewers to serve the planned industrial development along Friendly Drive would involve considerable filling along the west side of Friendly Drive, where the existing grade is below the road grade. Some of that fill might be obtained from the excavation for proposed wet detention basin WD9.

In the extreme northern part of the hydrologic unit, it would be necessary to ensure that an overland flow path is preserved from Friendly Drive to the ditch along USH 45 to enable runoff from the west side of the Drive in excess of the proposed storm sewer capacity to be conveyed to the ditch without flooding any new development.

Table 8

COSTS OF THE ALTERNATIVE STORMWATER MANAGEMENT PLANS FOR THE MILWAUKEE RIVER DRAINAGE AREA WITHIN THE CITY OF WEST BEND STUDY AREA

Hydrologic Unit Designation	Alternative No. 1 Storm Sewer Conveyance			Alternative No. 2 Storm Sewer Conveyance with Centralized Detention			Alternative No. 3 Storm Sewer and Open Channel Conveyance			Alternative No. 4 Storm Sewer and Open Channel Conveyance with Centralized Detention		
	Capital[a]	Annual Operation and Maintenance	Present Value[b]	Capital[a]	Annual Operation and Maintenance	Present Value[b]	Capital[a]	Annual Operation and Maintenance	Present Value[b]	Capital[a]	Annual Operation and Maintenance	Present Value[b]
A	--	--	--	$ 270,000	$ 980	$ 285,000	--	--	--	--	--	--
B	--	--	--	--	--	--	$ 183,000	$ 650	$ 194,000	$ 138,000	$ 1,810	$ 167,000
C	--	--	--	--	--	--	--	--	--	67,000	560	76,000
D	--	--	--	--	--	--	--	--	--	--	--	--
E	--	--	--	--	--	--	--	--	--	926,000	6,090	1,022,000
F	$ 609,000	$ -50	$ 608,000	696,000	1,890	726,000	--	--	--	--	--	--
G	426,000	-60	425,000	--	--	--	--	--	--	--	--	--
H	--	--	--	705,000	5,610	793,000	--	--	--	--	--	--
I	--	--	--	--	--	--	--	--	--	74,000	730	86,000
J	800,000	-210	797,000	--	--	--	--	--	--	--	--	--
K	5,566,000	-930	5,551,000	3,639,000	4,740	3,715,400	--	--	--	--	--	--
L	5,000,000	320	5,005,000	4,937,000	2,420	4,975,000	--	--	--	--	--	--
M	1,250,000	-70	1,249,000	1,081,000	1,930	1,111,000	--	--	--	--	--	--
N[c]	--	--	--	--	--	--	2,416,000[d]	9,580	2,567,000	2,445,000[d]	21,470	2,783,000
O[e]	--	--	--	--	--	--	470,000	770	482,000	191,000	1,770	219,000
P	203,000	0	203,000	155,000	600	164,000	--	--	--	--	--	--
Q	--	--	--	--	--	--	456,000	1,400	478,000	--	--	--
R	--	--	--	--	--	--	690,000	2,140	724,000	--	--	--
S	360,000	-240	356,000	--	--	--	--	--	--	--	--	--
T	--	--	--	--	--	--	757,000	3,010	804,000	771,000	3,260	822,000
Z	--	--	--	--	--	--	--	--	--	--	--	--
AB	62,000	0	62,000	--	--	--	--	--	--	--	--	--
AE	214,000	100	216,000	264,000	1,160	282,000	--	--	--	--	--	--
AF	261,000	200	264,000	--	--	--	--	--	--	--	--	--
AG-AH	176,000	-60	175,000	--	--	--	--	--	--	--	--	--
AI	211,000	0	211,000	--	--	--	--	--	--	--	--	--
AJ	149,000	0	149,000	--	--	--	--	--	--	--	--	--
AK	53,000	0	53,000	--	--	--	--	--	--	--	--	--
AL	237,000	0	237,000	--	--	--	--	--	--	--	--	--
AM	327,000	-30	326,500	350,000	1,440	373,000	--	--	--	--	--	--
AP	112,000	0	112,000	--	--	--	--	--	--	--	--	--
AQ	212,000	150	214,000	--	--	--	--	--	--	--	--	--
AS	365,000	-120	363,500	40,000	350	46,000	--	--	--	--	--	--
AU	489,000	-40	488,000	533,000	1,900	563,000	--	--	--	--	--	--
AY	386,000	1,860	415,000	405,000	3,780	464,000	--	--	--	--	--	--
AZ	--	--	--	--	--	--	--	--	--	--	--	--
BC	319,000	1,010	335,000	--	--	--	--	--	--	--	--	--
BE	--	--	--	777,000	3,010	824,000	--	--	--	--	--	--
Total	$17,787,000	$1,830	$17,815,000	$13,852,000	$29,810	$14,320,000	$4,972,000	$17,550	$5,249,000	$4,612,000	$35,690	$5,175,000

Table 8 (continued)

Hydrologic Unit Designation	Alternative No. 5 Storm Sewer Conveyance with Decentralized Detention			Alternative No. 6 Open Channel Conveyance			Alternative No. 7 Open Channel Conveyance with Centralized Detention		
	Capital[a]	Annual Operation and Maintenance	Present Value[b]	Capital[a]	Annual Operation and Maintenance	Present Value[b]	Capital[a]	Annual Operation and Maintenance	Present Value[b]
A	- -	- -	- -	- -	- -	- -	- -	- -	- -
B	- -	- -	- -	- -	- -	- -	- -	- -	- -
C	- -	- -	- -	- -	- -	- -	- -	- -	- -
D	- -	- -	- -	- -	- -	- -	$148,000	$2,800	$192,000
E	- -	- -	- -	- -	- -	- -	- -	- -	- -
F	- -	- -	- -	- -	- -	- -	- -	- -	- -
G	- -	- -	- -	- -	- -	- -	- -	- -	- -
H	$ 636,000	$ 7,430	$ 753,000	- -	- -	- -	- -	- -	- -
I	- -	- -	- -	- -	- -	- -	- -	- -	- -
J	- -	- -	- -	- -	- -	- -	- -	- -	- -
K	- -	- -	- -	- -	- -	- -	- -	- -	- -
L	- -	- -	- -	- -	- -	- -	- -	- -	- -
M	- -	- -	- -	- -	- -	- -	- -	- -	- -
N	- -	- -	- -	- -	- -	- -	- -	- -	- -
O	- -	- -	- -	- -	- -	- -	- -	- -	- -
P	- -	- -	- -	- -	- -	- -	- -	- -	- -
Q	- -	- -	- -	- -	- -	- -	- -	- -	- -
R	- -	- -	- -	- -	- -	- -	- -	- -	- -
S	- -	- -	- -	- -	- -	- -	- -	- -	- -
T	- -	- -	- -	- -	- -	- -	- -	- -	- -
Z	33,000	180	36,000	- -	- -	- -	- -	- -	- -
AB	- -	- -	- -	- -	- -	- -	- -	- -	- -
AE	- -	- -	- -	- -	- -	- -	- -	- -	- -
AF	- -	- -	- -	- -	- -	- -	- -	- -	- -
AG-AH	- -	- -	- -	- -	- -	- -	- -	- -	- -
AI	- -	- -	- -	- -	- -	- -	- -	- -	- -
AJ	- -	- -	- -	- -	- -	- -	- -	- -	- -
AK	- -	- -	- -	- -	- -	- -	- -	- -	- -
AL	- -	- -	- -	- -	- -	- -	- -	- -	- -
AM	- -	- -	- -	- -	- -	- -	- -	- -	- -
AP	- -	- -	- -	- -	- -	- -	- -	- -	- -
AQ	- -	- -	- -	- -	- -	- -	- -	- -	- -
AS	- -	- -	- -	- -	- -	- -	- -	- -	- -
AU	- -	- -	- -	- -	- -	- -	- -	- -	- -
AY	- -	- -	- -	- -	- -	- -	- -	- -	- -
AZ	- -	- -	- -	$3,000	$100	$4,500	- -	- -	- -
BC	352,000	2,480	391,000	- -	- -	- -	- -	- -	- -
BE	- -	- -	- -	- -	- -	- -	- -	- -	- -
Total	$1,021,000	$10,090	$1,180,000	$3,000	$100	$4,500	$148,000	$2,800	$192,000

[a] *Includes 35 percent for engineering, administration, and contingencies. Costs are for year 1991 with* *__Engineering News-Record__* *Construction Cost Index = 5,015.*

[b] *Present value computations assume a 50-year life and 6 percent annual interest.*

[c] *Alternative No. 8, Storm Sewer and Open Channel Conveyance with Storm Sewers in River Road and Centralized Detention for Water Quality Control, was also developed for this hydrologic unit. Alternative No. 8 has capital, annual operation and maintenance, and present value costs of $2,555,000; $9,530; and $2,705,000, respectively.*

[d] *Includes $644,000 for the water quality control portion of proposed wet detention basin WD3.*

[e] *Alternative No. 9, Storm Sewer and Open Channel Conveyance with Centralized Detention and Storm Sewers in River Road, was also developed for this hydrologic unit. Alternative No. 9 has capital, annual operation and maintenance, and present value costs of $161,000; $1,770; and $189,000, respectively.*

Source: SEWRPC.

Table 9

COMPONENTS AND COSTS OF THE RECOMMENDED STORMWATER DRAINAGE PLAN FOR THE MILWAUKEE RIVER DRAINAGE AREA OUTSIDE THE WINGATE CREEK SUBWATERSHED IN THE CITY OF WEST BEND

Hydrologic Unit	Project and Component Description[a]	Estimated Cost	
		Capital[b]	Annual Operation and Maintenance[c]
A	1. Install 435 feet of 18-inch storm sewer	$ 27,000	$ 170
	2. Install 750 feet of 21-inch storm sewer	53,000	300
	3. Install 335 feet of 24-inch storm sewer	28,000	130
	4. Install 370 feet of 27-inch storm sewer	34,000	150
	5. Install 225 feet of 30-inch storm sewer	24,000	90
	6. Install 350 feet of 36-inch storm sewer	46,000	70
	7. Install 365 feet of 42-inch storm sewer	58,000	70
	Subtotal	$ 270,000	$ 980
B	1. Install 810 feet of new 15-inch-diameter storm sewer	$ 42,000	$ 330
	2. Install 210 feet of new 18-inch-diameter storm sewer	13,000	80
	3. Install 110 feet of new 21-inch-diameter storm sewer	8,000	40
	4. Install 455 feet of new 30-inch-diameter storm sewer	48,000	180
	5. Construct 50-foot-long open channel	1,000	30
	6. Construct detention basin B-1 with a storage volume of 0.5 acre-foot	16,000	1,100
	7. 65 feet of 30-inch storm sewer for basin B-1 inlet	7,000	30
	8. 50 feet of 15-inch-diameter storm sewer for basin B-1 outlet	3,000	20
	Subtotal	$ 138,000	$ 1,810
C	1. Install 770 feet of new 12-inch-diameter storm sewer	$ 34,000	$ 310
	2. Install 100 feet of new 15-inch-diameter storm sewer	5,000	40
	3. Install 140 feet of new 23-inch-wide by 14-inch-high HE storm sewer	9,000	60
	4. Replace 3.4-foot-wide by 2.4-foot-high CMPA under Newark Road with a 60-foot-long, 30-inch-diameter reinforced concrete culvert	9,000	20
	5. Construct 240-foot-long, 2-foot-deep, riprap-lined drainage swale	9,000	100
	6. Construct 70-foot-long, 3-foot-deep open channel	1,000	30
	Subtotal	$ 67,000	$ 560
D	1. Detention basin WD10 with a 100-year storm live storage volume of 4.9 acre-feet. Water quantity control cost	$ 148,000	$ 2,800
	Subtotal	$ 148,000	$ 2,800
E	1. Install 250 feet of new 12-inch storm sewer	$ 11,000	$ 90
	2. Install 290 feet of new 15-inch storm sewer	16,000	110
	3. Install 355 feet of new 18-inch storm sewer	22,000	130
	4. Install 130 feet of new 21-inch storm sewer	9,000	50
	5. Install 490 feet of new 24-inch storm sewer	41,000	180
	6. Install 65 feet of new 27-inch storm sewer	6,000	30
	7. Install 695 feet of new 42-inch storm sewer	110,000	130
	8. Install 380 feet of new 45-inch-wide by 29-inch-high HE storm sewer	57,000	70

Table 9 (continued)

Hydrologic Unit	Project and Component Description[a]	Estimated Cost	
		Capital[b]	Annual Operation and Maintenance[c]
E (continued)	9. Install 1,065 feet of new 51-inch-wide by 31-inch-high RCPA storm sewer	$ 198,000	$ 200
	10. Replace 75 feet of 18-inch storm sewer in Roosevelt Drive North with 27-inch storm sewer	10,000	0
	11. Replace 287 feet of 18-inch storm sewer between Roosevelt Drive North and Sunset Ridge Drive with 27-inch storm sewer	37,000	0
	12. Replace 87 feet of 36-inch-wide by 26-inch-high CMPA storm sewer in Sunset Ridge Drive with 51-inch-wide by 36-inch-high RCPA	23,000	0
	13. Replace 56 feet of 58-inch-wide by 36-inch-high CMPA storm sewer in 18th Avenue with 53-inch-wide by 34-inch-high HE storm sewer	15,000	0
	14. Replace 250 feet of 27-inch storm sewer in 18th Avenue with 58-inch-wide by 36-inch-high RCPA storm sewer	78,000	0
	15. Replace 143 feet of 58-inch-wide by 36-inch-high CMPA storm sewer in drainage easement west of 18th Avenue with dual 68-inch-wide by 43-inch-high HE storm sewer	104,000	0
	16. Replace 140 feet of 12-inch storm sewer in Primrose Lane with 18-inch storm sewer	12,000	0
	17. Replace 130 feet of 18-inch storm sewer in Larkspur Lane with 21-inch storm sewer	13,000	0
	18. Construct two-acre dry detention basin east of Wildwood Road (CTH B)	97,000	5,000
	19. Construct 315-foot-long open channel west of Main Street	8,000	100
	20. Install three 100-foot-long, 48-inch RCP culverts under extension of 18th Avenue at crossing of unnamed Tributary No. 3	59,000	0
	Subtotal	$ 926,000	$ 6,090
F	1. Replace 673 feet of 21-inch storm sewer in Skyline Drive between Barton Avenue and Barbie Drive with 38-inch by 24-inch HE storm sewer	$ 114,000	$ 0
	2. Replace 24 feet of 12-inch storm sewer in easement east of Acorn Road and west of Skyline Drive with 21-inch storm sewer	2,000	0
	3. Replace 380 feet of 12-inch CMP storm sewer in easement east of Acorn Road and west of Skyline Drive with 21-inch storm sewer	36,000	0
	4. Replace 29 feet of 21-inch storm sewer in Acorn Road, between Parkfield Drive and Briar Road with 38-inch by 24-inch HE storm sewer	5,000	0
	5. Replace 329 feet of 18-inch storm sewer in Acorn Road, between Parkfield Drive and Briar Road with 38-inch by 24-inch HE storm sewer	56,000	0
	6. Replace 308 feet of 15-inch storm sewer in Briar Drive, north of Acorn Road with 30-inch by 19-inch HE storm sewer	38,000	0

Table 9 (continued)

Hydrologic Unit	Project and Component Description[a]	Estimated Cost	
		Capital[b]	Annual Operation and Maintenance[c]
F (continued)	7. Replace 330 feet of 18-inch storm sewer in Acorn Road west of Parkfield Drive with 24-inch storm sewer	$ 37,000	$ 0
	8. Replace 390 feet of 30-inch storm sewer in easement between Jackson Street and Hi-Mount Road with 42-inch storm sewer	87,000	-70
	9. Replace 58 feet of 30-inch storm sewer in Stratford Road between Jackson Street and Hi-Mount Road with 42-inch storm sewer	13,000	-10
	10. 170 feet of 21-inch storm sewer in easement north of Jackson Street and west of Salisbury Road	12,000	70
	11. Replace 231 feet of 36-inch by 22-inch CMPA in easement between Northwestern Avenue and Stratford Road with 42-inch storm sewer	52,000	-40
	12. Replace 153 feet of 50-inch by 31-inch CMPA easement between Northwestern Avenue and Stratford Road north of Hi-Mount Road with 42-inch storm sewer	34,000	0
	13. Replace 123 feet of 36-inch storm sewer in easement west of Northwestern Avenue into the Milwaukee River north of Hi-Mount Road with 48-inch storm sewer	31,000	0
	14. Replace 168 feet of 50-inch by 31-inch CMPA in easement west of Northwestern Avenue and into the Milwaukee River north of Hi-Mount Road with 42-inch storm sewer	43,000	0
	15. Replace 130 feet of 24-inch storm sewer in Northwestern Avenue and west of Northwestern with 18-inch storm sewer	11,000	0
	16. Replace 60 feet of 24-inch storm sewer in Northwestern Avenue and west of Northwestern with 18-inch storm sewer	5,000	0
	17. Replace 196 feet of 15-inch storm sewer at the intersection of Hi-Mount Road and Stratford Road and in Northwestern Avenue north of Hi-Mount Road with 18-inch storm sewer	16,000	0
	18. Replace 210 feet of 15-inch storm sewer at the intersection of Hi-Mount Road and Stratford Road and in Northwestern Avenue north of Hi-Mount Road with 18-inch storm sewer	17,000	0
	Subtotal	$ 609,000	$ -50
G	1. Replace 208 feet of 24-inch storm sewer in Sunset Ridge Road between Adams Street and Roosevelt Drive with 45-inch by 29-inch HE storm sewer	$ 43,000	$ -40
	2. Replace 116 feet of 24-inch storm sewer in Sunset Ridge Road between Adams Street and Roosevelt Drive with 36-inch storm sewer	22,000	-20
	3. Replace 21 feet of 36-inch CMP storm sewer in Sunset Ridge Road between Adams Street and Roosevelt Drive with 36-inch storm sewer	4,000	0

Table 9 (continued)

Hydrologic Unit	Project and Component Description[a]	Estimated Cost Capital[b]	Estimated Cost Annual Operation and Maintenance[c]
G (continued)	4. Replace 131 feet of 15-inch storm sewer in Jefferson Street just west of Sunset Ridge Road with 24-inch storm sewer	$ 15,000	$ 0
	5. Replace 306 feet of 15-inch storm sewer in Sunset Ridge Road between Roosevelt Drive and Jefferson Street with 24-inch storm sewer	34,000	0
	6. Replace 156 feet of 18-inch storm sewer in Roosevelt Drive, west of Sunset Ridge Road with 38-inch by 24-inch HE storm sewer	26,000	0
	7. Replace 364 feet of 18-inch storm sewer in Roosevelt Drive between Sunset Ridge Road and Main Street with 38-inch by 24-inch HE storm sewer	61,000	0
	8. Replace 15 feet of 18-inch storm sewer in Roosevelt Drive between Sunset Ridge Road and Main Street with 38-inch by 24-inch HE storm sewer	3,000	0
	9. Replace 86 feet of 18-inch storm sewer in Main Street north of Roosevelt Drive with 38-inch by 24-inch HE storm sewer	15,000	0
	10. Replace 43 feet of 24-inch CMP storm sewer in Main Street north of Roosevelt Drive with 38-inch by 24-inch HE storm sewer	7,000	0
	11. Replace 200 feet of 24-inch CMP storm sewer in easement between Main Street and Fairview Drive with 38-inch by 24-inch HE storm sewer	34,000	0
	12. Replace 224 feet of 24-inch CMP storm sewer in School Place between Fairview Drive and River Drive with 38-inch by 24-inch HE storm sewer	38,000	0
	13. Replace 294 feet of 24-inch CMP storm sewer in School Place between Fairview Drive and River Drive with 38-inch by 24-inch HE storm sewer	50,000	0
	14. Replace 380 feet of 30-inch CMP storm sewer in River Drive north of School Place with 38-inch by 24-inch HE storm sewer	64,000	0
	15. Replace 62 feet of 30-inch CMP storm sewer in River Drive north of School Place with 38-inch by 24-inch HE storm sewer	10,000	0
	Subtotal	$ 426,000	$ -60
H	1. 660 feet of 12-inch storm sewer	$ 29,000	$ 260
	2. 250 feet of 15-inch storm sewer	16,000	100
	3. 330 feet of 21-inch storm sewer	58,000	240
	4. 1,835 feet of 24-inch storm sewer	206,000	730
	5. Detention basin WD25 with a 100-year storm live storage volume of 3.2 acre-feet. Water quantity control cost[d]	102,000	1,700
	6. Detention basin WD26 with a 100-year storm live storage volume of 0.5 acre-feet. Water quantity control cost[d]	26,000	300
	Subtotal	$ 437,000	$ 3,330
I	1. 260 feet of 24-inch storm sewer	$ 34,000	$ 150
	2. 370 feet of 27-inch storm sewer	21,000	100

Table 9 (continued)

Hydrologic Unit	Project and Component Description[a]	Estimated Cost	
		Capital[b]	Annual Operation and Maintenance[c]
I (continued)	3. 1,100 feet of 2.5-foot average depth roadside swale along Brown Lane	$ 13,000	$ 440
	4. Two 50-foot-long, 18-inch-diameter culverts under Brown Lane	6,000	40
	Subtotal	$ 74,000	$ 730
J	1. Replace 225 feet of 18-inch clay storm sewer in Summit Drive south of Chestnut Street with 30-inch storm sewer	$ 34,000	$ 0
	2. Replace 410 feet 18-inch clay storm sewer in Chestnut Street west of Summit Drive with 21-inch storm sewer	39,000	0
	3. Replace 195 feet of 18-inch clay storm sewer in Chestnut Street east of 10th Avenue with 30-inch storm sewer	29,000	0
	4. Replace 46 feet of 18-inch clay storm sewer at intersection of Chestnut Street and 10th Avenue with 30-inch storm sewer	7,000	0
	5. Replace 364 feet of 18-inch clay storm sewer in 10th Avenue between Chestnut Street and Poplar Street with 42-inch storm sewer	82,000	-70
	6. Replace 263 feet of 12-inch clay storm sewer in 11th Avenue, north of Poplar Street with 24-inch storm sewer	29,000	0
	7. Replace 57 feet of 12-inch clay storm sewer in intersection of 11th Avenue and Poplar Street with 24-inch storm sewer	6,000	0
	8. Replace 364 feet of 12-inch clay storm sewer in Poplar Street east of 11th Avenue with 18-inch storm sewer	30,000	0
	9. Replace 297 feet of 12-inch clay storm sewer in Poplar Street west of 10th Avenue with 21-inch storm sewer	28,000	0
	10. Replace 17 feet of 24-inch storm sewer in Poplar Street west of 10th Avenue with 48-inch storm sewer	4,000	0
	11. Replace 308 feet of 30-inch storm sewer in Poplar Street between 9th Avenue and 10th Avenue with 48-inch storm sewer	79,000	-60
	12. Replace 309 feet of 15-inch storm sewer in Poplar Street between 8th Avenue and 9th Avenue with 36-inch storm sewer	60,000	60
	13. Replace 333 feet of 15-inch clay storm sewer in Poplar Street between 7th Avenue and 8th Avenue with 36-inch storm sewer	64,000	60
	14. Replace 32 feet of 30-inch storm sewer in intersection of 7th Avenue and Poplar Street with 42-inch storm sewer	7,000	-10
	15. Replace 131 feet of 30-inch storm sewer in Poplar Street east of 7th Avenue with 48-inch storm sewer	33,000	-20

Table 9 (continued)

Hydrologic Unit	Project and Component Description[a]	Estimated Cost	
		Capital[b]	Annual Operation and Maintenance[c]
J (continued)	16. Replace 36 feet of 30-inch storm sewer in intersection of Poplar Street and alley between 6th Avenue and 7th Avenue with 48-inch storm sewer . . .	$ 9,000	$ -10
	17. Replace 159 feet of 30-inch storm sewer in alley between 6th Avenue and 7th Avenue north of Poplar Street with 54-inch storm sewer	55,000	-30
	18. Replace 108 feet of 30-inch storm sewer in alley between 6th Avenue and 7th Avenue and Poplar Street and Walnut Street with 54-inch storm sewer	37,000	-20
	19. Replace 320 feet of 30-inch storm sewer in Walnut Street and alley between 6th Avenue and 7th Avenue with 54-inch storm sewer	110,000	-60
	20. Replace 17 feet of 30-inch storm sewer in intersection of 6th Avenue and Walnut Street with 66-inch storm sewer	8,000	0
	21. Replace 36 feet of 30-inch storm sewer in intersection of Walnut Street and 6th Avenue with 36-inch storm sewer	7,000	-10
	22. Replace 139 feet of 30-inch storm sewer in Walnut Street between 6th Avenue and alley east of 6th Avenue with 36-inch storm sewer	27,000	-30
	23. Replace 61 feet of 42-inch storm sewer outfall from intersection of Walnut Street and Main Street to Milwaukee River with 48-inch storm sewer	16,000	-10
	Subtotal	$ 800,000	$ -210
K	1. Replace 92 feet of 58-inch by 36-inch CMPA storm sewer at intersection of Hawthorn Drive and 5th Avenue with 53-inch by 34-inch HE storm sewer	$ 24,000	$ 0
	2. Basin K-3 inlet, 90 feet	17,000	20
	3. Basin K-3 outlet, 100 feet	11,000	40
	4. Replace 326 feet of 58-inch by 36-inch CMPA in 5th Avenue south of Decorah Road with 48-inch storm sewer	83,000	0
	5. Replace 649 feet of 10-inch storm sewer along easement in 5th Avenue extended south of Hawthorn Drive with 21-inch storm sewer	62,000	0
	6. Replace 281 feet of 15-inch storm sewer in Orchard Street between 6th Avenue and 7th Avenue with 18-inch storm sewer	23,000	0
	7. Replace 299 feet of 18-inch storm sewer in 6th Avenue between Orchard Street and Spring Drive with 38-inch by 24-inch HE storm sewer	50,000	0
	8. Replace 710 feet of 30-inch CMP storm sewer in 6th Avenue between Orchard Street and Decorah Road with 36-inch storm sewer	137,000	-130
	9. Replace 305 feet of 30-inch CMP storm sewer in Decorah Road between 5th and 6th Avenues with 27-inch storm sewer	39,000	0
	10. Replace 353 feet of 12-inch clay storm sewer in Decorah Road between 5th and 6th Avenues with 15-inch storm sewer	23,000	0

Table 9 (continued)

Hydrologic Unit	Project and Component Description[a]	Estimated Cost	
		Capital[b]	Annual Operation and Maintenance[c]
K (continued)	11. Install 90 feet of 18-inch storm sewer in the future extension of Highland View Drive	$ 6,000	$ 40
	12. Replace 287 feet of 15-inch storm sewer in Highland View Drive with 18-inch storm sewer	24,000	0
	13. Replace 514 feet of 18-inch storm sewer in Highland View Drive with 53-inch by 34-inch HE storm sewer at a slope of 0.28 percent	134,000	0
	14. Replace 475 feet of 15-inch storm sewer in Bobolink Lane between Highland View Drive and Silverbrook Drive with 27-inch storm sewer	61,000	0
	15. Replace 236 feet of 15-inch storm sewer in Bobolink Lane between Highland View Drive and Silverbrook Drive with 30-inch storm sewer	35,000	0
	16. Replace 159 feet of 18-inch storm sewer in Highland View Drive east of Bobolink Lane with 318 feet of double 53-inch by 34-inch HE storm sewer at a slope of 0.28 percent	83,000	0
	17. Basin K-2 inlet, 144 feet of double 53-inch by 34-inch HE storm sewer at a slope of 0.28 percent	38,000	0
	18. Basin K-2 outlet, 70 feet of 15-inch storm sewer	5,000	-100
	19. Replace 513 feet of 15-inch CMP storm sewer along easement between Decorah Road and Evergreen Street with 30-inch storm sewer	77,000	0
	20. Replace 234 feet of 15-inch and 18-inch storm sewer in Evergreen Street east of Silverbrook Drive with 30-inch storm sewer	39,000	0
	21. Replace 203 feet of 18-inch storm sewer in Evergreen Street east of Highland View Drive with 42-inch storm sewer	45,000	-40
	22. Replace 559 feet of 36-inch storm sewer in Highland View Drive south of Pine Drive with 42-inch storm sewer	125,000	0
	23. Replace 232 feet of 36-inch storm sewer in Pine Drive at Highland View Drive with 48-inch storm sewer	59,000	0
	24. Replace 596 feet of 27-inch storm sewer in Pine Drive between Highland View Drive and 8th Avenue with 48-inch storm sewer	152,000	-110
	25. Replace 884 feet of 30-inch storm sewer in Pine Drive west of 6th Avenue to 8th Avenue with 42-inch storm sewer	198,000	-170
	26. Replace 134 feet of 36-inch storm sewer in 6th Avenue north of Pine Drive angled northeast with 48-inch storm sewer	34,000	0
	27. Replace 200 feet of 52-inch by 36-inch CMP storm sewer between 5th and 6th Avenues south of Oak Street with 54-inch storm sewer	69,000	-40
	28. Replace 1,754 feet 60-inch by 36-inch CMPA storm sewer in 5th Avenue between Oak Street and Decorah Road with 53-inch by 34-inch HE storm sewer	457,000	0
	29. Replace 466 feet of 40-inch storm sewer just east of 5th Avenue between Maple and Oak Street with 42-inch storm sewer	104,000	0

Table 9 (continued)

Hydrologic Unit	Project and Component Description[a]	Estimated Cost	
		Capital[b]	Annual Operation and Maintenance[c]
K (continued)	30. Replace 423 feet of 30-inch storm sewer in 5th Avenue between Maple Street and Oak Street with 53-inch by 34-inch HE storm sewer	$ 110,000	$ -80
	31. Replace 110 feet of 30-inch storm sewer in Maple Street west of 5th Avenue with 53-inch by 34-inch HE storm sewer	29,000	-20
	32. Replace 468 feet of 15-inch and 18-inch clay storm sewer in Maple Street and 5th Avenue east of 5th Avenue with 27-inch storm sewer	60,000	0
	33. Replace 368 feet of 82-inch by 63-inch SPPA storm sewer in alley and easement between 5th Avenue and Main Street north of Maple Street with 83-inch by 53-inch HE storm sewer	171,000	0
	34. Replace 276 feet of 24-inch storm sewer in Main Street north of Maple Street with 30-inch storm sewer	41,000	0
	35. Replace 486 feet of cut stone pipe that is 5.5 feet high, 5.0 feet wide at the base, and 3.5 feet wide at the top (top is an arch with a radius of 2.5 feet) in Main Street between Chestnut Street and Maple Street with 72-inch storm sewer	255,000	-90
	36. Replace 103 feet of 75-inch by 61.5-inch concrete box at outfall from Kilbourn Street to Milwaukee River with 98-inch by 63-inch HE storm sewer	63,000	0
	37. Replace 539 feet of 15-inch storm sewer in 3rd Avenue between Oak Street and Locust Street with 24-inch storm sewer	60,000	0
	38. Replace 234 feet of 21-inch storm sewer in intersection of Kilbourn Street and 3rd Avenue and in 3rd Avenue south of Kilbourn Street with 30-inch storm sewer	35,000	0
	39. Replace 132 feet of 24-inch storm sewer in intersection of Kilbourn Street and 3rd Avenue and in 3rd Avenue south of Kilbourn Street with 45-inch by 29-inch HE storm sewer	27,000	-30
	40. Replace 1,292 feet of 12-inch clay storm sewer in 2nd Avenue from Oak Street to Kilbourn Street and in Kilbourn Street to 3rd Avenue with 38-inch by 24-inch HE storm sewer	218,000	0
	41. Replace 75 feet of 24-inch storm sewer just east of intersection of Chestnut Street and Kilbourn Street with 45-inch by 29-inch HE storm sewer	16,000	-10
	42. Replace 212 feet of 12-inch storm sewer in Chestnut Street between Main Street and Kilbourn Street with 18-inch storm sewer	17,000	0
	43. Replace 348 feet of 12-inch storm sewer in Kilbourn Street north of Chestnut Street with 18-inch storm sewer	29,000	0
	Storm Sewer Subtotal	$ 3,345,000	$ -720
	44. 3.3 acre-foot detention basin located in Decorah Hills Park between Decorah Road and Highland View Drive extended, T11N, R19E, northeast quarter, Section 23 (basin K-2)	$ 112,000	$ 1,400

Table 9 (continued)

Hydrologic Unit	Project and Component Description[a]	Estimated Cost	
		Capital[b]	Annual Operation and Maintenance[c]
K (continued)	45. 3.9 acre-foot detention basin located north of Hawthorn Drive between 5th and 6th Avenues, T11N, R19E, northeast quarter, Section 23 (basin K-3)	$ 277,000	$ 1,700
	46. 4.2 acre-foot detention basin located on Badger School grounds southeast of the intersection of 6th Avenue and Oak Street, T11N, R19E, southeast quarter, Section 14 (basin WD4)	279,000	1,900
	Subtotal	$ 4,013,000	$ 4,280
L	1. Replace 287 feet of 15-inch storm sewer in Butternut Street between Main Street and Eder Lane with 38-inch by 24-inch HE storm sewer	$ 48,000	$ 0
	2. Replace 661 feet of 21-inch storm sewer in Main Street north of Butternut Street with 42-inch storm sewer	148,000	-130
	3. Replace 226 feet of 42-inch storm sewer in Main Street between Butternut Street and Vine Street with 76-inch by 48-inch HE storm sewer	98,000	0
	4. Replace 471 feet of 42-inch storm sewer in Main Street between Butternut Street and Vine Street with 76-inch by 48-inch HE storm sewer	205,000	0
	5. Replace 289 feet of 60-inch by 38-inch storm sewer in Vine Street between Main Street and Eder Lane with 76-inch by 48-inch HE storm sewer	126,000	0
	6. Replace 278 feet of 60-inch by 38-inch storm sewer in Vine Street between Eder Lane and Sylvan Way with 556 feet of double 68-inch by 43-inch HE storm sewer	202,000	0
	7. Replace 680 feet of 60-inch by 38-inch storm sewer in Vine Street between Eder Lane and Sylvan Way with 68-inch by 43-inch HE storm sewer	247,000	0
	8. Replace 319 feet of 60-inch by 38-inch storm sewer in Vine Street between Eder Lane and Sylvan Way with 76-inch by 48-inch HE storm sewer	139,000	0
	9. Replace 32 feet of 76-inch by 48-inch storm sewer at 0.03 percent slope in Vine Street between Eder Lane and Sylvan Way with 76-inch by 48-inch HE storm sewer at 0.86 percent slope	14,000	0
	10. Replace 393 feet of 50-inch by 31-inch CMPA storm sewer in Green Valley Place between Sandra Lane and Sylvan Way with 53-inch by 34-inch HE storm sewer	102,000	0
	11. Replace 377 feet of 50-inch by 31-inch CMPA storm sewer in Green Valley Place between Sandra Lane and Sylvan Way with 53-inch by 34-inch HE storm sewer	98,000	0
	12. Replace 247 feet of 50-inch by 31-inch CMPA storm sewer in Sylvan Way between Vine Street and Green Valley Place with 60-inch by 38-inch HE storm sewer	78,000	0
	13. Replace 392 feet of 24-inch storm sewer in easement on east side of Sylvan Way with 30-inch storm sewer	59,000	0

Table 9 (continued)

Hydrologic Unit	Project and Component Description[a]	Estimated Cost	
		Capital[b]	Annual Operation and Maintenance[c]
L (continued)	14. Replace 1,068 feet of 18-inch storm sewer in Eder Lane and Terrace Drive between Vine Street and Lincoln Drive East with 36-inch storm sewer	$ 206,000	$ -200
	15. Replace 250 feet of 24-inch storm sewer in Terrace Drive between Lincoln Drive East and Birchwood Drive with 42-inch storm sewer	56,000	-50
	16. Replace 356 feet of 24-inch storm sewer in easement south of Birchwood Drive and west of railroad tracks with 53-inch by 34-inch HE storm sewer	93,000	-70
	17. Replace 60 feet of 36-inch by 23-inch RCPA in easement south of Birchwood Drive and west of railroad tracks with 53-inch by 34-inch storm sewer	16,000	-10
	18. Install 1,902 feet of 54-inch storm sewer parallel to existing 54-inch storm sewer along railway right-of-way south of Decorah Road	655,000	360
	19. Replace 56 feet of 15-inch and 21-inch storm sewer in Main Street between Hawthorn Drive and Vine Street with 30-inch storm sewer	8,000	0
	20. Replace 300 feet of 21-inch storm sewer in Main Street between Hawthorn Drive and Vine Street with 42-inch storm sewer	67,000	-60
	21. Replace 544 feet of 27-inch storm sewer in Main Street between Hawthorn Drive and Vine Street with 48-inch storm sewer	139,000	-100
	22. Replace 585 feet of 15-inch and 18-inch storm sewer in Main Street between Decorah Road and Hawthorn Drive with 38-inch by 24-inch HE storm sewer	99,000	0
	23. Replace 152 feet of 44-inch by 27-inch RCPA in Hawthorn Drive between Main Street and Lincoln Drive West with 48-inch storm sewer	39,000	0
	24. Replace 199 feet of 36-inch storm sewer in Hawthorn Drive between Main Street and Lincoln Drive West with 48-inch storm sewer	51,000	0
	25. Replace 928 feet of 42-inch storm sewer in Hawthorn Drive between Lincoln Drive West and Birchwood Drive with 54-inch storm sewer	319,000	0
	26. Replace 273 feet of 42-inch storm sewer in Hawthorn Drive between Lincoln Drive West and Birchwood Drive with 54-inch storm sewer	94,000	0
	27. Replace 456 feet of 42-inch storm sewer in easement east of Birchwood Drive to railroad tracks (south of Decorah Road) with 60-inch storm sewer	191,000	0
	28. Install 2,452 feet of 66-inch storm sewer at a slope of 0.87 percent parallel to existing 60-inch storm sewer in easement east of railroad right-of-way located north and south of Decorah Road	1,102,000	470
	29. Install 574 feet of 72-inch storm sewer parallel to existing 60-inch storm sewer in easement east of railroad right-of-way north of Kilbourn Street	301,000	110
	Subtotal	$ 5,000,000	$ 320

Table 9 (continued)

Hydrologic Unit	Project and Component Description[a]	Estimated Cost	
		Capital[b]	Annual Operation and Maintenance[c]
M	1. Replace 181 feet of 18-inch storm sewer in Indiana Avenue south of Eastern Avenue with 24-inch storm sewer	$ 20,000	$ 0
	2. Replace 200 feet of 58-inch by 36-inch CMPA storm sewer in Redwood Street between Eastern Avenue and Madison Avenue with 42-inch storm sewer	45,000	0
	3. Replace 289 feet of 58-inch by 36-inch CMPA storm sewer in Eastern Avenue between Pleasant Drive and Redwood Street with 42-inch storm sewer	65,000	0
	4. Replace 324 feet of 58-inch by 36-inch CMPA storm sewer in easement just west of Pleasant Drive between Locust drive and Decorah Road with 60-inch by 38-inch HE storm sewer	102,000	0
	5. Replace 217 feet of 58-inch by 36-inch CMPA storm sewer in Riverview Drive between Locust Drive and Decorah Road with 60-inch by 38-inch HE storm sewer	68,000	0
	6. Replace 276 feet of 58-inch by 36-inch CMPA storm sewer in Riverview Drive between Locust Drive and Decorah Road with 60-inch by 38-inch HE storm sewer	87,000	0
	7. Replace 358 feet of 30-inch CMP storm sewer in Locust Street between Pennsylvania Avenue and Riverview Drive with 48-inch storm sewer	91,000	-70
	8. Replace 260 feet of 72-inch by 44-inch CMPA storm sewer in Riverview Drive between Riverview Place and Locust Street with 60-inch by 38-inch HE storm sewer	82,000	0
	9. Replace 711 feet of 72-inch by 44-inch CMPA storm sewer in Riverview Drive between Riverview Place and Kilbourn Avenue with 60-inch by 38-inch HE storm sewer	224,000	0
	10. Replace 174 feet of 72-inch by 44-inch CMPA storm sewer in easement north of the intersection of Kilbourn Avenue and Riverview Drive with 66-inch storm sewer	78,000	0
	Storm Sewer Subtotal	$ 862,000	$ -70
	11. 4.6 acre-foot detention basin located southeast of the intersection of Eastern Avenue and Decorah Road, T11N, R19E, northeast quarter, Section 24 (basin M-1)	$ 219,000	$ 2,000
	Subtotal	$ 1,081,000	$ 1,930
N[e]	1. Install 485 feet of new 18-inch storm sewer	$ 30,000	$ 190
	2. Install 575 feet of new 24-inch storm sewer	47,000	230
	3. Install 1,715 feet of new 30-inch storm sewer	180,000	690
	4. Install 1,690 feet of new 42-inch storm sewer	267,000	320
	5. Install 335 feet of new 48-inch storm sewer	65,000	60
	6. Install 1,310 feet of new 54-inch storm sewer	294,000	250
	7. Install 800 feet of new 60-inch storm sewer	207,000	150
	8. Install 790 feet of new 48-inch storm sewer	202,000	150
	9. Install 750 feet of new 83-inch-wide by 53-inch-high HE storm sewer	263,000	100

Table 9 (continued)

Hydrologic Unit	Project and Component Description[a]	Estimated Cost	
		Capital[b]	Annual Operation and Maintenance[c]
N[e] (continued)	10. Replace 280 feet of 72-inch-wide by 48-inch-high CMPA storm sewer in Lang Street with 68-inch-wide by 43-inch-high HE storm sewer	$ 102,000	$ 0
	11. Construct 160-foot-long open channel south of Lang Street	35,000	100
	12. Install 415 feet of new 15-inch storm sewer	22,000	170
	13. Install 385 feet of new 24-inch storm sewer	32,000	150
	14. Install 440 feet of new 27-inch storm sewer	41,000	180
	15. Install 670 feet of new 36-inch storm sewer	89,000	130
	16. Install 60 feet of new 68-inch-wide by 43-inch-high HE storm sewer	15,000	10
	17. Construct 200-foot-long, riprap-lined open channel from proposed 48-inch-diameter storm sewer outfall to the Milwaukee River	20,000	100
	Subtotal	$ 1,911,000	$ 2,980
O[f]	1. Construct 1,200-foot-long open channel in industrial park north of Lang Street	$ 75,000	$ 500
	2. Construct 880-foot-long open channel through area between Lang and Washington Streets	23,000	370
	3. Detention basin WD6 with a 100-year live storage volume of 3.2 acre-feet	63,000	900
	Subtotal	$ 161,000	$ 1,770
P	1. Replace 55 feet of 24-inch storm sewer in Schoenhaar Drive between Hans Street and Creek Drive with 30-inch storm sewer	$ 8,000	$ 0
	2. Replace 302 feet of 42-inch storm sewer in Schoenhaar Drive north of Washington Street with 68-inch by 43-inch HE storm sewer	110,000	0
	3. Replace 203 feet of 48-inch storm sewer in easement south of Washington Street between Schoenhaar and Lenora Drives with 60-inch storm sewer	85,000	0
	Subtotal	$ 203,000	$ 0
Q	1. Replace 647 feet of 21-inch storm sewer in Redwood Street between Juniper and Imperial Courts with 36-inch storm sewer	$ 125,000	$ 0
	2. Replace 348 feet of 30-inch storm sewer in Redwood Street between Imperial Court and River Road with 53-inch-wide by 34-inch-high HE storm sewer	91,000	0
	3. Replace 231 feet of 30-inch storm sewer in River Road South between Redwood Street and Kilbourn Street with 53-inch-wide by 34-inch-high HE storm sewer at 0.70 percent slope	60,000	0
	4. Replace 231 feet of 30-inch storm sewer in River Road South between Redwood Street and Kilbourn Street with 53-inch-wide by 34-inch-high HE storm sewer at 0.70 percent slope	60,000	0
	5. Replace 171 feet of 36-inch storm sewer east of River Road South between Redwood Street and Kilbourn Street with 53-inch-wide by 34-inch-high HE storm sewer at 0.82 percent slope	45,000	0
	6. Construct 0.5-mile-long open channel through area east of River Road. Provide 160 feet total of double 48-inch RCP culvert at proposed upstream road crossing	75,000	1,400
	Subtotal	$ 456,000	$ 1,400

Table 9 (continued)

Hydrologic Unit	Project and Component Description[a]	Estimated Cost Capital[b]	Estimated Cost Annual Operation and Maintenance[c]
R	1. Install 550 feet of 15-inch storm sewer	$ 29,000	$ 220
	2. Install 370 feet of 18-inch storm sewer	23,000	150
	3. Install 800 feet of 21-inch storm sewer	56,000	320
	4. Install 690 feet of 24-inch storm sewer	208,000	280
	5. Install 1,160 feet of 27-inch storm sewer	108,000	470
	6. Install 460 feet of 36-inch storm sewer	61,000	90
	7. Install 800 feet of 45-inch by 29-inch concrete HE storm sewer	119,000	150
	8. Install two 470-foot-long, 30-inch-diameter RCP culverts under the proposed realigned west Bend Airport runway and taxiway	70,000	380
	9. Install one 60-foot-long, 30-inch-diameter RCP culvert under assumed future collector street	4,000	20
	10. Install one 110-foot-long, 30-inch-diameter RCP culvert under proposed realigned STH 33	9,000	40
	11. Install one 60-foot-long, 18-inch-diameter RCP culvert under assumed future collector street	3,000	20
	Subtotal	$ 690,000	$ 2,140
S	1. 500 feet of 36-inch storm sewer in Indiana Avenue between Locust Street and Oak Street	$ 97,000	$ -100
	2. Replace 364 feet of 12-inch clay storm sewer in Indiana Avenue between Oak Street and Kilbourn Street with 36-inch storm sewer	70,000	-70
	3. Replace 591 feet of 12-inch clay storm sewer in Pennsylvania Avenue between Oak Street and Kilbourn Street and in Kilbourn Street between Pennsylvania Avenue and Indiana Avenue with 30-inch by 19-inch storm sewer	73,000	0
	4. Replace 273 feet of 12-inch clay storm sewer in Kilbourn Street between Michigan Avenue and Indiana Avenue with 21-inch storm sewer	26,000	0
	5. Replace 139 feet of 12-inch clay storm sewer in Kilbourn Street between Michigan Avenue and Indiana Avenue with 21-inch storm sewer	13,000	0
	6. Replace 267 feet of 18-inch clay storm sewer in Indiana Avenue between Kilbourn Street and the Milwaukee River with 42-inch storm sewer	60,000	-50
	7. Replace 94 feet of 18-inch clay storm sewer in Indiana Avenue between Kilbourn Street and the Milwaukee River with 42-inch storm sewer	21,000	-20
	Subtotal	$ 360,000	$ -240
T	1. Install 520 feet of 12-inch storm sewer	$ 23,000	$ 210
	2. Install 1,395 feet of 15-inch storm sewer	231,000	560
	3. Install 785 feet of 18-inch storm sewer	48,000	150
	4. Install 405 feet of 21-inch storm sewer	29,000	160
	5. Install 1,795 feet of 24-inch storm sewer	148,000	660
	6. Install 1,295 feet of 27-inch storm sewer	120,000	520
	7. Install 590 feet of 30-inch storm sewer	62,000	230
	8. Install 80 feet of 36-inch storm sewer	11,000	20
	9. 360 feet of 38-inch by 24-inch concrete HE storm sewer	45,000	70

Table 9 (continued)

Hydrologic Unit	Project and Component Description[a]	Estimated Cost	
		Capital[b]	Annual Operation and Maintenance[c]
T (continued)	10. 1,070-foot-long, trapezoidal, turf-lined channel with one vertical on four horizontal side slopes and a 4-foot bottom width	$ 31,000	$ 430
	11. Two 34-foot-long, 24-inch-diameter culverts under North River Road	4,000	0
	12. Incremental quantity control portion of basin WD27, 0.83-acre-foot detention basin to serve planned development	19,000	250
	Subtotal	$ 771,000	$ 3,260
Z	1. Replace 264 feet of 12-inch polyvinyl chloride storm sewer in private drive east of Camden Lane with 15-inch storm sewer	$ 18,000	$ 100
	2. Replace 143 feet of 12-inch storm sewer in Woodlawn Avenue south of Greentree Road with 15-inch storm sewer	9,000	60
	3. Replace 43 feet of 24-inch corrugated metal storm sewer at the hydrologic unit outfall to the Milwaukee River with 27-inch storm sewer	6,000	20
	Subtotal	$ 33,000	$ 180
AB	1. Replace 159 feet of 12-inch storm sewer in Monroe Street southwest of Roosevelt Drive with 18-inch storm sewer at a slope of 2.8 percent	$ 13,000	$ 0
	2. Replace 77 feet of 15-inch storm sewer in the intersection of Monroe Street and Roosevelt Drive with 21-inch storm sewer at a slope of 2.5 percent	7,000	0
	3. Replace 348 feet of 15-inch storm sewer in Monroe Street between Roosevelt and River Drives with 24-inch storm sewer at a slope of 3.9 percent	39,000	0
	4. Replace an estimated 30 feet of 2-foot-square concrete box culvert in the intersection of River Drive and Monroe Street with 24-inch storm sewer at a slope of 3.9 percent	3,000	0
	Subtotal	$ 62,000	$ 0
AE	1. Replace 419 feet of 15-inch storm sewer in Main Street southeast of Barton Avenue with 21-inch storm sewer at a slope of 2.9 percent	$ 41,000	$ 0
	2. Replace 439 feet of 18-inch storm sewer in Main Street between Spring Street and Fond du Lac Street with 24-inch storm sewer at a slope of 1.85 percent	49,000	0
	3. Replace 310 feet of 18-inch storm sewer in Main Street south of Fond du Lac Street with 24-inch storm sewer at a slope of 2.9 percent	35,000	0
	4. Replace 339 feet of 24-inch storm sewer in an easement between Main Street and the Milwaukee River with 53-inch-wide by 34-inch-high HE pipe at a slope of 0.34 percent	88,000	0
	5. Construct a 100-foot-long outlet channel from the downstream end of the proposed 53-inch-wide by 34-inch-high HE outfall to the Milwaukee River	1,000	100
	Subtotal	$ 214,000	$ 100

Table 9 (continued)

Hydrologic Unit	Project and Component Description[a]	Estimated Cost	
		Capital[b]	Annual Operation and Maintenance[c]
AF	1. Replace 99 feet of 12-inch storm sewer in Main Street at Martin Court with 21-inch storm sewer	$ 9,000	$ 0
	2. Replace 422 feet of 15-inch storm sewer in Main Street between Martin Court and Silverbrook Drive with 24-inch storm sewer	47,000	0
	3. Replace 95 feet of 18-inch storm sewer in Silverbrook Drive extended at the outlet of subbasin MR367 with 36-inch storm sewer	18,000	-20
	4. Install 57 feet of 18-inch storm sewer in Washington Street (STH 33)	5,000	20
	5. Replace 357 feet of 12-inch storm sewer in Washington Street (STH 33) with 336 feet of 18-inch storm at slopes of 5.0 and 5.5 percent and with 44 feet of 21-inch storm sewer at a slope of 2.0 percent[g]	32,000	10
	6. Install 85 feet of 30-inch storm sewer at a slope of 0.41 percent in the intersection of Washington Street (STH 33) and 8th Avenue[h]	13,000	30
	7. Replace 115 feet of 18-inch clay storm sewer in 8th Avenue with 30-inch storm sewer at a slope of 0.41 percent	17,000	0
	8. Replace 272 feet of 18-inch clay storm sewer in Main Street and Beech Street extended at the outlet of Subbasin MR154 with 27-inch storm sewer	34,000	0
	9. Install 40 feet of 18-inch storm sewer in Washington Street (STH 33)[i]	3,000	20
	10. Install 90 feet of 12-inch storm sewer in 9th Avenue[i,j]	5,000	40
	11. Install 123 feet of 18-inch storm sewer in 9th Avenue and Washington Street (STH 33)[i,j]	10,000	50
	12. Install 79 feet of 12-inch storm sewer in 7th Avenue[i,j]	4,000	30
	13. Install 48 feet of 18-inch storm sewer in 7th Avenue[i,j]	4,000	20
	14. Replace 628 feet of 12- and 15-inch storm sewer in Washington Street (STH 33) with 624 feet of 21-inch storm sewer	60,000	0
	Subtotal	$ 261,000	$ 200
AH	1. Replace 141 feet of 12-inch storm sewer in Barton Avenue (STH 144) with 21-inch storm sewer	$ 13,000	$ 0
	2. Replace 318 feet of 12-inch storm sewer and 187 feet of various types of storm sewer in Monroe Street and Monroe Street extended at the outfall to the Milwaukee River with 18-inch storm sewer at a slope of 3.6 percent	41,000	0
	3. Replace 161 feet of 15-inch storm sewer in Schmidt Road with 18-inch storm sewer	13,000	0
	4. Replace 255 feet of 24-inch storm sewer in Schmidt Road with 30-inch storm sewer	38,000	0
	5. Replace 342 feet of 27-inch storm sewer in Schmidt Road with 45-inch-wide by 29-inch-high HE storm sewer	71,000	-60
	Subtotal	$ 176,000	$ -60

Table 9 (continued)

Hydrologic Unit	Project and Component Description[a]	Estimated Cost	
		Capital[b]	Annual Operation and Maintenance[c]
AI	1. Replace 276 feet of 15-inch clay storm sewer in Mayer Street with 24-inch storm sewer at a slope of 1.3 percent	$ 31,000	$ 0
	2. Replace 162 feet of 15-inch clay storm sewer in Mayer Street with 21-inch storm sewer	16,000	0
	3. Replace 170 feet of 18-inch clay storm sewer in Wilson Street with 196 feet of 27-inch storm sewer at a slope of 2.2 percent	25,000	0
	4. Replace 291 feet of 18-inch clay storm sewer in North Street between Wilson and E. Washington Streets with 27-inch storm sewer at a slope of 3.7 percent	37,000	0
	5. Replace 60 feet of 18-inch storm sewer in the intersection of North and E. Washington Streets with 24-inch storm sewer	7,000	0
	6. Replace 37 feet of 15-inch clay storm sewer in the intersection of Edgewood Lane and Wisconsin Street with 27-inch storm sewer at a slope of 0.82 percent	5,000	0
	7. Replace 33 feet of 15-inch clay storm sewer in Wisconsin Street with 27-inch storm sewer at a slope of 0.82 percent	4,000	0
	8. Replace 335 feet of 18-inch clay storm sewer in Wisconsin Street with 27-inch storm sewer at a slope of 0.82 percent	43,000	0
	9. Replace 191 feet of 36-inch storm sewer in E. Washington Street at the hydrologic unit outlet with 42-inch storm sewer	43,000	0
	Subtotal	$ 211,000	$ 0
AJ	1. Replace 513 feet of 12-inch clay pipe storm sewer in Forest Avenue between Willow Lane and Water Street with 18-inch storm sewer	$ 42,000	$ 0
	2. Replace 373 feet of 12-inch clay storm sewer in Water Street with 30-inch-wide by 19-inch-high HE reinforced concrete storm sewer	46,000	0
	3. Replace 418 feet of 12-inch clay or reinforced concrete storm sewer in Water Street with 24-inch storm sewer at a slope of 1.9 percent	47,000	0
	4. Replace 126 feet of 12-inch storm sewer in Island Avenue with 24-inch storm sewer at a slope of 2.7 percent	14,000	0
	Subtotal	$ 149,000	$ 0
AK	1. Replace 410 feet of 12-inch storm sewer in, and in an easement west of, Island Avenue between Water Street and E. Washington Street (STH 33) with 27-inch storm sewer	$ 53,000	$ 0
	Subtotal	$ 53,000	$ 0
AL	1. Replace 261 feet of 15-inch clay storm sewer in Forest Avenue with 21-inch storm sewer	$ 25,000	$ 0
	2. Replace 296 feet of 15-inch clay storm sewer in Forest Avenue with 38-inch-wide by 24-inch-high HE reinforced concrete storm sewer	50,000	0

Table 9 (continued)

Hydrologic Unit	Project and Component Description[a]	Estimated Cost	
		Capital[b]	Annual Operation and Maintenance[c]
AL (continued)	3. Replace 265 feet of 15-inch clay storm sewer in Forest Avenue with 27-inch storm sewer	$ 34,000	$ 0
	4. Replace 33 feet of 18-inch corrugated metal storm sewer in Forest Avenue with 27-inch storm sewer . . .	4,000	0
	5. Replace 496 feet of 18-inch corrugated metal storm sewer in Forest Avenue extended with 30-inch storm sewer	74,000	0
	6. Replace 288 feet of 12-inch clay and reinforced concrete storm sewer in Forest Avenue with 23-inch-wide by 14-inch-high HE reinforced concrete storm sewer	24,000	0
	7. Replace 235 feet of 12-inch storm sewer in Forest Avenue with 24-inch storm sewer	26,000	0
	Subtotal	$ 237,000	$ 0
AM	1. Replace 26 feet of 12-inch storm sewer in the intersection of Washington Street (STH 33) and Indiana Avenue with 18-inch storm sewer at a slope of 2.2 percent	$ 2,000	$ 0
	2. Replace 86 feet of 15-inch storm sewer in Indiana Avenue with 18-inch storm sewer at a slope of 2.2 percent	7,000	0
	3. Replace 504 feet of 12-inch storm sewer in Indiana Avenue with 18-inch storm sewer	42,000	0
	4. Replace 604 feet of 15-inch clay and RCP storm sewer in Indiana Avenue with 24-inch storm sewer	68,000	0
	5. Replace 832 feet of 24-inch storm sewer in Indiana Avenue with 30-inch storm sewer at a slope of 0.99 percent	125,000	0
	6. Replace 335 feet of 21-inch storm sewer in Indiana Avenue with 30-inch storm sewer at a slope of 0.99 percent	50,000	0
	7. Replace 170 feet of 24-inch storm sewer in Indiana Avenue with 36-inch storm sewer	33,000	-30
	Subtotal	$ 327,000	$ -30
AP	1. Replace 645 feet of 15-inch storm sewer in Hillcrest Street with 21-inch storm sewer	$ 62,000	$ 0
	2. Replace 307 feet of 18-inch storm sewer in Hillcrest Street with 24-inch storm sewer	34,000	0
	3. Replace 144 feet of 18-inch storm sewer in Eastern Avenue with 24-inch storm sewer	16,000	0
	Subtotal	$ 112,000	$ 0
AQ	1. Replace 675 feet of 58-inch-wide by 36-inch-high CMP storm sewer with 53-inch-wide by 34-inch-high HE storm sewer	$ 176,000	$ 0
	2. Install 380 feet of 21-inch storm sewer through Riverside Park north of Kilbourn Street	36,000	150
	Subtotal	$ 212,000	$ 150

Table 9 (continued)

Hydrologic Unit	Project and Component Description[a]	Estimated Cost	
		Capital[b]	Annual Operation and Maintenance[c]
AS	1. Detention basin WD28 with a 10-year live storage volume of 1.1 acre-foot. Water quantity control cost[k]	$ 23,000	$ 350
	2. 65 feet of 30-inch storm sewer for inlet to detention basin WD28	10,000	- -[l]
	3. 65 feet of 24-inch storm sewer for outlet from detention basin WD28	7,000	- -[l]
	Subtotal	$ 40,000	$ 350
AU	1. Replace 12 feet of 12-inch clay storm sewer in the intersection of Elm Street and 10th Avenue with 21-inch storm sewer at a slope of 1.2 percent	$ 1,000	$ 0
	2. Replace 283 feet of 15-inch clay storm sewer in Elm Street with 21-inch storm sewer at a slope of 1.2 percent	27,000	0
	3. Replace 38 feet of 15-inch clay storm sewer in the intersection of Elm Street and 9th Avenue with 24-inch storm sewer at a slope of 2.2 percent	4,000	0
	4. Replace 178 feet of 15-inch clay storm sewer in 9th Avenue with 30-inch storm sewer at a slope of 0.76 percent	27,000	0
	5. Replace 260 feet of two parallel 15-inch clay storm sewers in 9th Avenue with one 30-inch storm sewer at a slope of 0.76 percent	39,000	0
	6. Replace 47 feet of 6-inch clay storm sewer in the intersection of Cedar Street and 10th Avenue with 12-inch storm sewer	2,000	0
	7. Replace 85 feet of 12-inch clay storm sewer in 10th Avenue with 12-inch storm sewer at a slope of 2.6 percent	4,000	0
	8. Replace 26 feet of 12-inch clay storm sewer in the intersection of Cedar Street and 10th Avenue with 12-inch storm sewer at a slope of 3 percent	1,000	0
	9. Replace 336 feet of 24-inch clay storm sewer in the intersection of Cedar Street and 9th Avenue and in Cedar Street between 8th and 9th Avenues with 30-inch storm sewer at a slope of 2.5 percent	51,000	0
	10. Replace 167 feet of 18-inch clay storm sewer in an easement east of 8th Avenue with 21-inch storm sewer at a slope of 4.9 percent	16,000	0
	11. Replace 300 feet of 12-inch clay storm sewer in an alley south of Cedar Street between 7th and 8th Avenues and in an easement between the alley and 7th Avenue with 30-inch storm sewer at a slope of 1.2 percent	45,000	0
	12. Replace 340 feet of 24-inch reinforced concrete and clay storm sewer in the intersection of Cedar Street and 8th Avenue and in Cedar Street between 7th and 8th Avenues with 30-inch storm sewer at a slope of 3.6 percent	50,000	0

Table 9 (continued)

Hydrologic Unit	Project and Component Description[a]	Estimated Cost	
		Capital[b]	Annual Operation and Maintenance[c]
AU (continued)	13. Replace 179 feet of 24-inch clay storm sewer in Cedar Street between 7th Avenue and Main Street with 36-inch storm sewer	$ 35,000	$ -30
	14. Replace 65 feet of 15-inch clay storm sewer in Cedar Street between 7th Avenue and Main Street with 36-inch storm sewer at a slope of 1.7 percent	13,000	-10
	15. Replace 283 feet of 36-inch reinforced concrete and corrugated metal storm sewer in Mill Street and at the hydrologic unit outlet to the Milwaukee River with 42-inch storm sewer at a slope of 0.85 percent	64,000	0
	16. Replace 38 feet of 12-inch storm sewer in Main Street with 18-inch storm sewer	3,000	0
	17. Replace 187 feet of 18-inch storm sewer in Main Street with 24-inch storm sewer at a slope of 0.89 percent	21,000	0
	18. Replace 386 feet of 30-inch storm sewer in Main Street with 42-inch storm sewer at a slope of 0.79 percent	86,000	0
	Subtotal	$ 489,000	$ -40
AY	1. Install 660 feet of 12 inch storm sewer	$ 33,000	$ 270
	2. Install 1,220 feet of 15-inch storm sewer	76,000	490
	3. Install 1,130 feet of 18-inch storm sewer	76,000	450
	4. Install 425 feet of 21-inch storm sewer	29,000	170
	5. Install 35 feet of 24-inch storm sewer	3,000	10
	6. Install 370 feet of 27-inch storm sewer	34,000	100
	7. Install 555 feet of 30-inch storm sewer	71,000	230
	8. Install 325 feet of 36-inch storm sewer	63,000	60
	9. Construct 35-foot-long, turf-lined open channel from 24-inch-diameter storm sewer to Milwaukee River	500	30
	10. Construct 25-foot-long, turf-lined open channel from 18-inch-diameter storm sewer to Milwaukee River	400	50
	Subtotal	$ 385,900	$ 1,860
AZ	1. 285-foot minimum length, trapezoidal, turf-lined open channel with 3-foot-wide bottom and one vertical on four horizontal side slopes; located between Woodford Drive and the Wisconsin Central Transportation Corporation	$ 3,000	$ 100
	Subtotal	$ 3,000	$ 100
BC	1. Install 205 feet of 12-inch storm sewer	$ 9,000	$ 80
	2. Install 370 feet of 18-inch storm sewer	23,000	150
	3. Install 360 feet of 24-inch storm sewer	30,000	140
	4. Install 940 feet of 27-inch storm sewer	88,000	350
	5. Install 570 feet of 36-inch storm sewer	75,000	110
	6. Install 530 feet of 42-inch storm sewer	84,000	100
	7. Construct 75-foot-long, riprap-lined, open channel from detention basin WD24 outlet to Milwaukee River	4,000	30
	8. Construct 120-foot-long, riprap-lined, open channel from 27-inch storm sewer outfall to Milwaukee River	6,000	50
	Subtotal	$ 319,000	$ 1,010

Table 9 (continued)

Hydrologic Unit	Project and Component Description[a]	Estimated Cost	
		Capital[b]	Annual Operation and Maintenance[c]
BE	1. Install 720 feet of new 24-inch storm sewer	$ 60,000	$ 280
	2. Install 230 feet of new 24-inch storm sewer	21,000	90
	3. Install 815 feet of 30-inch storm sewer	86,000	320
	4. Install 295 feet of new 36-inch storm sewer	39,000	60
	5. Install 430 feet of new 48-inch storm sewer	84,000	80
	6. Install 360 feet of new 51-inch-wide by 31-inch-high RCPA storm sewer	67,000	70
	7. Install 440 feet of new 53-inch-wide by 34-inch-high storm sewer	81,000	80
	8. Install 1,180 feet of new 58-inch-wide by 36-inch-high RCPA storm sewer	266,000	230
	9. Detention basin WD7 with a 10-year storm live storage volume of 7.2 acre-feet. Water quantity control cost	73,000	1,800
	Subtotal	$ 777,000	$ 3,010
- -	Total	$22,602,000	$40,700

NOTE: The following abbreviations have been used: CMP = corrugated metal pipe; CMPA = corrugated metal pipe arch; HE = horizontal elliptical; RCP = reinforced concrete pipe; RCPA = reinforced concrete pipe arch; and SPPA = structural plate pipe arch.

[a] *All new and replacement storm sewers are reinforced concrete pipe.*

[b] *Includes 35 percent for engineering, administration, and contingencies. Costs are for year 1991 with Engineering News-Record Construction Cost Index = 5,015.*

[c] *Costs were noted to be zero when the alternative proposed replacement of a component with a component having similar operation and maintenance cost.Negative costs were noted when the replacement component was estimated to have a smaller operation and maintenance cost than that of the existing facility.*

[d] *The water quality control costs of detention basins WD25 and WD26 which are set forth in Table 19 to enable comparison of alternatives are omitted here since those costs are included in Table 86 of Chapter IV of this volume.*

[e] *The water quality control cost of detention basin WD3 which is set forth in Table 36 to enable comparison of alternatives is omitted here since that cost is included in Table 86 of Chapter IV of this volume.*

[f] *The existing storm sewers are utilized.*

[g] *Wisconsin Department of Transportation Project No. 1410-01-70, "Proposed Improvement of W. Washington Street," November 23, 1992, design drawings call for an 18-inch storm sewer at this location. A 21-inch storm sewer is recommended here to convey the estimated peak rate of runoff from a 10-year recurrence interval storm and to insure the proper functioning of downstream replacement storm sewers, as recommended under this plan.*

[h] *Wisconsin Department of Transportation Project No. 1410-01-70 calls for an 18-inch storm sewer at this location. A 30-inch storm sewer is recommended here to convey the estimated peak rate of runoff from a 10-year recurrence interval storm and to insure the proper functioning of downstream replacement storm sewers, as recommended under this plan.*

[i] *As called for under Wisconsin Department of Transportation Project No. 1410-01-70.*

[j] *Replacing existing storm sewers and laid along a different alignment.*

[k] *As set forth in Chapter IV of this Volume, the capital cost of the water quality control portion of basin WD28 is $85,000 and the annual operation and maintenance cost is $1,800.*

[l] *Annual operation and maintenance cost included under Item 1.*

Source: SEWRPC.

The components and costs of the recommended plan are set forth in Table 9. The approximate location, alignment, and configuration of the recommended facilities, including the nonpoint source pollution control measures recommended in Chapter IV of this volume, are shown graphically on Map 14. The total present value cost of this plan is $285,000, consisting of an estimated capital cost of $270,000 and an estimated annual operation and maintenance cost increase of $980.

Hydrologic Unit MR-B

Evaluation of the Stormwater Management System: Hydrologic Unit MR-B is a 0.06-square-mile area located along the Milwaukee River, as shown on Map 1 in Chapter I of this volume. Under planned year 2010 conditions, about 98 percent of the hydrologic unit would be developed in urban uses, which consist primarily of low- and medium-density residential uses. The existing stormwater management system consists of roadside swales and driveway culverts in the urbanized southern portion of this hydrologic unit. There are no identified intermittent or perennial streams within the hydrologic unit and the existing roadside swales discharge directly to the Milwaukee River. Owing to the relatively low development density of the hydrologic unit under existing conditions, there are no known existing, significant stormwater drainage problems in the unit.

Alternative Stormwater Drainage Plans: The following two alternative stormwater management plans were considered for Hydrologic Unit B: 1) a storm sewer and open channel conveyance plan and 2) a storm sewer and open channel conveyance with centralized detention plan.

Alternative Plan No. B-1, Storm Sewer and Open Channel Conveyance: Under planned land use conditions, the storm sewer and open channel conveyance alternative plan would convey runoff through the provision of 1,760 lineal feet of new 24-inch- to 36-inch-diameter reinforced concrete storm sewer and 50 lineal feet of turf-lined trapezoidal open channel. The channel would provide an outlet for the proposed storm sewer and it would have average side slopes of one vertical on four horizontal, or other equivalent shape, and would have an average channel-bottom width of three feet. This alternative also assumes utilization of the roadside swales in the existing residential development south of Norman Road to convey runoff. Map 7 shows the approximate location and alignment of the stormwater drainage facilities proposed under this alternative. Table 10 presents the salient characteristics and estimated costs of the proposed storm sewers comprising this alternative plan. The total present value cost of this alternative plan is $193,000, including an estimated capital cost of $183,000 and an estimated annual operation and maintenance cost increase of $650.

Alternative Plan No. B-2, Storm Sewer and Open Channel Conveyance with Centralized Detention: This alternative enables the downsizing of 1,585 lineal feet of proposed new storm sewers because of the reduction in peak flood flows achieved through the provision of detention storage for the control of runoff. In addition, 175 lineal feet of storm sewer which would be installed under Alternative B-1 would be eliminated under Alternative B-2. The alternative calls for 1,700 lineal feet of new 15-inch- to 30-inch-diameter reinforced concrete storm sewer. Map 8 shows the approximate location, alignment, and configuration of the facilities called for under this alternative. Table 11 presents the salient characteristics and estimated costs of the proposed storm sewers and the 0.5-acre-foot detention basin B-1 which comprise this alternative plan. The total present value cost of this alternative plan is $167,000, consisting of an estimated capital cost of $138,000, including land acquisition for the detention basin, and an estimated annual operation and maintenance cost increase of $1,810.

Evaluation of Alternative Stormwater Drainage Plans: The foregoing information provides a basis for a comparative evaluation of the two alternative stormwater drainage plans. Each alternative was designed to serve anticipated future development within the hydrologic unit. Thus, the principal criteria for the comparative evaluation were reduced to cost and implementability.

Alternative B-2 is less costly than Alternative B-1, but Alternative B-1 would be more easily implemented since it would involve installing storm sewers generally within existing rights-of-way and easements and would not require purchasing land or easements for the provision of detention basins.

Recommended Stormwater Management Plan: Because of the lower cost of Alternative B-2, Storm Sewer and Open Channel Conveyance with Centralized Detention, it is recommended for adoption in Hydrologic Unit B. The compo-

Map 7

STORM SEWER AND OPEN CHANNEL CONVEYANCE ALTERNATIVE PLAN FOR STORMWATER MANAGEMENT IN THE MILWAUKEE RIVER DRAINAGE AREA

HYDROLOGIC UNITS MR-A, MR-B, MR-D, MR-U, MR-V, AND MR-AW

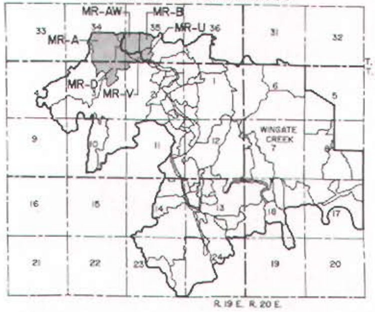
LEGEND

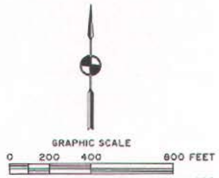
—	HYDROLOGIC UNIT BOUNDARY UNDER EXISTING DRAINAGE CONDITIONS
MR-B	HYDROLOGIC UNIT IDENTIFICATION
— —	SUBBASIN BOUNDARY
MR 257	SUBBASIN IDENTIFICATION
→	SUBBASIN OUTLET
— —	LIMITS OF PLANNED URBAN SERVICE AREA
●	PROPOSED MANHOLE
30	PROPOSED STORM SEWER OR CULVERT (SIZE IN INCHES)
—	PROPOSED OPEN CHANNEL

NOTE: 1.) PIPES ARE CONSTRUCTED OF REINFORCED CONCRETE.

2.) THIS ALTERNATIVE WAS NOT DEVELOPED FOR HYDROLOGIC UNITS MR-A, MR-D, MR-U, MR-V, AND MR-AW.

MILWAUKEE RIVER DRAINAGE AREA
HYDROLOGIC UNIT LOCATION MAP



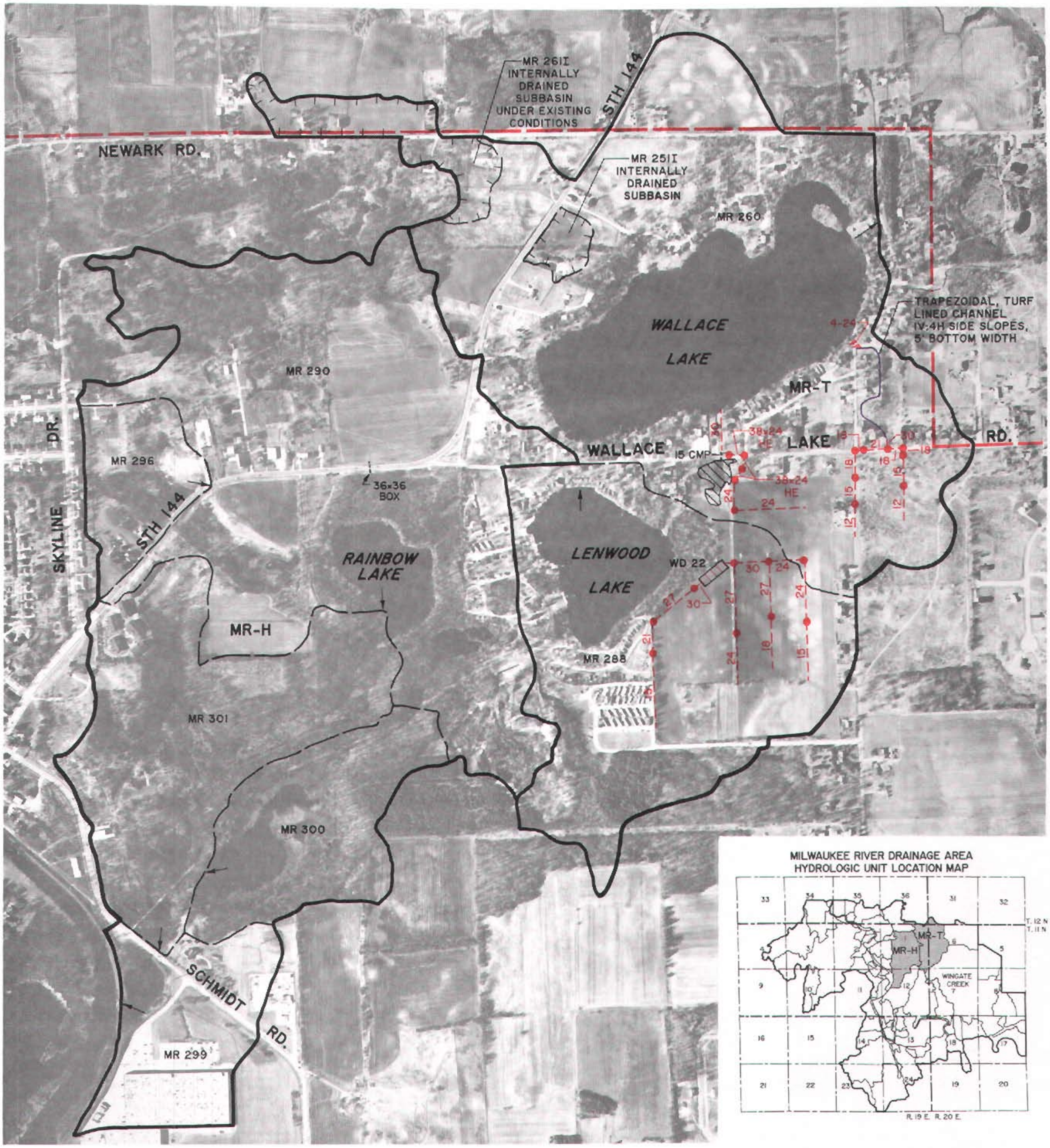


DATE OF PHOTOGRAPHY: MARCH 1990

Map 7 (continued)

STORM SEWER AND OPEN CHANNEL CONVEYANCE ALTERNATIVE PLAN FOR STORMWATER MANAGEMENT IN THE MILWAUKEE RIVER DRAINAGE AREA

HYDROLOGIC UNITS MR-H AND MR-T



LEGEND

—	HYDROLOGIC UNIT BOUNDARY UNDER EXISTING DRAINAGE CONDITIONS
MR-T	HYDROLOGIC UNIT IDENTIFICATION
— —	SUBBASIN BOUNDARY
MR 260	SUBBASIN IDENTIFICATION
→	SUBBASIN OUTLET
— —	LIMITS OF PLANNED URBAN SERVICE AREA
15	EXISTING CULVERT (SIZE IN INCHES)
24	PROPOSED STORM SEWER (SIZE IN INCHES)
●	PROPOSED MANHOLE
—	PROPOSED OPEN CHANNEL
WD 22 ▨	PERMANENT POND AREA OF PROPOSED WET DETENTION BASIN AND DESIGNATION
▨	EXISTING NATURAL DETENTION OR RETENTION STORAGE AREA
HE	HORIZONTAL ELLIPTICAL REINFORCED CONCRETE PIPE
CMP	CORRUGATED METAL PIPE

NOTE:

1.) PIPES ARE CONSTRUCTED OF REINFORCED CONCRETE UNLESS DESIGNATED AS ABOVE.

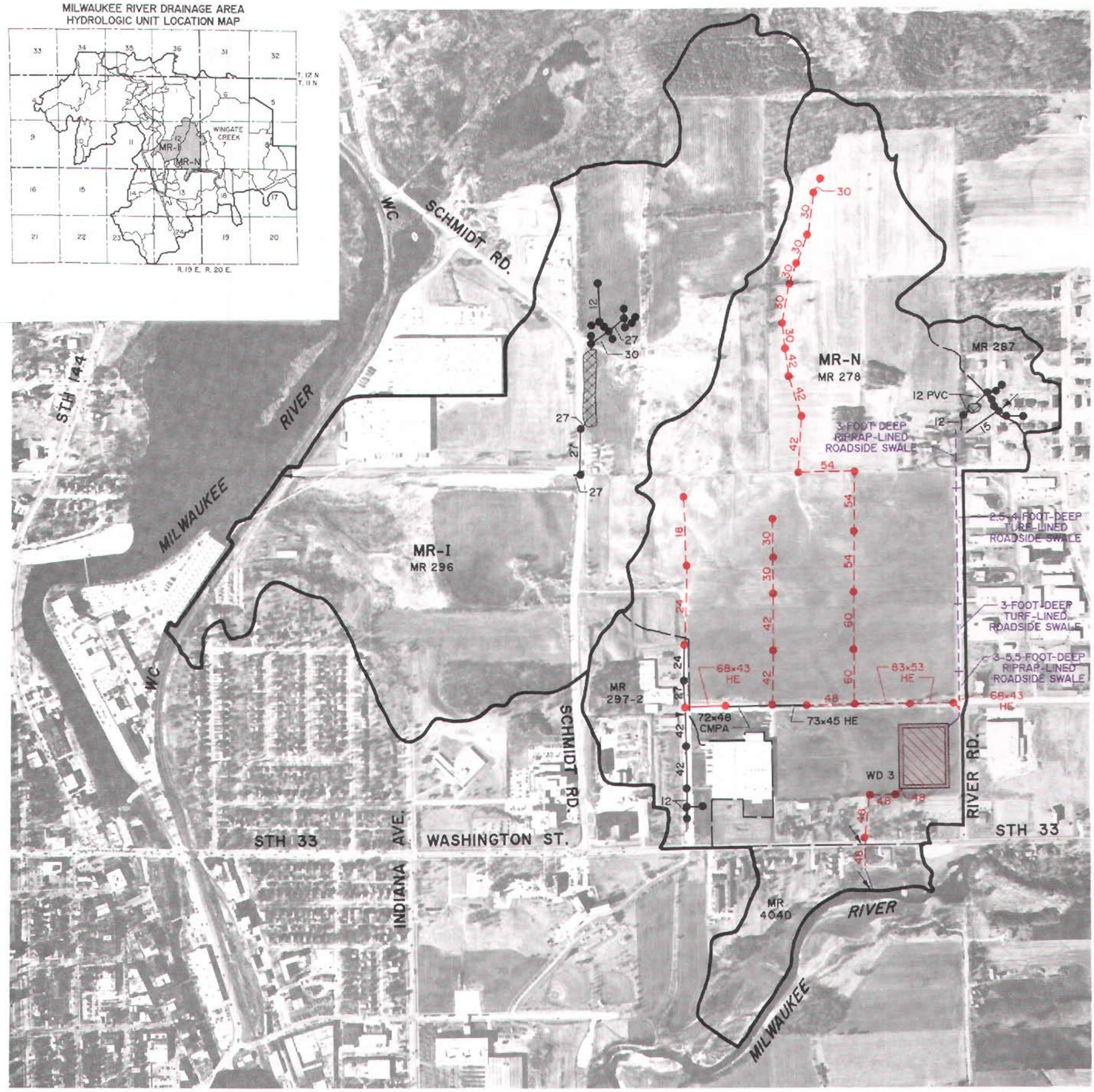
2.) THIS ALTERNATIVE WAS NOT DEVELOPED FOR HYDROLOGIC UNIT H. THEREFORE, THE EXISTING STORMWATER MANAGEMENT SYSTEM IS SHOWN FOR THAT UNIT.

GRAPHIC SCALE
0 200 400 800 FEET
DATE OF PHOTOGRAPHY: MARCH 1990

Map 7 (continued)

STORM SEWER AND OPEN CHANNEL CONVEYANCE ALTERNATIVE PLAN FOR STORMWATER MANAGEMENT IN THE MILWAUKEE RIVER DRAINAGE AREA

HYDROLOGIC UNITS MR-I AND MR-N



LEGEND

▬	HYDROLOGIC UNIT BOUNDARY UNDER EXISTING DRAINAGE CONDITIONS
MR-N	HYDROLOGIC UNIT IDENTIFICATION
— —	SUBBASIN BOUNDARY
MR 278	SUBBASIN IDENTIFICATION
→	SUBBASIN OUTLET
24	EXISTING STORM SEWER TO BE RETAINED (SIZE IN INCHES)
●	EXISTING MANHOLE OR CATCHBASIN
68×43 HE	PROPOSED REPLACEMENT CULVERT DESIGNED FOR 10-YEAR STORM (SIZE IN INCHES)
24	PROPOSED STORM SEWER OR CULVERT (SIZE IN INCHES)
●	PROPOSED MANHOLE
_ 3 _	PROPOSED ROADSIDE SWALE
—	PROPOSED OPEN CHANNEL
WD 3 ▨	PERMANENT POND AREA OF PROPOSED WET DETENTION BASIN AND DESIGNATION
WD 3 ▨	PROPOSED DUAL-PURPOSE DETENTION BASIN AND DESIGNATION
▩	EXISTING CONSTRUCTED DETENTION BASIN
PVC	POLYVINYL CHLORIDE
CMPA	CORRUGATED METAL PIPE ARCH
HE	HORIZONTAL ELLIPTICAL REINFORCED CONCRETE PIPE

NOTE:

1.) PIPES ARE CONSTRUCTED OF REINFORCED CONCRETE UNLESS DESIGNATED AS ABOVE.

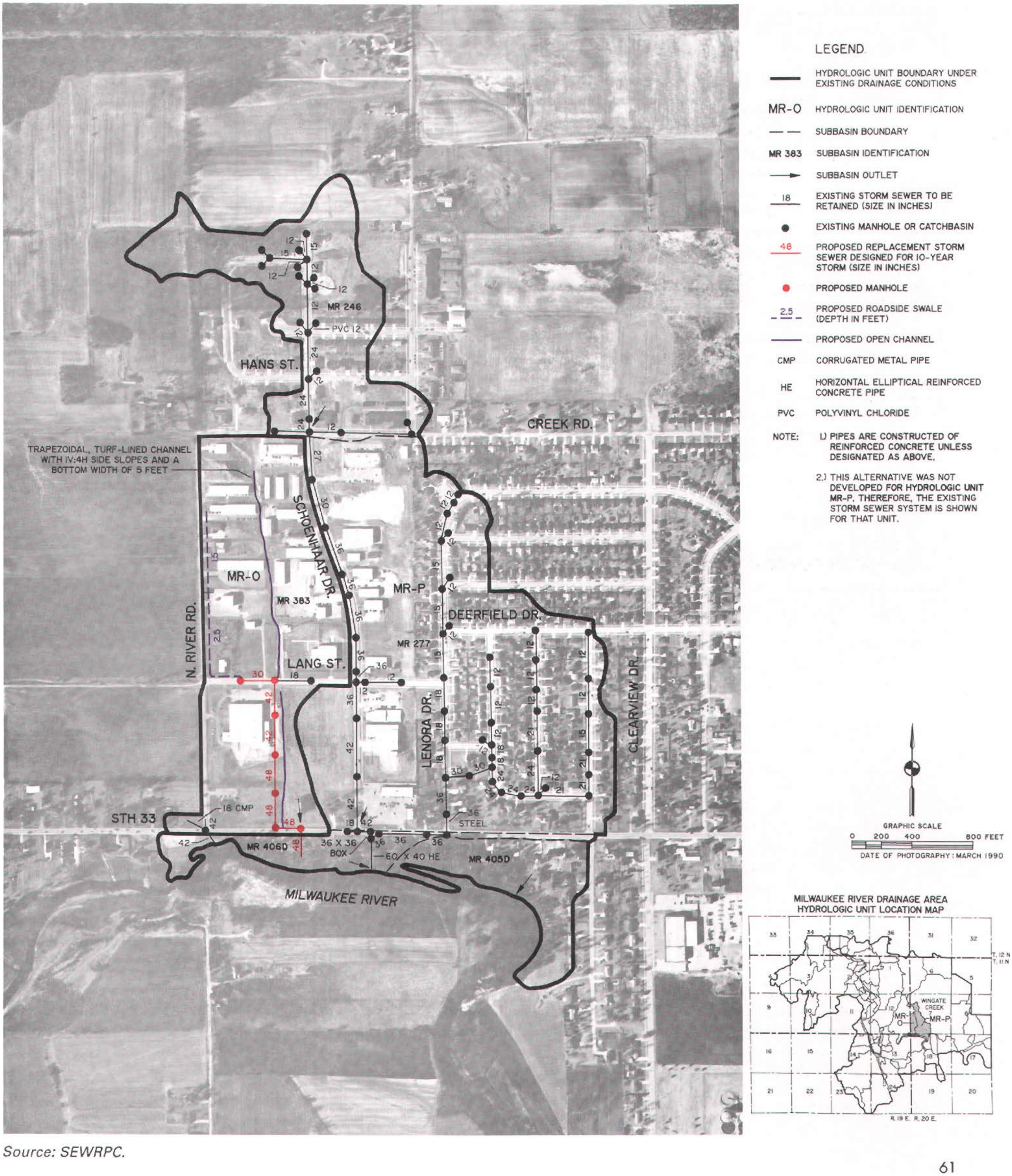
2.) THIS ALTERNATIVE WAS NOT DEVELOPED FOR HYDROLOGIC UNIT I. THEREFORE, THE EXISTING STORM SEWER SYSTEM IS SHOWN FOR THAT UNIT.

GRAPHIC SCALE
0 200 400 800 FEET
DATE OF PHOTOGRAPHY: MARCH 1990

Map 7 (continued)

STORM SEWER AND OPEN CHANNEL CONVEYANCE ALTERNATIVE PLAN FOR STORMWATER MANAGEMENT IN THE MILWAUKEE RIVER DRAINAGE AREA

HYDROLOGIC UNITS MR-O AND MR-P



Source: SEWRPC.

Table 10

ALTERNATIVE B-1: COMPONENTS AND COSTS OF THE STORM SEWER AND OPEN CHANNEL CONVEYANCE STORMWATER DRAINAGE PLAN FOR WEST BEND HYDROLOGIC UNIT MR-B

Hydrologic Unit	Project and Component Description[a]	Estimated Cost	
		Capital[b]	Annual Operation and Maintenance
B	1. Install 345 feet of new 24-inch-diameter storm sewer	$ 28,000	$140
	2. Install 465 feet of new 27-inch-diameter storm sewer	43,000	190
	3. Install 560 feet of new 30-inch-diameter storm sewer	59,000	220
	4. Install 390 feet of new 36-inch-diameter storm sewer	52,000	70
	5. Construct 50-foot-long open channel	1,000	30
- -	Total	$183,000	$650

[a] *All new and replacement storm sewers are reinforced concrete pipe.*

[b] *Includes 35 percent for engineering, administration, and contingencies. Costs are for year 1991 with Engineering News-Record CCI = 5,015.*

Source: SEWRPC.

Table 11

ALTERNATIVE B-2: COMPONENTS AND COSTS OF THE STORM SEWER AND OPEN CHANNEL CONVEYANCE WITH CENTRALIZED DETENTION STORMWATER DRAINAGE PLAN FOR WEST BEND HYDROLOGIC UNIT MR-B

Hydrologic Unit	Project and Component Description[a]	Estimated Cost	
		Capital[b]	Annual Operation and Maintenance
B	1. Install 810 feet of new 15-inch-diameter storm sewer	$ 42,000	$ 330
	2. Install 210 feet of new 18-inch-diameter storm sewer	13,000	80
	3. Install 110 feet of new 21-inch-diameter storm sewer	8,000	40
	4. Install 455 feet of new 30-inch-diameter storm sewer	48,000	180
	5. Construct 50-foot-long open channel	1,000	30
	6. Construct detention basin B-1 with a storage volume of 0.5 acre-foot	16,000	1,100
	7. 65 feet of 30-inch storm sewer for basin B-1 inlet	7,000	30
	8. 50 feet of 15-inch-diameter storm sewer for basin B-1 outlet	3,000	20
- -	Total	$138,000	$1,810

[a] *All new and replacement storm sewers are reinforced concrete pipe.*

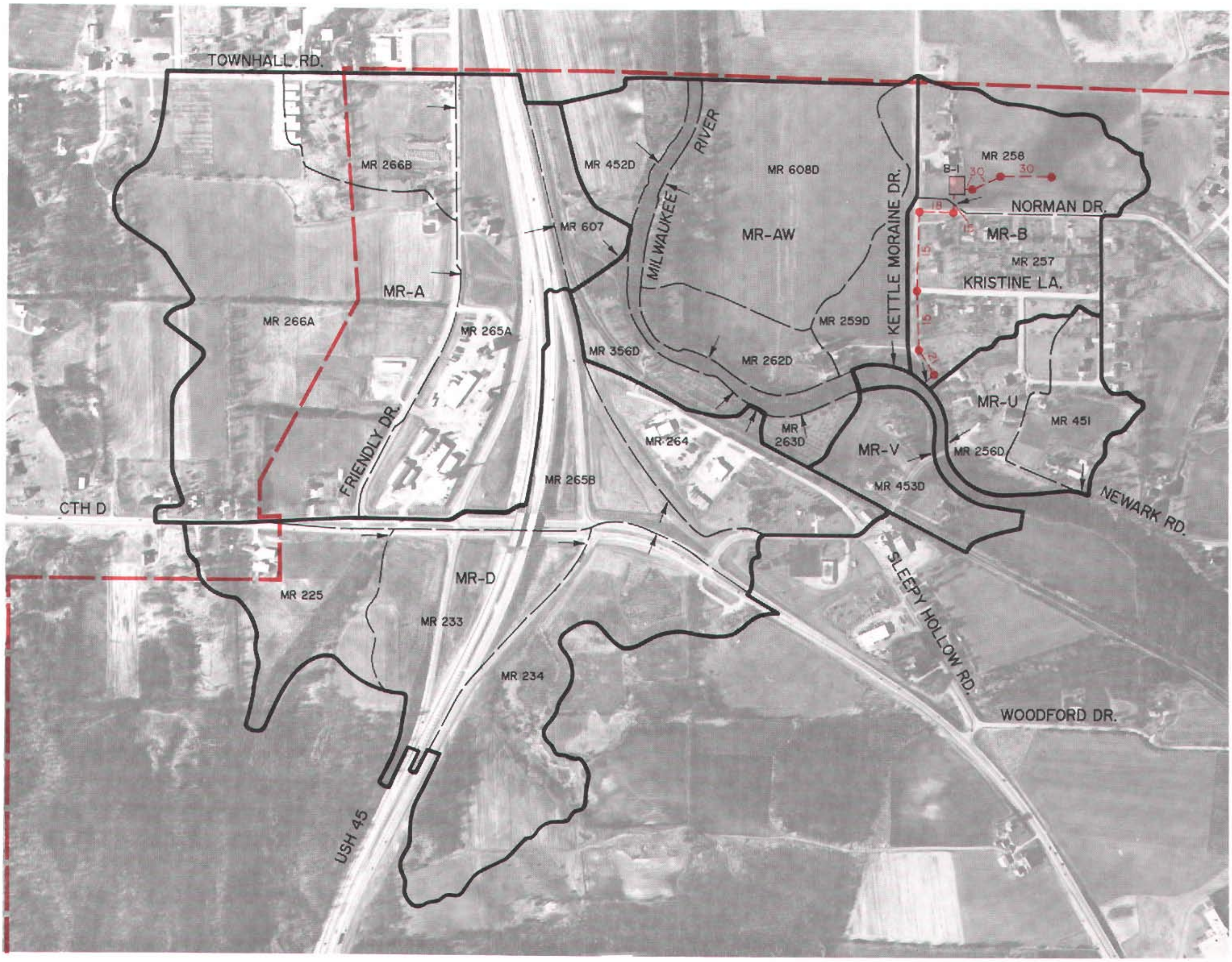
[b] *Includes 35 percent for engineering, administration, and contingencies. Costs are for year 1991 with Engineering News-Record CCI = 5,015.*

Source: SEWRPC.

Map 8

STORM SEWER AND OPEN CHANNEL CONVEYANCE WITH CENTRALIZED DETENTION ALTERNATIVE PLAN FOR STORMWATER MANAGEMENT IN THE MILWAUKEE RIVER DRAINAGE AREA

HYDROLOGIC UNITS MR-A, MR-B, MR-D, MR-U, MR-V, AND MR-AW

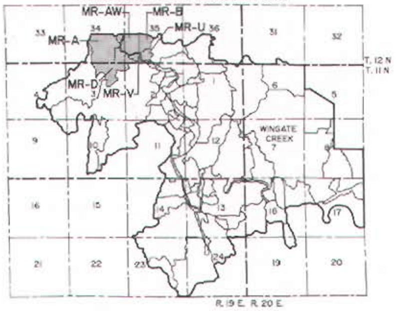


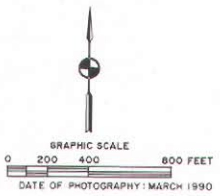
LEGEND

▬	HYDROLOGIC UNIT BOUNDARY UNDER EXISTING DRAINAGE CONDITIONS
MR-B	HYDROLOGIC UNIT IDENTIFICATION
— —	SUBBASIN BOUNDARY
MR 257	SUBBASIN IDENTIFICATION
⟶	SUBBASIN OUTLET
— —	LIMITS OF PLANNED URBAN SERVICE AREA
●	PROPOSED MANHOLE
30	PROPOSED STORM SEWER OR CULVERT (SIZE IN INCHES)
—	PROPOSED OPEN CHANNEL
B-I ▨	PROPOSED DRY DETENTION BASIN AND DESIGNATION

NOTE:
1.) PIPES ARE CONSTRUCTED OF REINFORCED CONCRETE.
2.) THIS ALTERNATIVE WAS NOT DEVELOPED FOR HYDROLOGIC UNITS MR-A, MR-D, MR-U, MR-V, AND MR-AW.

MILWAUKEE RIVER DRAINAGE AREA HYDROLOGIC UNIT LOCATION MAP



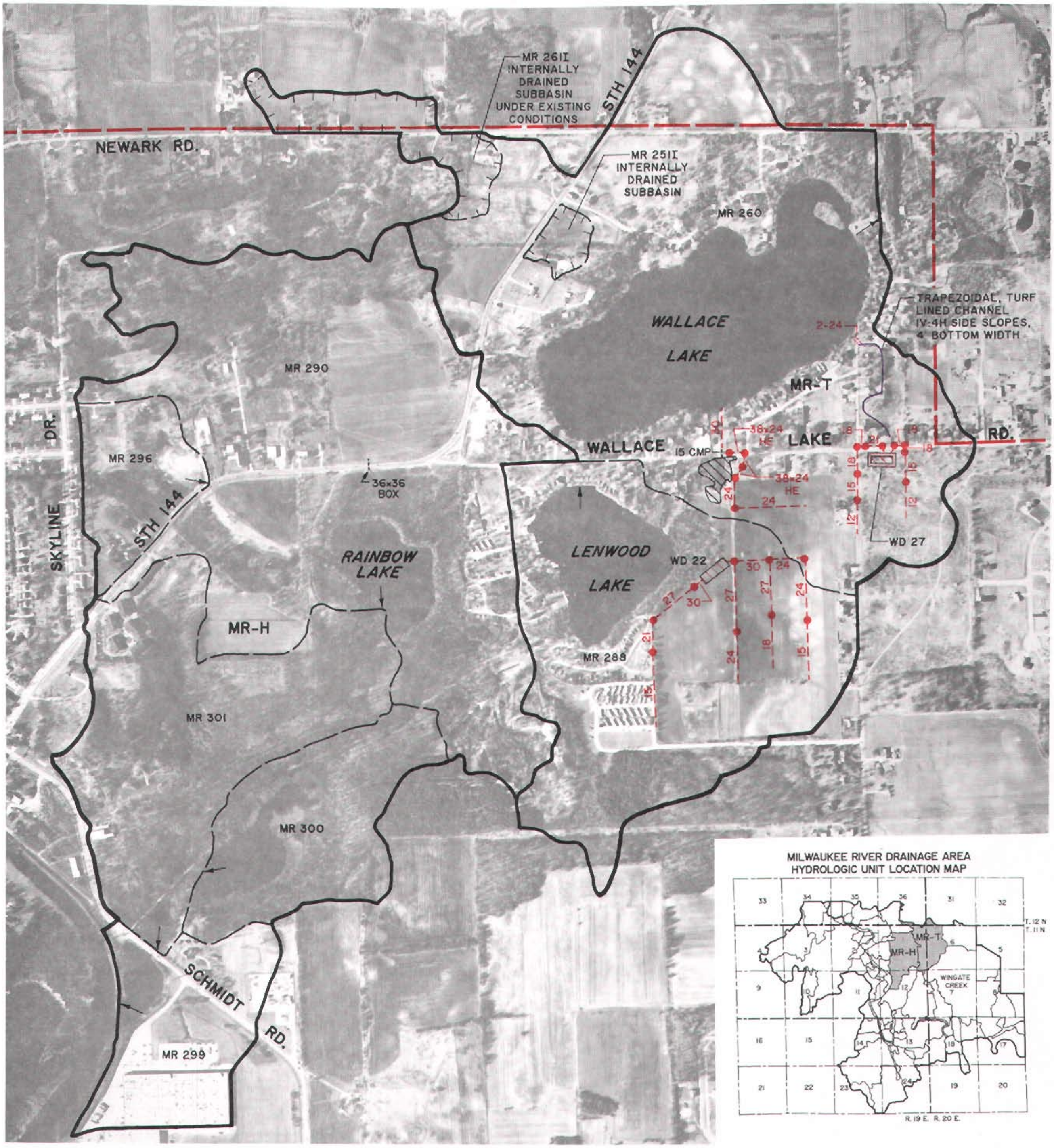


DATE OF PHOTOGRAPHY: MARCH 1990

Map 8 (continued)

STORM SEWER AND OPEN CHANNEL CONVEYANCE WITH CENTRALIZED DETENTION ALTERNATIVE PLAN FOR STORMWATER MANAGEMENT IN THE MILWAUKEE RIVER DRAINAGE AREA

HYDROLOGIC UNITS MR-H AND MR-T



LEGEND

▬	HYDROLOGIC UNIT BOUNDARY UNDER EXISTING DRAINAGE CONDITIONS
MR-T	HYDROLOGIC UNIT IDENTIFICATION
— —	SUBBASIN BOUNDARY
MR 260	SUBBASIN IDENTIFICATION
⟶	SUBBASIN OUTLET
— —	LIMITS OF PLANNED URBAN SERVICE AREA
_15_	EXISTING CULVERT (SIZE IN INCHES)
_18_	PROPOSED STORM SEWER (SIZE IN INCHES)
●	PROPOSED MANHOLE
—	PROPOSED OPEN CHANNEL
WD 22 ▨	PERMANENT POND AREA OF PROPOSED WET DETENTION BASIN AND DESIGNATION
WD 27 ▨	PROPOSED DUAL-PURPOSE DETENTION BASIN AND DESIGNATION
▨	EXISTING NATURAL DETENTION OR RETENTION STORAGE AREA
HE	HORIZONTAL ELLIPTICAL REINFORCED CONCRETE PIPE
CMP	CORRUGATED METAL PIPE

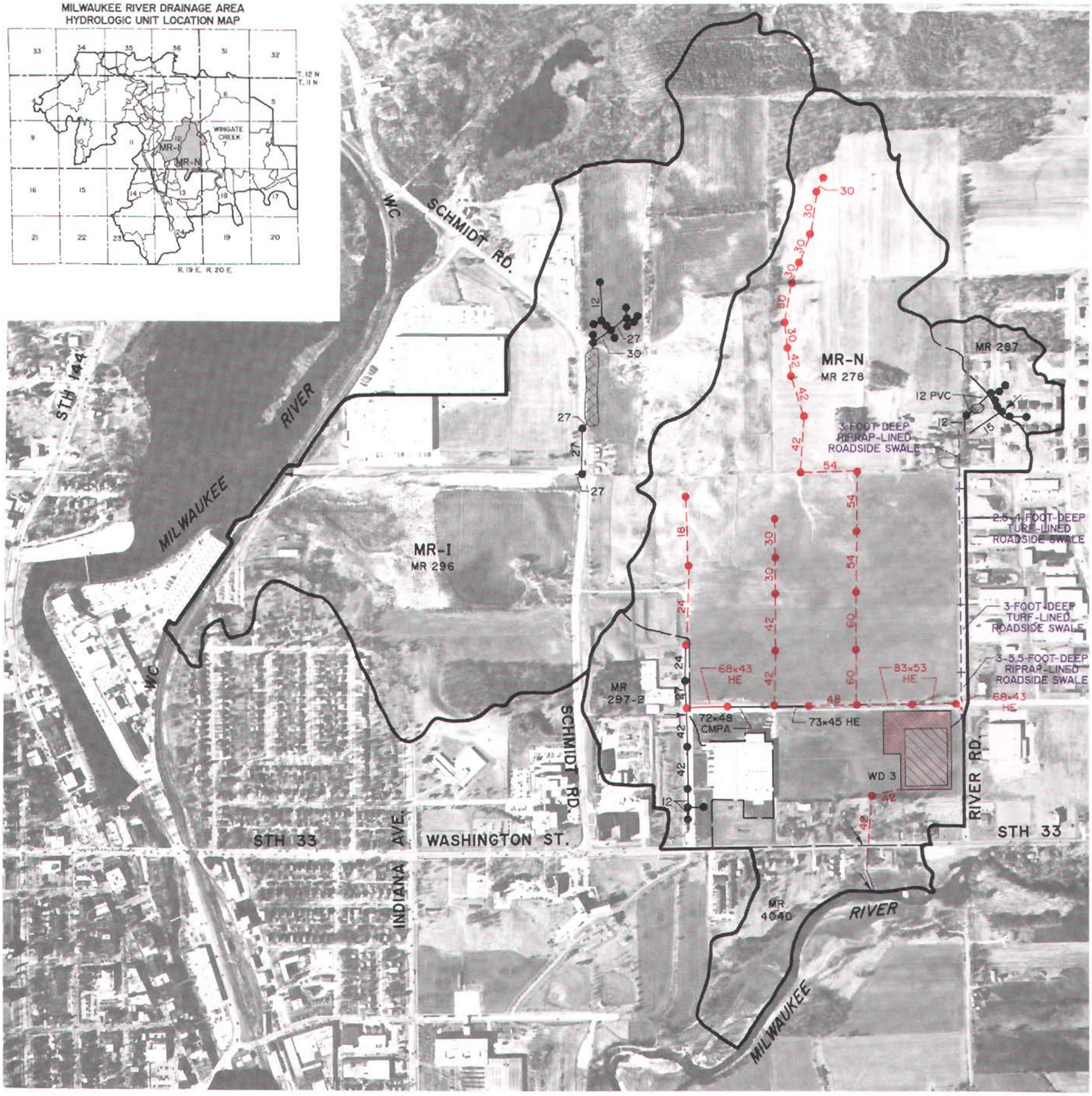
NOTE:
1.) PIPES ARE CONSTRUCTED OF REINFORCED CONCRETE UNLESS DESIGNATED AS ABOVE.
2.) THIS ALTERNATIVE WAS NOT DEVELOPED FOR HYDROLOGIC UNIT H. THEREFORE, THE EXISTING STORMWATER MANAGEMENT SYSTEM IS SHOWN FOR THAT UNIT.

GRAPHIC SCALE
0 200 400 800 FEET
DATE OF PHOTOGRAPHY: MARCH 1980

Map 8 (continued)

STORM SEWER AND OPEN CHANNEL CONVEYANCE WITH CENTRALIZED DETENTION ALTERNATIVE PLAN FOR STORMWATER MANAGEMENT IN THE MILWAUKEE RIVER DRAINAGE AREA

HYDROLOGIC UNITS MR-I AND MR-N



LEGEND

—	HYDROLOGIC UNIT BOUNDARY UNDER EXISTING DRAINAGE CONDITIONS
MR-N	HYDROLOGIC UNIT IDENTIFICATION
— —	SUBBASIN BOUNDARY
MR 278	SUBBASIN IDENTIFICATION
→	SUBBASIN OUTLET
24	EXISTING STORM SEWER TO BE RETAINED (SIZE IN INCHES)
●	EXISTING MANHOLE OR CATCHBASIN
68x43 HE	PROPOSED REPLACEMENT CULVERT DESIGNED FOR 10-YEAR STORM (SIZE IN INCHES)
24	PROPOSED STORM SEWER OR CULVERT (SIZE IN INCHES)
●	PROPOSED MANHOLE
3	PROPOSED ROADSIDE SWALE
—	PROPOSED OPEN CHANNEL
WD 3 ▨	PERMANENT POND AREA OF PROPOSED WET DETENTION BASIN AND DESIGNATION
WD 3 ▨	PROPOSED DUAL-PURPOSE DETENTION BASIN AND DESIGNATION
▨	EXISTING CONSTRUCTED DETENTION BASIN
PVC	POLYVINYL CHLORIDE
CMPA	CORRUGATED METAL PIPE ARCH
HE	HORIZONTAL ELLIPTICAL REINFORCED CONCRETE PIPE

NOTE:

1.) PIPES ARE CONSTRUCTED OF REINFORCED CONCRETE UNLESS DESIGNATED AS ABOVE.

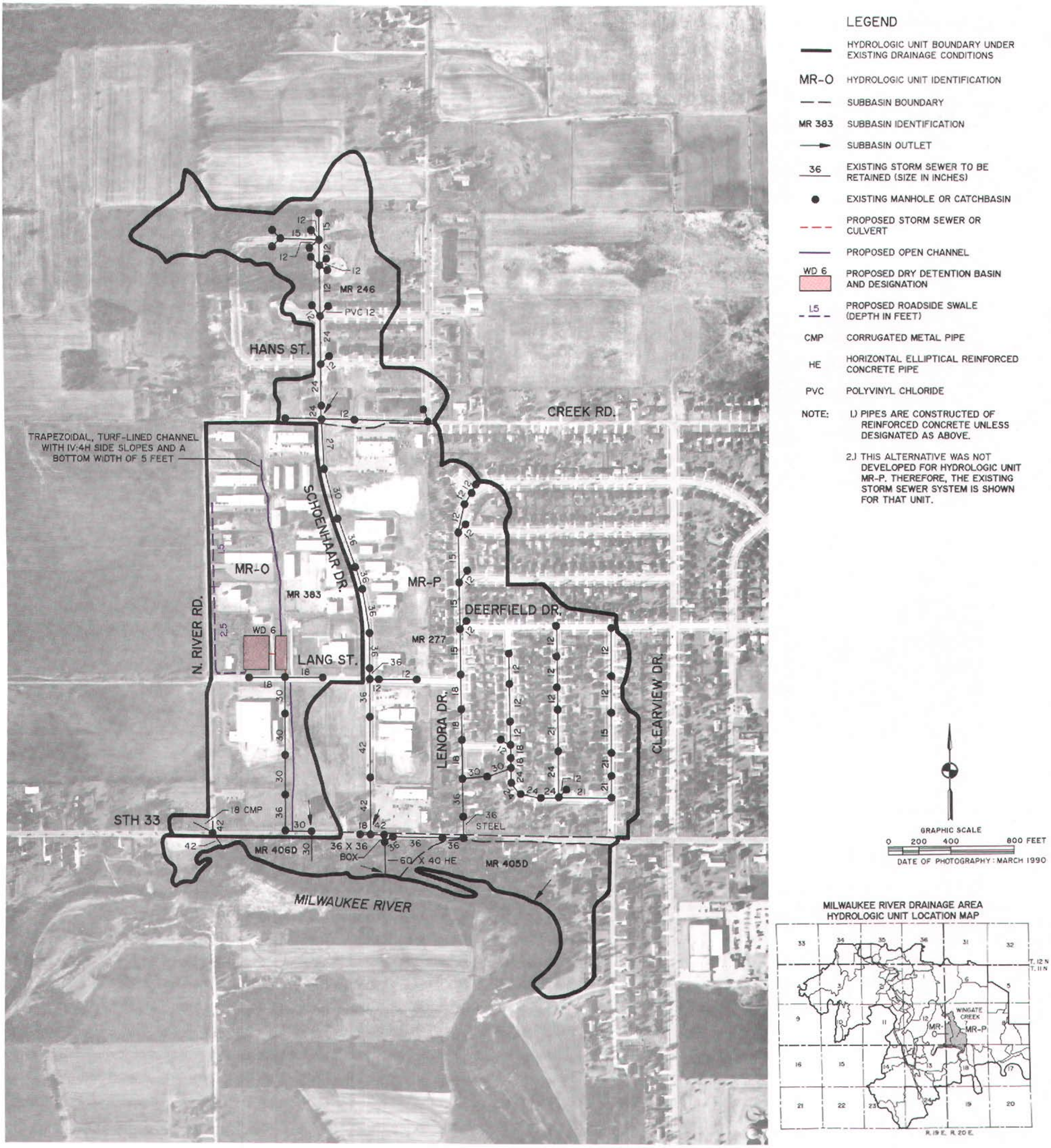
2.) THIS ALTERNATIVE WAS NOT DEVELOPED FOR HYDROLOGIC UNIT I. THEREFORE, THE EXISTING STORM SEWER SYSTEM IS SHOWN FOR THAT UNIT.

GRAPHIC SCALE
0 200 400 800 FEET
DATE OF PHOTOGRAPHY: MARCH 1990

Map 8 (continued)

STORM SEWER AND OPEN CHANNEL CONVEYANCE WITH CENTRALIZED DETENTION ALTERNATIVE PLAN FOR STORMWATER MANAGEMENT IN THE MILWAUKEE RIVER DRAINAGE AREA

HYDROLOGIC UNITS MR-O AND MR-P



Source: SEWRPC.

nents and costs of the recommended plan are set forth in Table 9 and the approximate location, alignment, and configuration of the recommended facilities is shown graphically on Map 14.

Hydrologic Unit MR-C

Evaluation of the Stormwater Management System: Hydrologic Unit MR-C is a 0.19-square-mile area located along the Milwaukee River, as shown on Map 1 in Chapter I of this volume. Under planned year 2010 conditions, the hydrologic unit would be about 54 percent developed for urban use, predominantly low- and medium-density residential. The remaining 46 percent would be devoted to agricultural, open land, woodland, and wetland uses. The existing stormwater management system consists of roadside swales and a system of interconnected wetlands and ponds north of Newark Road. The outlet is a culvert beneath Newark Road discharging to the Milwaukee River. Owing to the relatively low development density of the hydrologic unit under existing conditions and the flood-attenuating effects of the natural drainage system, there are no known existing, significant stormwater drainage problems in the unit.

Alternative Stormwater Drainage Plans: Because almost half of the hydrologic unit is to remain in agricultural, wetland, and open space uses and because detention storage already exists in the system of interconnected wetlands and ponds so located that both existing and planned development would be served, the only additional stormwater drainage measures required in this hydrologic unit are storm sewers to serve planned medium-density, single-family residential developments.

Recommended Stormwater Management Plan: The recommended plan calls for the provision of 1,010 lineal feet of new storm sewer, ranging in size from 12-inch-diameter to 23-inch-wide by 14-inch-high horizontal elliptical reinforced concrete pipe to serve areas of planned medium-density, single-family residential development.

The existing system of interconnected wetlands and ponds comprise two wetlands identified on the State wetland inventory maps. This system serves as a detention area under existing conditions, a function which would be preserved under the recommended plan. Modifications to the existing outlet structures from those ponds and wetlands are not required. It is recommended that runoff from the agricultural area in the eastern portion of the hydrologic unit be conveyed in a 100-foot-long, 15-inch-diameter reinforced concrete pipe followed by a 140-foot-long, 23-inch-wide by 14-inch-high horizontal elliptical reinforced concrete pipe. These pipes would be buried under a 310-foot-long drainage swale to be located in drainage easements along the side lot lines of residential properties. The drainage swale, which would serve the purpose of conveying runoff in excess of pipe capacity, would be lined with riprap, with average side slopes of one vertical on three horizontal. The 23-inch-wide by 14-inch-high horizontal elliptical pipe would terminate about 70 feet east of the wetland. Outflow from the pipe would be conveyed in a turf-lined, three-foot-deep trapezoidal outflow channel which would terminate outside the wetland. In addition, the plan recommends replacing the 3.4-foot-wide, 2.4-foot-high corrugated metal pipe arch under Newark Road with a 60-foot-long, 30-inch-diameter reinforced concrete pipe to accommodate the widening of Newark Road as recommended under the Washington County Jurisdictional Highway System Plan.

The components and costs of the recommended plan are set forth in Table 9. The total capital cost of this plan is about $67,000 and the estimated annual operation and maintenance cost increase is $560. The recommended stormwater drainage plan is summarized in graphic form on Map 14.

Hydrologic Unit MR-D

Evaluation of the Stormwater Management System: Hydrologic Unit MR-D is a 0.18-square-mile area located along the Milwaukee River, as shown on Map 1 in Chapter I of this volume. Under planned year 2010 land use conditions, about 60 percent of the hydrologic unit would be developed for urban uses, primarily industrial, commercial, and freeway. The remaining 40 percent would be devoted to woodland, wetland, park and recreational, agricultural, and other open space uses. The existing stormwater management system consists of roadside swales and culverts which discharge to a short unnamed tributary to the Milwaukee River.

Because of the relatively low development density of the hydrologic unit under existing conditions and the flood-attenuating effects of the natural drainage system result, there are no known existing, significant stormwater drainage problems in the unit.

Alternative Stormwater Drainage Plans: Planned urban development in this hydrologic unit would be concentrated in the northeast portion in a corridor along CTH D. Additional stormwater management facilities to serve the planned rural areas outside the corridor or to handle runoff from USH 45 are not necessary. The existing and proposed industrial and commercial development in this hydrologic unit is well-suited to an open channel-roadside swale drainage system. Because wet detention basin WD10 is called for under the water quality management element presented in Chapter IV of this volume, the open channel conveyance with centralized detention alternative plan was the most logical plan for this unit and the development of alternatives was not necessary.

Recommended Stormwater Management Plan: The recommended plan calls for utilizing the existing system of roadside swales, open channels, and culverts and constructing basin WD10 as a dual-purpose basin with a permanent pond volume of eight acre-feet and a surcharge storage volume of 4.9 acre-feet in addition to the permanent pond volume. Even if the basin were not intended to serve a water quantity control function, this amount of surcharge storage would be provided because of the need to excavate to an elevation at which the permanent pond would receive runoff conveyed by the existing upstream and downstream culvert system. The reduction in the 100-year recurrence interval peak flood flow because of the surcharge storage, would prevent flooding along the unnamed tributary to the Milwaukee River north of CTH D. The planned condition flood inundation area along that tributary is shown on Map 14.

The components and costs of the recommended plan are set forth in Table 9. The approximate location, alignment, and configuration of the recommended facilities, including the nonpoint source pollution control measures recommended in Chapter IV of this volume, are shown graphically on Map 14. The total present value cost of this plan is $192,000, consisting of an estimated capital cost of $148,000 and an estimated annual operation and maintenance cost increase of $2,800.

Hydrologic Unit MR-E

Evaluation of the Stormwater Management System: Hydrologic Unit MR-E is a 1.36-square-mile area located as shown on Map 1 in Chapter I of this volume. Under existing land use conditions, about 24 percent of the unit is developed in urban land uses. Under planned year 2010 conditions, the hydrologic unit would be about 58 percent developed for urban uses, predominantly low- and medium-density residential. The remaining 42 percent would be devoted to agricultural, open land, woodland, and wetland uses. The existing stormwater management system consists of roadside swales, curb and gutters with attendant storm sewers in some areas of residential development, several man-made ponds, and a system of interconnected wetlands which are drained by two unnamed intermittent streams. The main stream runs in a generally easterly direction for about 1.32 miles from USH 45 to its confluence with the Milwaukee River. The second stream is tributary to the first. It begins at the Juech Wildlife Area and runs in a northerly direction for about 0.80 mile, generally parallel to 18th Avenue. A third intermittent stream is located entirely within subbasin MR240. That stream runs in a westerly direction for about 0.38 mile from Main Street to its confluence with the first stream noted above.

Problems with both inadequate minor and major system hydraulic capacities were identified in parts of this hydrologic unit. As seen in Table 12, a comparison of the planned land use condition 10-year recurrence interval storm flows with the capacities of the existing storm sewers shows that many sewers have inadequate capacities to meet the minor system requirement of conveying the peak rate of runoff from a 10-year storm. In addition, major system capacity problems were identified at two locations: 1) in Roosevelt Drive North, where ponding in a mid-block sag could result in overland flow and flooding of buildings during a 100-year recurrence interval storm, and 2) at the T intersection of 18th Avenue and Sunset Ridge Drive, where a lack of an overland flow path could result in the flooding of buildings during a 100-year storm. No flooding of existing structures along the three unnamed tributaries is anticipated for floods up to and including a 100-year event under planned land use and existing channel conditions.

Two additional major system problems were identified which could arise when the proposed extension of 18th Avenue is constructed. These are located at the western termini of Primrose and Larkspur Lanes. The existing outfall pipes

Table 12

COMPARISON OF EXISTING AND PROPOSED FLOWS AND HYDRAULIC CAPACITIES OF STORM SEWERS: HYDROLOGIC UNIT E, RECOMMENDED PLAN, STORM SEWER AND OPEN CHANNEL CONVEYANCE WITH CENTRALIZED DETENTION

Branch	Reach	Storm Sewer Location[a]	Existing Size[b] (inches)	Existing Capacity (cubic feet per second)	Planned Size[b] (inches)	Length (feet)	Planned Capacity (cubic feet per second)	Planned 10-Year Storm Flow (cubic feet per second)	Planned 100-Year Storm Flow (cubic feet per second)	Frequency Storm Used for Evaluation of Existing Storm Sewers and Replacement of Inadequate Storm Sewers (years)
1	7	In Roosevelt Drive North (102)	18	14	27	75	40	22	34	100
1	8	In easement between Roosevelt Drive North and Sunset Ridge Drive (102)	18	22	27	287	65	31	49	100
1	10	In Sunset Ridge Drive east of 18th Avenue (102)	21	42	Retain existing	275	42	54	85	10
1	12	In Sunset Ridge Drive at intersection with 18th Avenue (102)	36 by 26 CMPA	22	51 by 31 RCPA	87	56	54	85	10
1	14	In 18th Avenue at intersection with Sunset Ridge Drive (102)	58 by 36 CMPA	53	53 by 34 HE at 0.55 percent	56	77	76	121	10
5	10	In 18th Avenue between Patricia Drive and Sunset Ridge Drive (102)	27	6	58 by 36 RCPA at 0.22 percent	141	57	56	86	10
		In 18th Avenue between Patricia Drive and Sunset Ridge Drive (102)	27	22	58 by 36 RCPA at 0.22 percent	109	57	56	86	10
1	16	In easement between 18th Avenue and intermittent stream through Sunset Park (102)	58 by 36 CMPA	0[c]	Dual 68 by 43 HE at 0.28 percent	143	214	135	211	100
- -	- -	In Primrose Lane at 18th Avenue extended (115)	12	3	18	140	9	8	12	10[d]
- -	- -	In Larkspur Lane at 18th Avenue extended (115)	18	9	21	130	13	11	16	10[d]

NOTE: The following abbreviations have been used: CMPA = corrugated metal pipe arch; HE = horizontal elliptical; and RCPA = reinforced concrete pipe arch.

[a] *City storm sewer system plan sheet number in parentheses.*

[b] *Diameter of circular reinforced concrete pipe unless noted otherwise.*

[c] *Existing storm sewer has a negative grade.*

[d] *Assumes design of future 18th Avenue extension will include an overland flow route to the west for flows in excess of a 10-year recurrence interval event.*

Source: SEWRPC.

from the storm sewers serving each of these two streets are not capable of conveying either the 10- or 100-year peak discharges. Surcharged stormwater from these pipes is currently able to flow overland to the wetland to the west. Extension of 18th Avenue would eliminate this overland flow path, potentially resulting in ponding and possible structure flooding at these locations.

Alternative Stormwater Drainage Plans: Planned urban development will be located mainly along the outer fringes of this hydrologic unit, with runoff conveyed to the system of interconnected wetlands and the existing streams. Because of the natural flood-attenuating effects of these wetlands, additional stormwater detention basins are not necessary for quantity control purposes. One exception to this is at the outlet of subbasin MR109A. This currently rural subbasin is proposed completely for medium density residential development by the year 2010. Runoff from this subbasin discharges onto lands located outside the planned urban service area, lands for which no engineered conveyance measures are proposed. In order to limit the increase in runoff onto those lands, the construction of a centralized detention basin would be necessary. Therefore, a storm sewer and open channel conveyance with centralized detention alternative plan was the most logical plan for this unit and the development of additional alternatives was not necessary.

Recommended Stormwater Management Plan: The recommended plan calls for the provision of new and replacement storm sewers to abate existing stormwater runoff problems and to serve planned new urban development effectively. The plan includes 1,310 lineal feet of replacement storm sewer, ranging in size from 21-inch reinforced concrete pipe to 68-inch-wide by 43-inch-high horizontal elliptical reinforced concrete pipe and 3,890 lineal feet of new storm sewers ranging in size from 12-inch reinforced concrete pipe to 51-inch-wide by 31-inch-high reinforced concrete pipe arch. In addition to these storm sewers, dry detention basin E-1 would be constructed at the outlet of subbasin MR109A. This basin would be about 2.0 acres in size, with a storage volume of up to 3.5 acre-feet. It would be designed to limit the peak discharge to the existing development condition level for storms up to and including the 10-year recurrence interval event. Although not designed to control larger runoff events, some storage benefits would be derived during such events.

The three intermittent streams located within this hydrologic unit would remain in their present condition, with the exception of a 315-foot-long reach of that stream located in subbasin MR240. Along that reach the existing channel would be deepened by up to two feet and would be provided with a five foot bottom width and side slopes of one vertical on three horizontal. The channel would be lined with natural vegetation to match the downstream reaches of this stream. The plan also calls for the placement of three 48-inch-diameter reinforced concrete pipes, 100 feet in length, to accommodate the extension of 18th Avenue recommended under the Washington County Jurisdictional Highway System Plan. Finally, most of subbasin MR240 is proposed to be developed for medium-density residential use, including that area adjacent to this intermittent stream. In order to ensure sufficient drainage capacity and to help prevent development within the 100-year recurrence interval flood inundation area, it is recommended that a 100-foot-wide greenway also be established along this stream. Similar greenways along the remaining two intermittent streams within this hydrologic unit are not deemed necessary since the undeveloped lands adjacent to these streams are to remain in open space uses.

The water quality management portion of this plan as described in Chapter IV of this volume includes the provision of six wet detention basins within this hydrologic unit. All six basins are located so that they discharge directly to an existing wetland complex. Since these wetlands provide a significant amount of natural detention storage, and since no engineered stormwater conveyance components are located downstream of these six wet basins, they were not considered further for use as quantity control basins under this plan.

The components and costs of the recommended plan are set forth in Table 9. The total present value cost of this plan is $1,022,000, consisting of an estimated capital cost of $926,000 and an estimated annual operation and maintenance cost increase of $6,090. The approximate location, alignment, and configuration of the recommended stormwater drainage plan, along with the nonpoint source pollution control measures recommended in Chapter IV of this volume, are summarized graphically on Map 14.

Hydrologic Unit MR-F

Evaluation of the Stormwater Management System: Hydrologic Unit MR-F is a 0.14-square-mile area located as shown on Map 1 in Chapter I of this volume. Under existing land use conditions, about 95 percent of the hydrologic unit is developed in urban land uses. Under planned year 2010 conditions the hydrologic unit would essentially be completely developed in urban uses, predominantly medium-density residential use. The existing stormwater management system consists of roadway curbs and gutters, storm sewer inlets, and storm sewers. There are no identified intermittent or perennial streams within the hydrologic unit and the storm sewers discharge directly to the Milwaukee River.

Problems with both inadequate minor and major system hydraulic capacities were identified in parts of this hydrologic unit. As seen in Table 13, a comparison of the existing 10-year recurrence interval storm flows with the capacities of the existing storm sewers shows that many sewers have inadequate capacities to meet the minor system requirement of conveying the peak rate of runoff from a 10-year storm. In addition, major system capacity problems were identified at two locations: 1) in Skyline Drive at Acorn Road extended, where ponding in a mid-block sag could result in overland flow and flooding of buildings during a 100-year recurrence interval storm and 2) west of Stratford Road, where an inadequate overland flow path to the Milwaukee River could result in the flooding of buildings during a 100-year storm.

Alternative Stormwater Drainage Plans: The following two alternative stormwater management plans were developed for Hydrologic Unit F: 1) a storm sewer conveyance plan and 2) a storm sewer conveyance with centralized detention plan.

Alternative Plan No. F-1, Storm Sewer Conveyance: The storm sewer conveyance alternative plan calls for the provision of new and replacement storm sewers to abate existing stormwater runoff problems and to serve planned new urban development effectively. This alternative includes 3,790 lineal feet of replacement storm sewer, ranging in size from 18-inch- to 48-inch-diameter reinforced concrete pipe and 170 feet of new 21-inch-diameter storm sewer. Map 9 shows the approximate location and alignment of the new and replacement storm sewers proposed under this alternative. Table 13 presents a comparison of peak flows and existing and proposed storm sewer hydraulic capacities. Table 14 presents the salient characteristics and estimated costs of the new and replacement storm sewers comprising this alternative plan. The total present value cost of this alternative plan is $608,000, consisting of an estimated capital cost of $609,000 and an estimated $50 net annual operation and maintenance cost savings over existing conditions.

Alternative Plan No. F-2, Storm Sewer Conveyance with Centralized Detention: This alternative enables the downsizing of 1,140 lineal feet of replacement storm sewers because of the reduction in peak flood flows achieved through the provision of detention storage for the control of runoff from a 100-year recurrence interval storm. In addition, 380 lineal feet of storm sewer which would be replaced under Alternative F-1 is located at a proposed detention basin site and would, therefore, be eliminated under Alternative F-2. The alternative calls for 170 lineal feet of new 12-inch-diameter storm sewer and for 3,410 lineal feet of replacement storm sewers ranging in size from 18-inch- to 42-inch-diameter reinforced concrete pipe. Map 10 shows the approximate location, alignment, and configuration of the facilities called for under this alternative. Table 15 presents a comparison of peak flows and existing and proposed storm sewer hydraulic capacities. Table 16 presents the salient characteristics and estimated costs of the new and replacement storm sewers and the 0.3-acre-foot and 1.0-acre-foot detention basins which comprise this alternative plan. The total present value cost of this alternative plan is $726,000, consisting of an estimated capital cost of $696,000, including land acquisition for the detention basins, and an estimated annual operation and maintenance cost increase of $1,890.

Evaluation of Alternative Stormwater Drainage Plans: The foregoing information provides a basis for a comparative evaluation of the two alternative stormwater drainage plans. Each alternative was designed to resolve the identified existing drainage problems as well as to serve anticipated future development within the

Table 13

COMPARISON OF EXISTING AND PROPOSED FLOWS AND HYDRAULIC CAPACITIES OF STORM SEWERS: ALTERNATIVE F-1, STORM SEWER CONVEYANCE

Branch	Reach	Storm Sewer Location[a]	Existing Size[b] (inches)	Existing Capacity (cubic feet per second)	Planned Size[b] (inches)	Length (feet)	Planned Capacity (cubic feet per second)	Existing 10-Year Storm Flow (cubic feet per second)	Planned 10-Year Storm Flow (cubic feet per second)	Existing 100-Year Storm Flow (cubic feet per second)	Planned 100-Year Storm Flow (cubic feet per second)	Frequency Storm Used for Evaluation of Existing Storm Sewers and Replacement of Inadequate Storm Sewers (years)
1	0	In Skyline Drive north of Barbie Avenue and south of Barbie Drive (100)	21	8	38 by 24 HE	673	20	8	8	8[c]	15	100
1	2	In easement east of Acorn Road and west of Skyline Drive (100)	12	9	21	24	25	11	11	15	22	100
		In easement east of Acorn Road and west of Skyline Drive (100)	12 CMP	3	21	380	25	11	11	15	22	100
1	4	In Acorn Road between Parkfield Drive and Briar Drive (100)	21	29	38 by 24 HE	29	76	28	28	50	56	100
		In Acorn Road between Parkfield Drive and Briar Drive (100)	18	13	38 by 24 HE	329	52	28	28	50	56	10
2	0	In Briar Drive north of Acorn Road (100)	15	7	30 by 19 HE	308	23	15	15	29	29	10
1	6	In Acorn Road west of Parkfield Drive (100)	18[d]	6	24 at 1.38 percent	330	27	51	52	96	102	10
		In Acorn Road west of Parkfield Drive (100)	24[d]	25	Retain existing	320	25	51	52	96	102	10
1	8	In easement between Jackson Street and Hi-Mount Road west of Salisbury Road (101)	30	40	42 at 2.4 percent	390	156	62	63	115	121	100
1	10	In Stratford Road between Jackson Street and Hi-Mount Road (101)	30	46	42 at 2.4 percent	58	156	65	66	123	129	100
5	0	In easement north of Jackson Street and west of Salisbury Road	New sewer	- -	21	170	17	- -	7	- -	12	100
1	12	In easement between Northwestern Avenue and Stratford Road north of Hi-Mount Road (101)	36 by 22 CMPA	27	42 at 2.4 percent	231	156	37	87	105	167	100
		In easement between Northwestern Avenue and Stratford Road north of Hi-Mount Road (101)	50 by 31 CMPA	63	42 at 2.4 percent	153	156	37	87	105	167	100
1	14	In easement between Northwestern Avenue and Milwaukee River (101)	36	124	48 at 1.65 percent[e]	123	184	51	123	125	184	100
		In easement between Northwestern Avenue and Milwaukee River (101)	50 by 31 CMPA	82	48 at 1.65 percent[e]	168	184	51	123	125	184	100

Table 13 (continued)

Branch	Reach	Storm Sewer Location[a]	Existing Size[b] (inches)	Existing Capacity (cubic feet per second)	Planned Size[b] (inches)	Length (feet)	Planned Capacity (cubic feet per second)	Existing 10-Year Storm Flow (cubic feet per second)	Planned 10-Year Storm Flow (cubic feet per second)	Existing 100-Year Storm Flow (cubic feet per second)	Planned 100-Year Storm Flow (cubic feet per second)	Frequency Storm Used for Evaluation of Existing Storm Sewers and Replacement of Inadequate Storm Sewers (years)
4	0	In Northwestern Avenue and west of Northwestern Avenue (101)	24 CMP	5	18 at 0.87 percent	130	10	4	6	6	10	100
		In Northwestern Avenue and west of Northwestern Avenue (101)	24 CMP	18	18 at 0.87 percent	60	10	4	6	6	10	100
6	0	At the intersection of Hi-Mount Road and Stratford Road and in Northwestern Avenue north of Hi-Mount Road (101)	15	6	18 at 3.5 percent[e]	196	20	14	14	21	21	100
6	2	At the intersection of Hi-Mount Road and Stratford Road and in Northwestern Avenue north of Hi-Mount Road (101)	15	12	18 at 3.5 percent[e]	210	20	14	14	21	21	100

NOTE: The following abbreviations have been used: CMP = corrugated metal pipe; CMPA = corrugated metal pipe arch; HE = horizontal elliptical; and RCP = reinforced concrete pipe.

[a] *City storm sewer system plan sheet number in parentheses.*

[b] *Diameter of circular reinforced concrete pipe unless noted otherwise.*

[c] *Flow limited to storm sewer capacity.*

[d] *Branch 1, Reach 6 is an 18-inch-diameter RCP in parallel with a 24-inch-diameter RCP.*

[e] *Manhole 72 invert elevation lowered to 910.8 feet National Geodetic Vertical Datum.*

Source: SEWRPC.

hydrologic unit. Each, when expanded to include the nonpoint source pollution control measures recommended in Chapter IV of this volume, would achieve the same degree of abatement of nonpoint source pollution. Thus, the principal criteria for the comparative evaluation were reduced to cost and implementability.

Alternative F-1 is less costly than Alternative F-2 and would be more easily implemented since it would involve replacement of storm sewers within existing rights-of-way and easements and it would not require purchasing land now in private ownership for the provision of detention basins.

Recommended Stormwater Management Plan: On the basis of a comparative evaluation of the two alternative plans, Alternative Plan No. F-1, Storm Sewer Conveyance, is recommended for adoption in this hydrologic unit. The components and costs of the recommended plan are set forth in Table 9 and the approximate location, alignment, and configuration of the recommended facilities are shown graphically on Map 14.

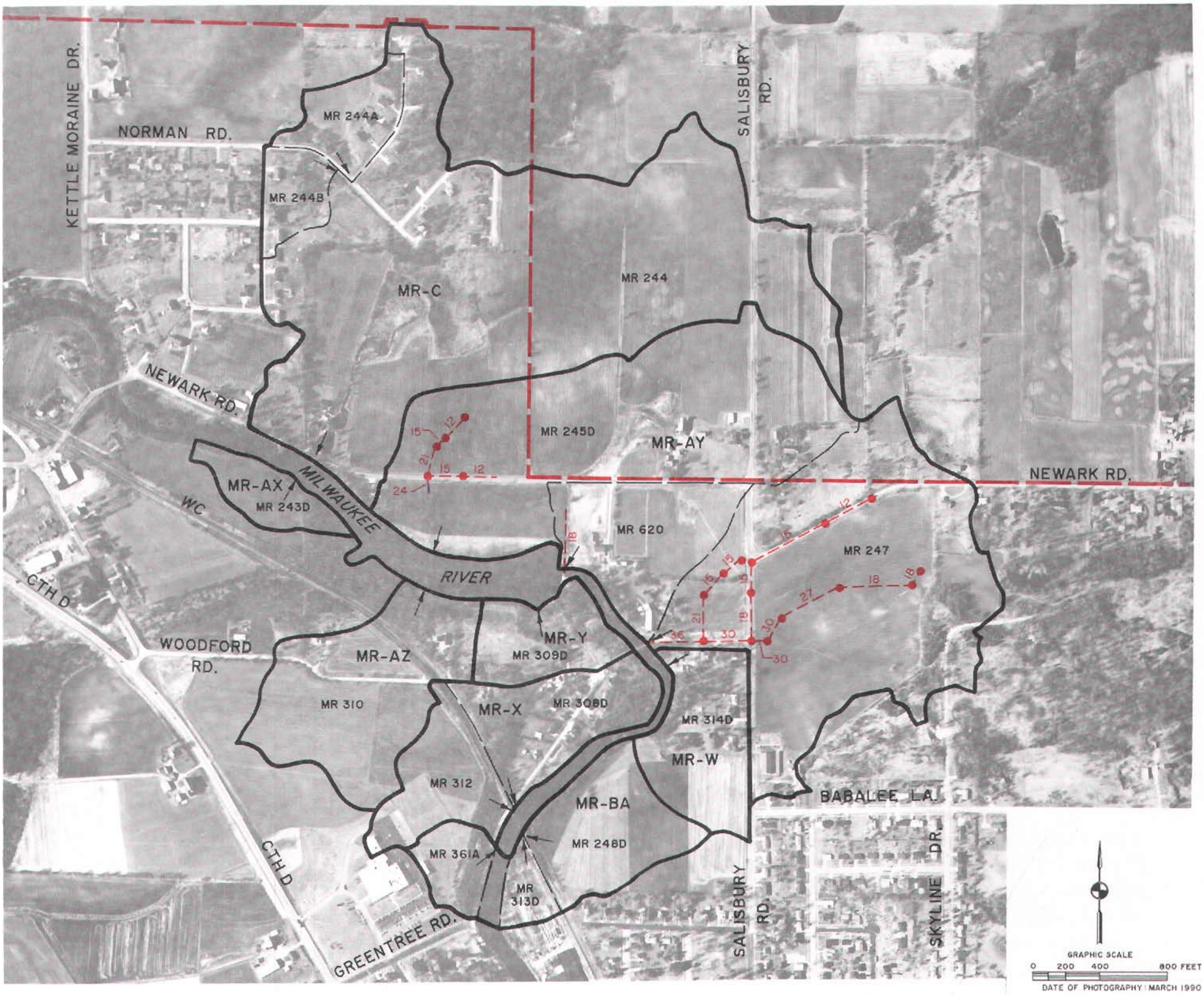
Hydrologic Unit MR-G

Evaluation of the Stormwater Management System: Hydrologic Unit MR-G is a 0.10-square-mile area located as shown on Map 1 in Chapter I of this volume. Under existing land use conditions, about 94 percent of the hydrologic unit is developed in urban land uses. Under planned year 2010 conditions the hydrologic unit would virtually be completely developed for urban uses. Those uses, predominantly medium-density residential, would also include high-density residential, commercial, and government and institutional uses. The existing stormwater management system consists of roadway curbs and gutters, storm sewer inlets, and storm

Map 9

STORM SEWER CONVEYANCE ALTERNATIVE PLAN FOR STORMWATER MANAGEMENT IN THE MILWAUKEE RIVER DRAINAGE AREA

HYDROLOGIC UNITS MR-C, MR-W, MR-X, MR-Y, MR-AX, MR-AY, MR-AZ, AND MR-BA



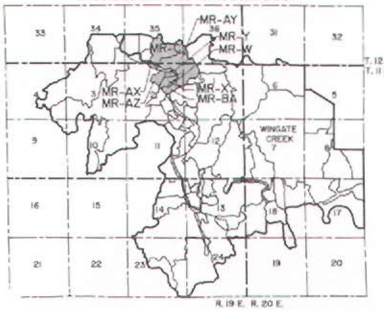
LEGEND

▬	HYDROLOGIC UNIT BOUNDARY UNDER EXISTING DRAINAGE CONDITIONS
MR-AY	HYDROLOGIC UNIT IDENTIFICATION
— —	SUBBASIN BOUNDARY
MR 310	SUBBASIN IDENTIFICATION
→	SUBBASIN OUTLET
— —	LIMITS OF PLANNED URBAN SERVICE AREA
●	PROPOSED MANHOLE
30 — —	PROPOSED STORM SEWER (SIZE IN INCHES)
—	PROPOSED OPEN CHANNEL

NOTE: 1.) PIPES ARE CONSTRUCTED OF REINFORCED CONCRETE.

2.) THIS ALTERNATIVE WAS NOT DEVELOPED FOR HYDROLOGIC UNITS MR-C, MR-W, MR-X, MR-Y, MR-AX, MR-AZ, AND MR-BA.

MILWAUKEE RIVER DRAINAGE AREA
HYDROLOGIC UNIT LOCATION MAP



Map 9 (continued)

STORM SEWER CONVEYANCE ALTERNATIVE PLAN FOR STORMWATER MANAGEMENT IN THE MILWAUKEE RIVER DRAINAGE AREA

HYDROLOGIC UNITS MR-F, MR-G, MR-Z, MR-AA, MR-AB, MR-AC, MR-AD, MR-AG, AND MR-AH

LEGEND

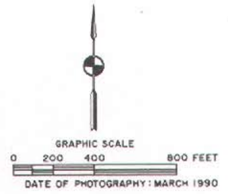
▬	HYDROLOGIC UNIT BOUNDARY UNDER EXISTING DRAINAGE CONDITIONS
MR-F	HYDROLOGIC UNIT IDENTIFICATION
— —	SUBBASIN BOUNDARY
MR 294	SUBBASIN IDENTIFICATION
→	SUBBASIN OUTLET
18	EXISTING STORM SEWER TO BE RETAINED (SIZE IN INCHES)
●	EXISTING MANHOLE OR CATCHBASIN
24	PROPOSED REPLACEMENT STORM SEWER DESIGNED FOR 10-YEAR STORM (SIZE IN INCHES)
21	PROPOSED REPLACEMENT STORM SEWER DESIGNED FOR 100-YEAR STORM (SIZE IN INCHES)
_21_	PROPOSED STORM SEWER (SIZE IN INCHES)
●	PROPOSED MANHOLE

▨	EXISTING CONSTRUCTED DETENTION BASIN
CMP	CORRUGATED METAL PIPE
HE	HORIZONTAL ELLIPTICAL REINFORCED CONCRETE PIPE
RCPA	REINFORCED CONCRETE PIPE ARCH
PVC	POLYVINYL CHLORIDE
CI	CAST IRON

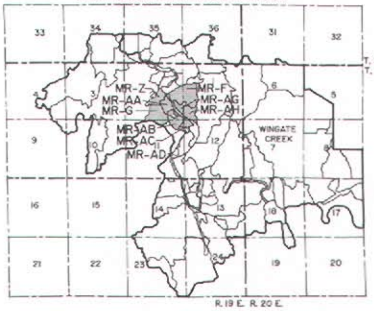
NOTE:

1.) PIPES ARE CONSTRUCTED OF REINFORCED CONCRETE UNLESS DESIGNATED AS ABOVE.

2.) THIS ALTERNATIVE WAS NOT DEVELOPED FOR HYDROLOGIC UNITS MR-G, MR-Z, MR-AA, MR-AB, MR-AC, MR-AD, MR-AG, AND MR-AH, THEREFORE, THE EXISTING STORM SEWER SYSTEM IS SHOWN FOR THOSE UNITS.



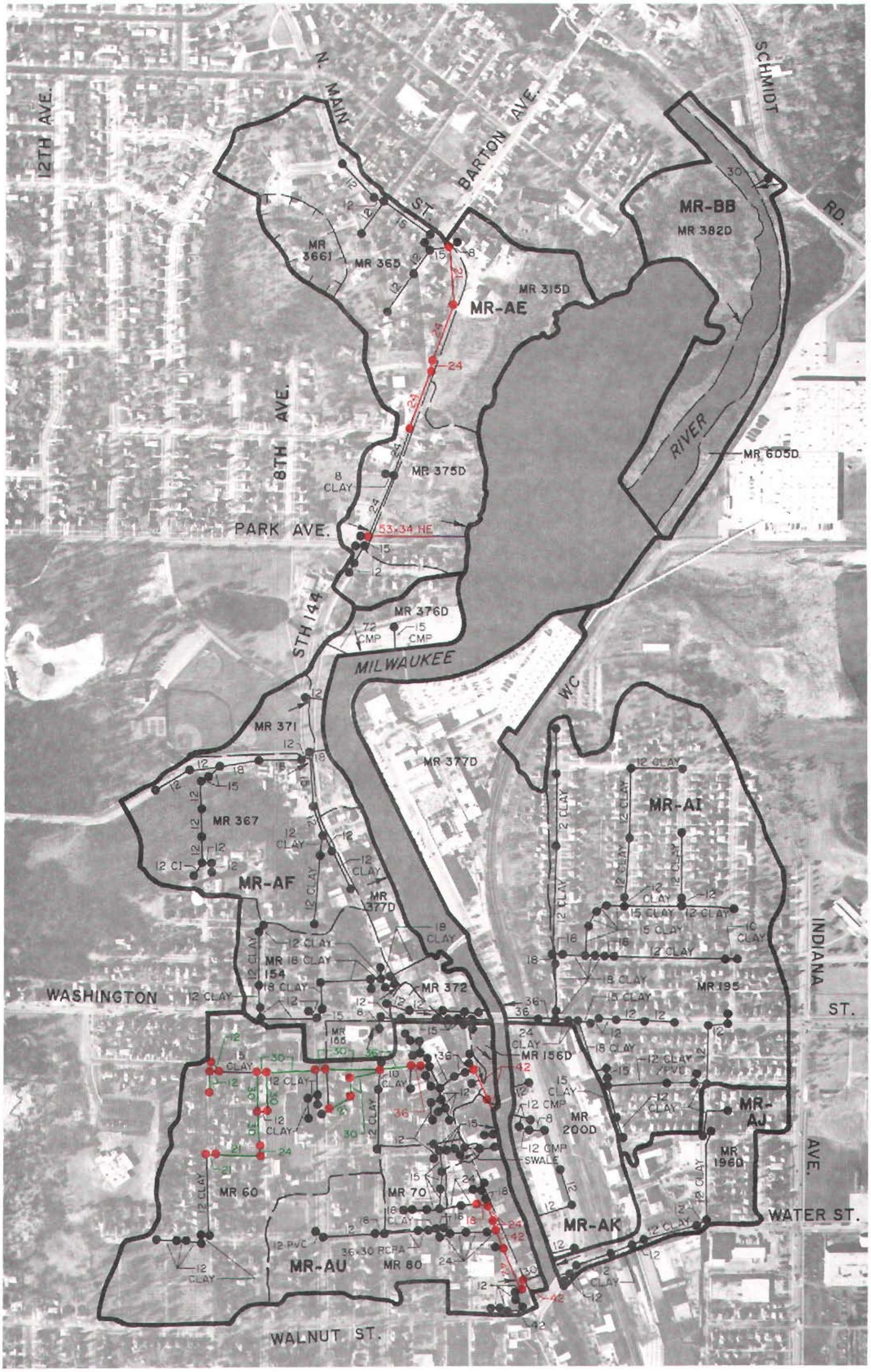
MILWAUKEE RIVER DRAINAGE AREA HYDROLOGIC UNIT LOCATION MAP



Map 9 (continued)

STORM SEWER CONVEYANCE ALTERNATIVE PLAN FOR STORMWATER MANAGEMENT IN THE MILWAUKEE RIVER DRAINAGE AREA

HYDROLOGIC UNITS MR-AE, MR-AF, MR-AI, MR-AJ, MR-AK, MR-AU, AND MR-BB



LEGEND

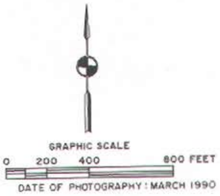
▬	HYDROLOGIC UNIT BOUNDARY UNDER EXISTING DRAINAGE CONDITIONS
MR-AE	HYDROLOGIC UNIT IDENTIFICATION
— —	SUBBASIN BOUNDARY
MR 365	SUBBASIN IDENTIFICATION
⟶	SUBBASIN OUTLET
24	EXISTING STORM SEWER TO BE RETAINED (SIZE IN INCHES)
●	EXISTING MANHOLE OR CATCHBASIN
24	PROPOSED REPLACEMENT STORM SEWER DESIGNED FOR 10-YEAR STORM (SIZE IN INCHES)
24	PROPOSED REPLACEMENT STORM SEWER DESIGNED FOR 100-YEAR STORM (SIZE IN INCHES)
●	PROPOSED MANHOLE
—	PROPOSED OPEN CHANNEL
CMP	CORRUGATED METAL PIPE
HE	HORIZONTAL ELLIPTICAL REINFORCED CONCRETE PIPE
CLAY	CLAY PIPE
RCPA	REINFORCED CONCRETE PIPE ARCH
PVC	POLYVINYL CHLORIDE
CI	CAST IRON

NOTE:

1.) PIPES ARE CONSTRUCTED OF REINFORCED CONCRETE UNLESS DESIGNATED AS ABOVE.

2.) DUE TO MAP SCALE LIMITATIONS SOME STORM SEWER SIZES IN CONGESTED AREAS ARE NOT SHOWN.

3.) THIS ALTERNATIVE WAS NOT DEVELOPED FOR HYDROLOGIC UNITS MR-AF, MR-AI, MR-AJ, MR-AK, AND MR-BB. THEREFORE, THE EXISTING STORM SEWER SYSTEM IS SHOWN FOR THOSE UNITS.



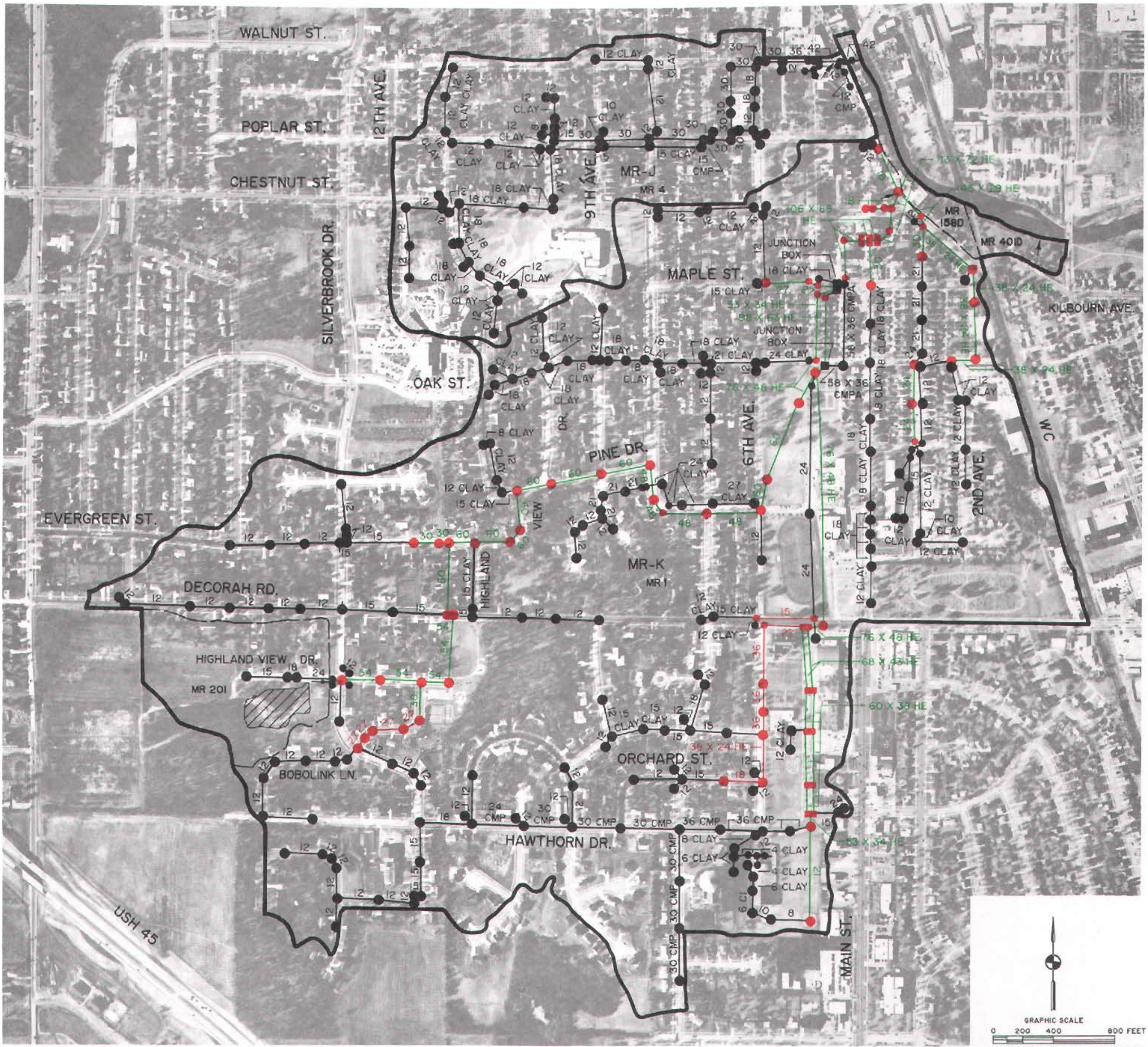
DATE OF PHOTOGRAPHY: MARCH 1990

MILWAUKEE RIVER DRAINAGE AREA HYDROLOGIC UNIT LOCATION MAP

Map 9 (continued)

STORM SEWER CONVEYANCE ALTERNATIVE PLAN FOR STORMWATER MANAGEMENT IN THE MILWAUKEE RIVER DRAINAGE AREA

HYDROLOGIC UNITS MR-J AND MR-K

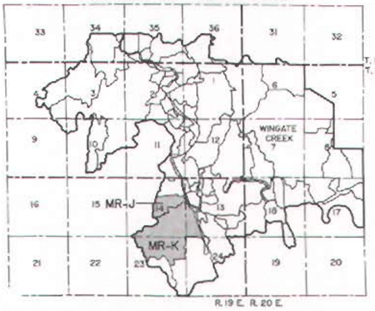


LEGEND

▬	HYDROLOGIC UNIT BOUNDARY UNDER EXISTING DRAINAGE CONDITIONS
MR-J	HYDROLOGIC UNIT IDENTIFICATION
—	SUBBASIN BOUNDARY
MR 4	SUBBASIN IDENTIFICATION
→	SUBBASIN OUTLET
24	EXISTING STORM SEWER TO BE RETAINED (SIZE IN INCHES)
●	EXISTING MANHOLE OR CATCHBASIN
27	PROPOSED REPLACEMENT STORM SEWER DESIGNED FOR 10-YEAR STORM (SIZE IN INCHES)
54	PROPOSED REPLACEMENT STORM SEWER DESIGNED FOR 100-YEAR STORM (SIZE IN INCHES)
●	PROPOSED MANHOLE
🟥	PROPOSED JUNCTION BOX
▨	EXISTING NATURAL DETENTION OR RETENTION STORAGE AREA
CMP	CORRUGATED METAL PIPE
CMPA	CORRUGATED METAL PIPE ARCH
HE	HORIZONTAL ELLIPTICAL REINFORCED CONCRETE PIPE
CLAY	CLAY PIPE
CI	CAST IRON

NOTE:
1.) PIPES ARE CONSTRUCTED OF REINFORCED CONCRETE UNLESS DESIGNATED AS ABOVE.
2.) THIS ALTERNATIVE WAS NOT DEVELOPED FOR HYDROLOGIC UNIT MR-J. THEREFORE, THE EXISTING STORM SEWER SYSTEM IS SHOWN FOR THAT UNIT.

MILWAUKEE RIVER DRAINAGE AREA HYDROLOGIC UNIT LOCATION MAP



Map 9 (continued)

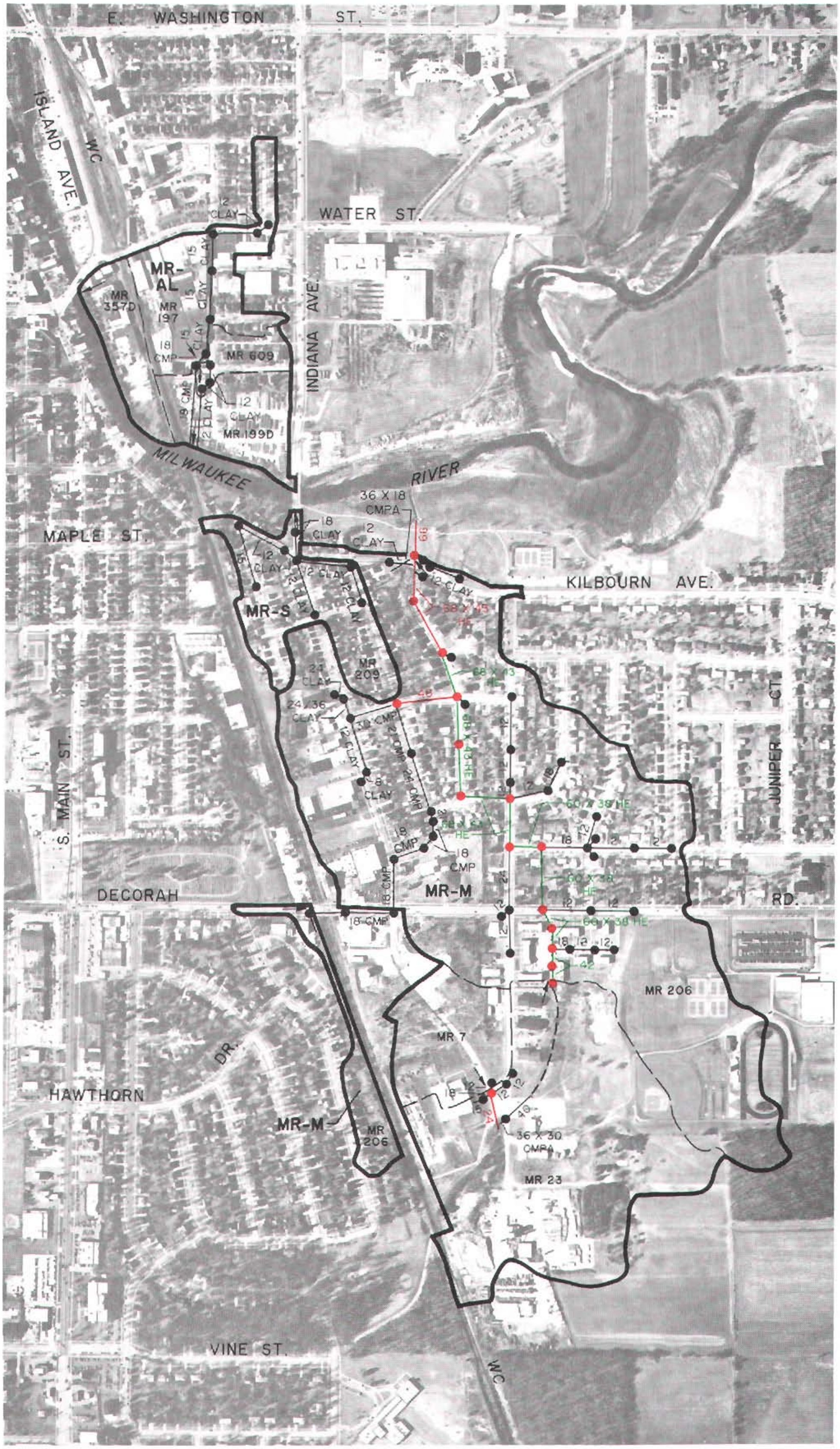
STORM SEWER CONVEYANCE ALTERNATIVE PLAN FOR STORMWATER MANAGEMENT IN THE MILWAUKEE RIVER DRAINAGE AREA

HYDROLOGIC UNITS MR-L AND MR-AV

Map 9 (continued)

STORM SEWER CONVEYANCE ALTERNATIVE PLAN FOR STORMWATER MANAGEMENT IN THE MILWAUKEE RIVER DRAINAGE AREA

HYDROLOGIC UNITS MR-M, MR-S, AND MR-AL



LEGEND

▬	HYDROLOGIC UNIT BOUNDARY UNDER EXISTING DRAINAGE CONDITIONS
MR-M	HYDROLOGIC UNIT IDENTIFICATION
— —	SUBBASIN BOUNDARY
MR-206	SUBBASIN IDENTIFICATION
→	SUBBASIN OUTLET
18	EXISTING STORM SEWER TO BE RETAINED (SIZE IN INCHES)
●	EXISTING MANHOLE OR CATCHBASIN
– – –	EXISTING OPEN CHANNEL
24	PROPOSED REPLACEMENT STORM SEWER DESIGNED FOR 10-YEAR STORM (SIZE IN INCHES)
42	PROPOSED REPLACEMENT STORM SEWER DESIGNED FOR 100-YEAR STORM (SIZE IN INCHES)
●	PROPOSED MANHOLE
CMP	CORRUGATED METAL PIPE
CMPA	CORRUGATED METAL PIPE ARCH
HE	HORIZONTAL ELLIPTICAL REINFORCED CONCRETE PIPE
CLAY	CLAY PIPE

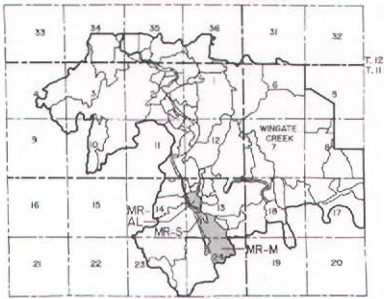
NOTE:

1.) PIPES ARE CONSTRUCTED OF REINFORCED CONCRETE UNLESS DESIGNATED AS ABOVE.

2.) THIS ALTERNATIVE WAS NOT DEVELOPED FOR HYDROLOGIC UNITS MR-S AND MR-AL. THEREFORE, THE EXISTING STORM SEWER SYSTEM IS SHOWN FOR THOSE UNITS.

GRAPHIC SCALE
0 200 400 800 FEET
DATE OF PHOTOGRAPHY: MARCH 1990

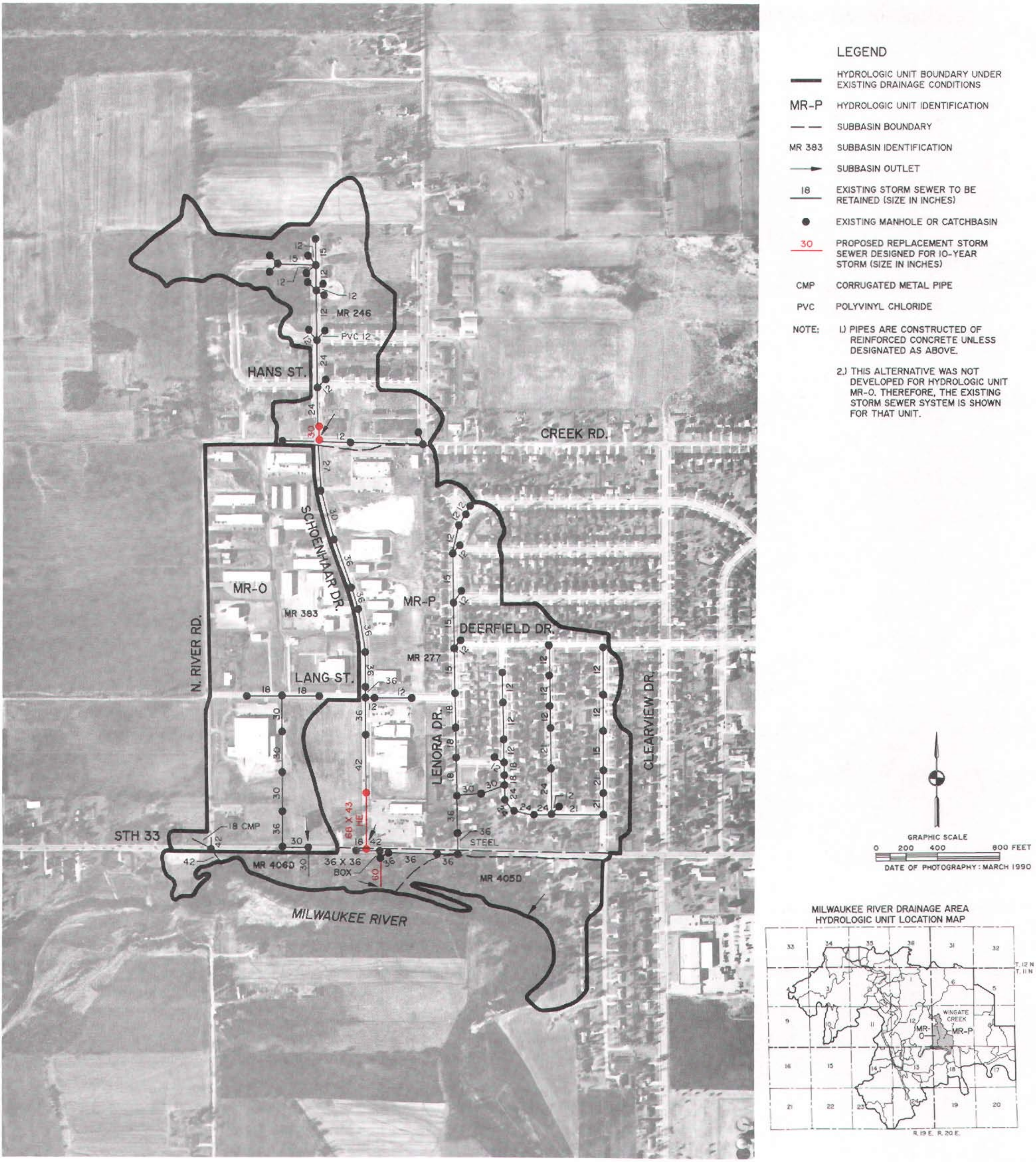
MILWAUKEE RIVER DRAINAGE AREA HYDROLOGIC UNIT LOCATION MAP



Map 9 (continued)

STORM SEWER CONVEYANCE ALTERNATIVE PLAN FOR STORMWATER MANAGEMENT IN THE MILWAUKEE RIVER DRAINAGE AREA

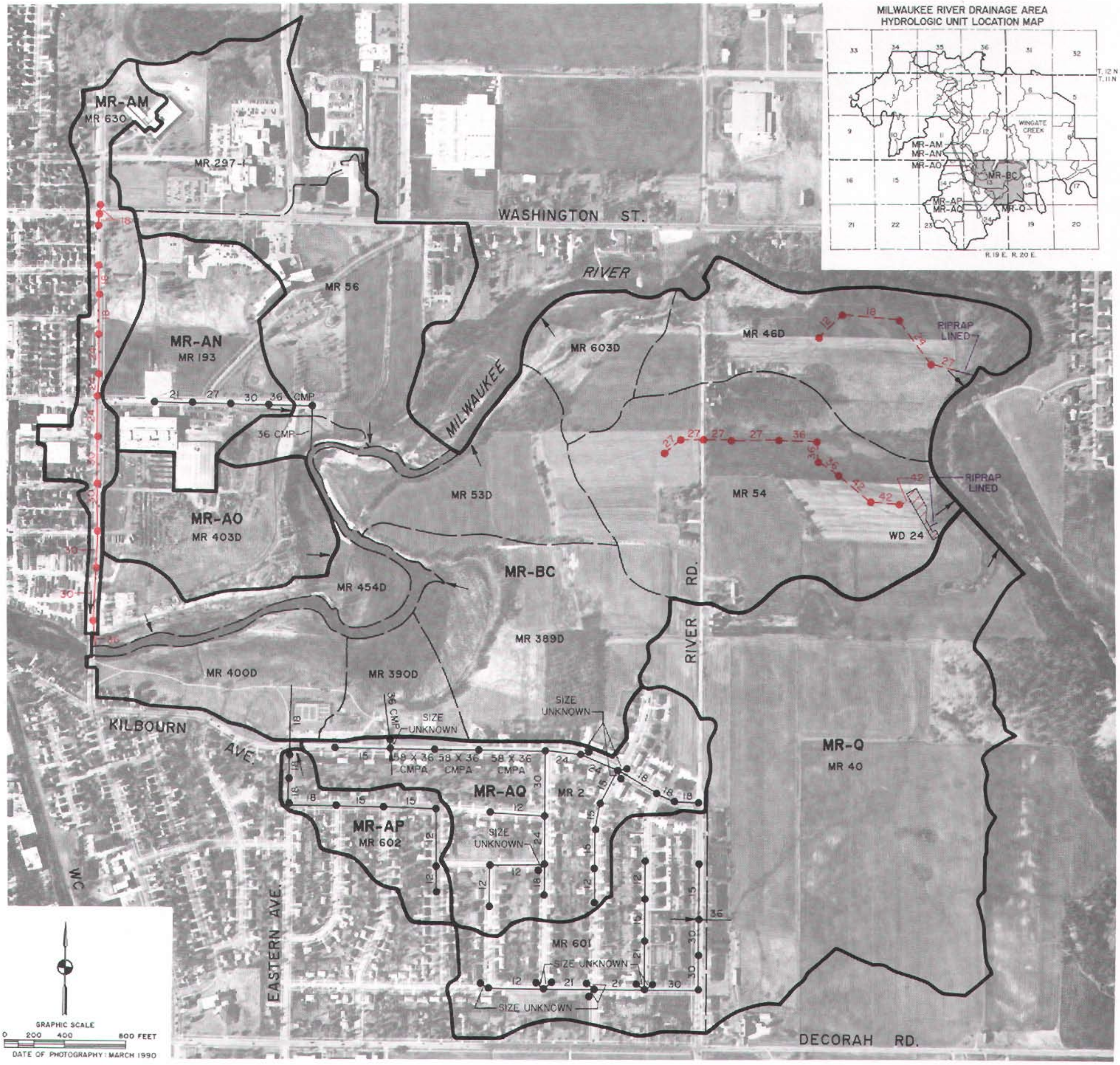
HYDROLOGIC UNITS MR-O AND MR-P



Map 9 (continued)

STORM SEWER CONVEYANCE ALTERNATIVE PLAN FOR STORMWATER MANAGEMENT IN THE MILWAUKEE RIVER DRAINAGE AREA

HYDROLOGIC UNITS MR-Q, MR-AM, MR-AN, MR-AO, MR-AP, MR-AQ, AND MR-BC



LEGEND

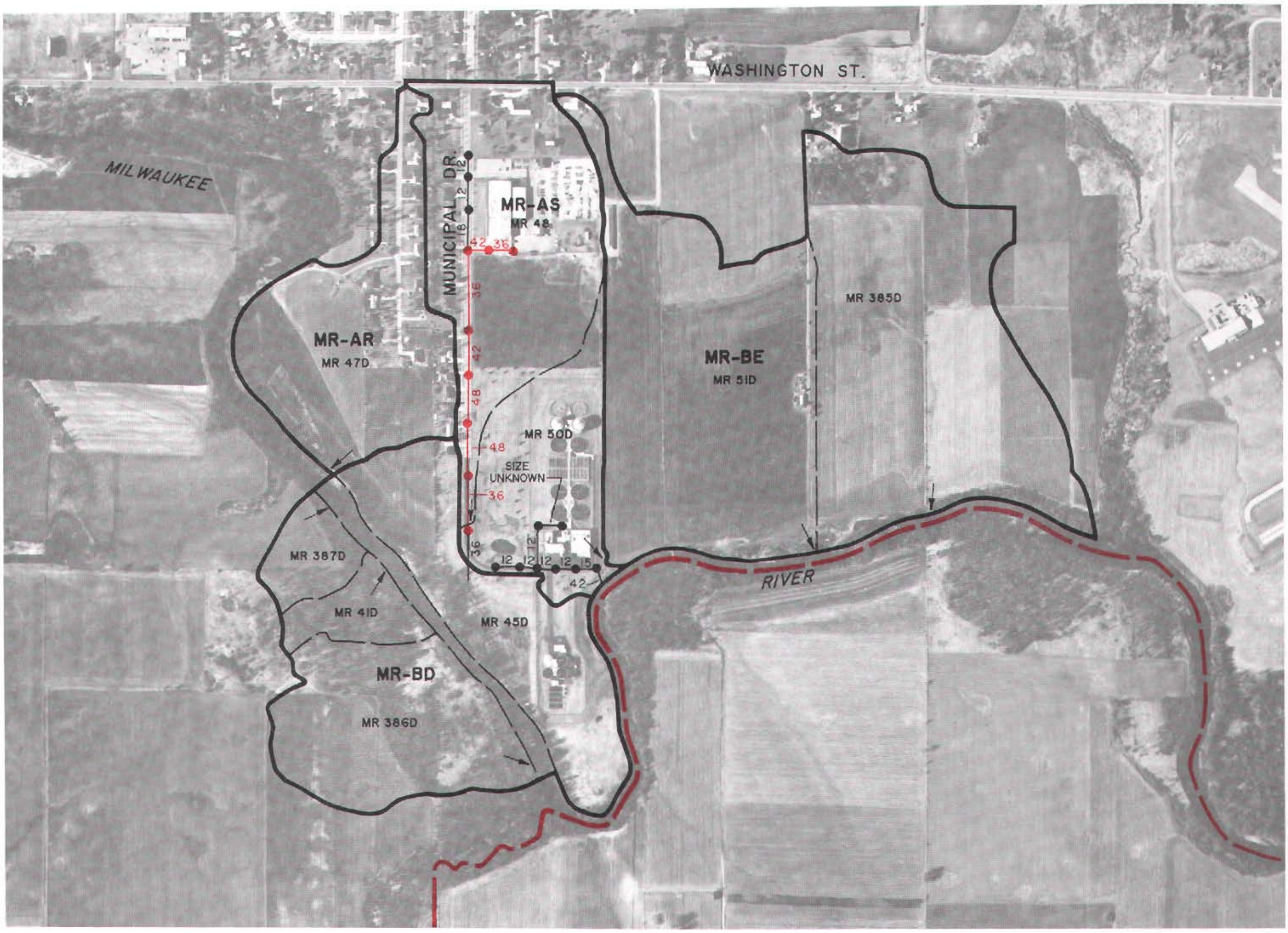
▬	HYDROLOGIC UNIT BOUNDARY UNDER EXISTING DRAINAGE CONDITIONS
MR-Q	HYDROLOGIC UNIT IDENTIFICATION
— —	SUBBASIN BOUNDARY
MR 602	SUBBASIN IDENTIFICATION
→	SUBBASIN OUTLET
12	EXISTING STORM SEWER TO BE RETAINED (SIZE IN INCHES)
●	EXISTING MANHOLE OR CATCHBASIN
30	PROPOSED REPLACEMENT STORM SEWER DESIGNED FOR 10-YEAR STORM (SIZE IN INCHES)
42	PROPOSED STORM SEWER OR CULVERT (SIZE IN INCHES)
●	PROPOSED MANHOLE
—	PROPOSED OPEN CHANNEL
WD 24 ▨	PERMANENT POND AREA OF PROPOSED WET DETENTION BASIN AND DESIGNATION
CMP	CORRUGATED METAL PIPE
CMPA	CORRUGATED METAL PIPE ARCH

NOTE:
1.) PIPES ARE CONSTRUCTED OF REINFORCED CONCRETE UNLESS DESIGNATED AS ABOVE.
2.) THIS ALTERNATIVE WAS NOT DEVELOPED FOR HYDROLOGIC UNITS MR-Q, MR-AN, MR-AO, MR-AP, AND MR-AQ. THEREFORE, THE EXISTING STORM SEWER SYSTEM IS SHOWN FOR THOSE UNITS.

Map 9 (continued)

STORM SEWER CONVEYANCE ALTERNATIVE PLAN FOR STORMWATER MANAGEMENT IN THE MILWAUKEE RIVER DRAINAGE AREA

HYDROLOGIC UNITS MR-AR, MR-AS, MR-BD, AND MR-BE

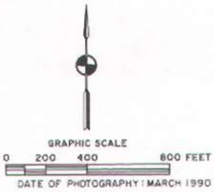


LEGEND

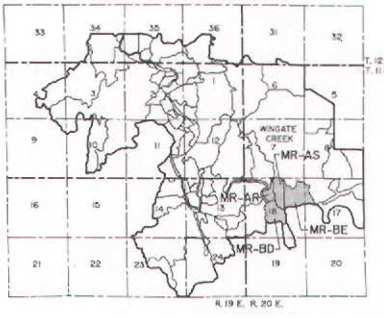
——	HYDROLOGIC UNIT BOUNDARY UNDER EXISTING DRAINAGE CONDITIONS
MR-AS	HYDROLOGIC UNIT IDENTIFICATION
— —	SUBBASIN BOUNDARY
MR 48	SUBBASIN IDENTIFICATION
——→	SUBBASIN OUTLET
— —	LIMITS OF PLANNED URBAN SERVICE AREA
12	EXISTING STORM SEWER TO BE RETAINED (SIZE IN INCHES)
●	EXISTING MANHOLE OR CATCHBASIN
48	PROPOSED REPLACEMENT STORM SEWER DESIGNED FOR 10-YEAR STORM (SIZE IN INCHES)
●	PROPOSED MANHOLE

NOTE: 1.) PIPES ARE CONSTRUCTED OF REINFORCED CONCRETE.

2.) THIS ALTERNATIVE WAS NOT DEVELOPED FOR HYDROLOGIC UNITS MR-AR, MR-BD, AND MR-BE.



MILWAUKEE RIVER DRAINAGE AREA HYDROLOGIC UNIT LOCATION MAP



Source: SEWRPC.

Table 14

ALTERNATIVE F-1: COMPONENTS AND COSTS FOR THE STORM SEWER CONVEYANCE STORMWATER DRAINAGE PLAN FOR WEST BEND HYDROLOGIC UNIT MR-F

Hydrologic Unit	Project and Component Description[a]	Estimated Cost	
		Capital[b]	Annual Operation and Maintenance[c]
F	1. Replace 673 feet of 21-inch storm sewer in Skyline Drive between Barton Avenue and Barbie Drive with 38-inch by 24-inch HE storm sewer	$114,000	$ 0
	2. Replace 24 feet of 12-inch storm sewer in easement east of Acorn Road and west of Skyline Drive with 21-inch storm sewer	2,000	0
	3. Replace 380 feet of 12-inch CMP storm sewer in easement east of Acorn Road and west of Skyline Drive with 21-inch storm sewer	36,000	0
	4. Replace 29 feet of 21-inch storm sewer in Acorn Road between Parkfield Drive and Briar Road with 38-inch by 24-inch HE storm sewer	5,000	0
	5. Replace 329 feet of 18-inch storm sewer in Acorn Road between Parkfield Drive and Briar Road with 38-inch by 24-inch HE storm sewer	56,000	0
	6. Replace 308 feet of 15-inch storm sewer in Briar Drive north of Acorn Road with 30-inch by 19-inch HE storm sewer	38,000	0
	7. Replace 330 feet of 18-inch storm sewer in Acorn Road west of Parkfield Drive with 24-inch storm sewer	37,000	0
	8. Replace 390 feet of 30-inch storm sewer in easement between Jackson Street and Hi-Mount Road with 42-inch storm sewer	87,000	-70
	9. Replace 58 feet of 30-inch storm sewer in Stratford Road between Jackson Street and Hi-Mount Road with 42-inch storm sewer	13,000	-10
	10. 170 feet of 21-inch storm sewer in easement north of Jackson Street and west of Salisbury Road	12,000	70
	11. Replace 231 feet of 36-inch by 22-inch CMPA in easement between Northwestern Avenue and Stratford Road with 42-inch storm sewer	52,000	-40
	12. Replace 153 feet of 50-inch by 31-inch CMPA in easement between Northwestern Avenue and Stratford Road north of Hi-Mount Road with 42-inch storm sewer	34,000	0
	13. Replace 123 feet of 36-inch storm sewer in easement west of Northwestern Avenue into the Milwaukee River north of Hi-Mount Road with 48-inch storm sewer	31,000	0
	14. Replace 168 feet of 50-inch by 31-inch CMPA in easement west of Northwestern Avenue and into the Milwaukee River north of Hi-Mount Road with 42-inch storm sewer	43,000	0
	15. Replace 130 feet of 24-inch storm sewer in Northwestern Avenue and west of Northwestern Avenue with 18-inch storm sewer	11,000	0
	16. Replace 60 feet of 24-inch storm sewer in Northwestern Avenue and west of Northwestern Avenue with 18-inch storm sewer	5,000	0

Table 14 (continued)

Hydrologic Unit	Project and Component Description[a]	Estimated Cost	
		Capital[b]	Annual Operation and Maintenance[c]
F (continued)	17. Replace 196 feet of 15-inch storm sewer at the intersection of Hi-Mount Road and Stratford Road and in Northwestern Avenue north of Hi-Mount Road with 18-inch storm sewer	$ 16,000	$ 0
	18. Replace 210 feet of 15-inch storm sewer at the intersection of Hi-Mount Road and Stratford Road and in Northwestern Avenue north of Hi-Mount Road with 18-inch storm sewer	17,000	0
- -	Total	$609,000	$-50

NOTE: The following abbreviations have been used: CMP = corrugated metal pipe; CMPA = corrugated metal pipe arch; and HE = horizontal elliptical.

[a] All new and replacement storm sewers are reinforced concrete pipe.

[b] Includes 35 percent for engineering, administration, and contingencies. Costs are for year 1991 with Engineering News-Record CCI = 5,015.

[c] Costs were noted to be zero when the alternative proposed replacement of a component with a component having similar operation and maintenance costs. Negative costs were noted when the replacement component was estimated to have a lesser operation and maintenance cost than that of the existing facility.

Source: SEWRPC.

sewers. There are no identified intermittent or perennial streams within the hydrologic unit and the storm sewers discharge directly to the Milwaukee River.

Problems with both inadequate minor and major system hydraulic capacities were identified in parts of this hydrologic unit. As seen in Table 17, a comparison of the existing 10-year recurrence interval storm flows with the capacities of the existing storm sewers shows that many sewers have inadequate capacities to meet the minor system requirement of passing the peak rate of runoff from a 10-year storm. In addition, major system capacity problems were identified at two locations where ponding in mid-block sags in the road could result in overland flow and flooding of buildings: 1) at the T intersection of Sunset Ridge Road and Adams Street and 2) in Jefferson Street east of 11th Avenue.

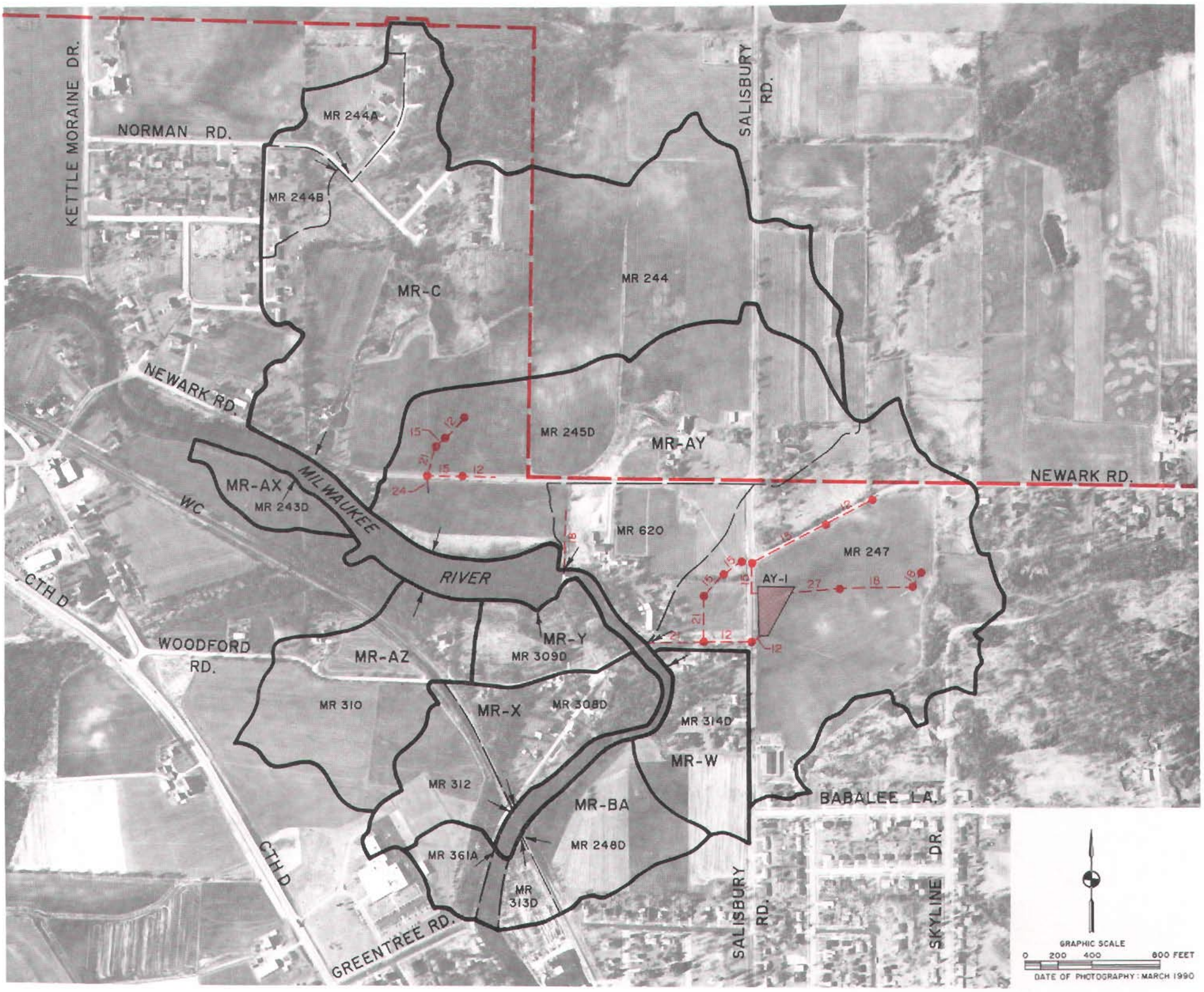
Alternative Stormwater Drainage Plans: The following two alternative stormwater management plans were considered for Hydrologic Unit G: 1) a storm sewer conveyance plan and 2) a storm sewer conveyance with decentralized detention plan.

Alternative Plan No. G-1, Storm Sewer Conveyance: This alternative plan calls for the provision of replacement storm sewers to abate existing stormwater runoff problems and to serve planned new urban development effectively. This alternative includes 2,610 lineal feet of replacement storm sewer, ranging in size from 24-inch-diameter reinforced concrete pipe to 45-inch-wide by 29-inch-high horizontal elliptical reinforced concrete pipe. Map 14 shows the approximate location and alignment of the replacement storm sewers proposed under this alternative. Table 17 presents a comparison of

Map 10

STORM SEWER CONVEYANCE WITH CENTRALIZED DETENTION ALTERNATIVE PLAN FOR STORMWATER MANAGEMENT IN THE MILWAUKEE RIVER DRAINAGE AREA

HYDROLOGIC UNITS MR-C, MR-W, MR-X, MR-Y, MR-AX, MR-AY, MR-AZ, AND MR-BA



LEGEND

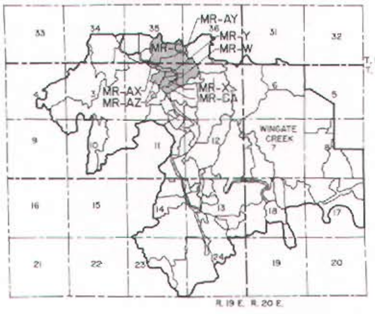
—	HYDROLOGIC UNIT BOUNDARY UNDER EXISTING DRAINAGE CONDITIONS
MR-AY	HYDROLOGIC UNIT IDENTIFICATION
— —	SUBBASIN BOUNDARY
MR 310	SUBBASIN IDENTIFICATION
→	SUBBASIN OUTLET
— —	LIMITS OF PLANNED URBAN SERVICE AREA
●	PROPOSED MANHOLE
18 - - -	PROPOSED STORM SEWER (SIZE IN INCHES)
—	PROPOSED OPEN CHANNEL
AY-I ▨	PROPOSED DRY DETENTION BASIN AND DESIGNATION

NOTE:

1.) PIPES ARE CONSTRUCTED OF REINFORCED CONCRETE.

2.) THIS ALTERNATIVE WAS NOT DEVELOPED FOR HYDROLOGIC UNITS MR-C, MR-W, MR-X, MR-Y, MR-AX, MR-AZ, AND MR-BA.

MILWAUKEE RIVER DRAINAGE AREA HYDROLOGIC UNIT LOCATION MAP



Map 10 (continued)

STORM SEWER CONVEYANCE WITH CENTRALIZED DETENTION ALTERNATIVE PLAN FOR STORMWATER MANAGEMENT IN THE MILWAUKEE RIVER DRAINAGE AREA

HYDROLOGIC UNITS MR-F, MR-G, MR-Z, MR-AA, MR-AB, MR-AC, MR-AD, MR-AG, AND MR-AH

LEGEND

▬	HYDROLOGIC UNIT BOUNDARY UNDER EXISTING DRAINAGE CONDITIONS
MR-F	HYDROLOGIC UNIT IDENTIFICATION
—	SUBBASIN BOUNDARY
MR 294	SUBBASIN IDENTIFICATION
→	SUBBASIN OUTLET
18	EXISTING STORM SEWER TO BE RETAINED (SIZE IN INCHES)
●	EXISTING MANHOLE OR CATCHBASIN
24	PROPOSED REPLACEMENT STORM SEWER DESIGNED FOR 10-YEAR STORM (SIZE IN INCHES)
48	PROPOSED REPLACEMENT STORM SEWER DESIGNED FOR 100-YEAR STORM (SIZE IN INCHES)
12	PROPOSED STORM SEWER (SIZE IN INCHES)
●	PROPOSED MANHOLE
F-1 🟥	PROPOSED DRY DETENTION BASIN AND DESIGNATION
▨	EXISTING CONSTRUCTED DETENTION BASIN
CMP	CORRUGATED METAL PIPE
HE	HORIZONTAL ELLIPTICAL REINFORCED CONCRETE PIPE
RCPA	REINFORCED CONCRETE PIPE ARCH
PVC	POLYVINYL CHLORIDE
CI	CAST IRON

NOTE:

1.) PIPES ARE CONSTRUCTED OF REINFORCED CONCRETE UNLESS DESIGNATED AS ABOVE.

2.) THIS ALTERNATIVE WAS NOT DEVELOPED FOR HYDROLOGIC UNITS MR-G, MR-Z, MR-AA, MR-AB, MR-AC, MR-AD, MR-AG, AND MR-AH, THEREFORE, THE EXISTING STORM SEWER SYSTEM IS SHOWN FOR THOSE UNITS.

GRAPHIC SCALE

0 200 400 800 FEET

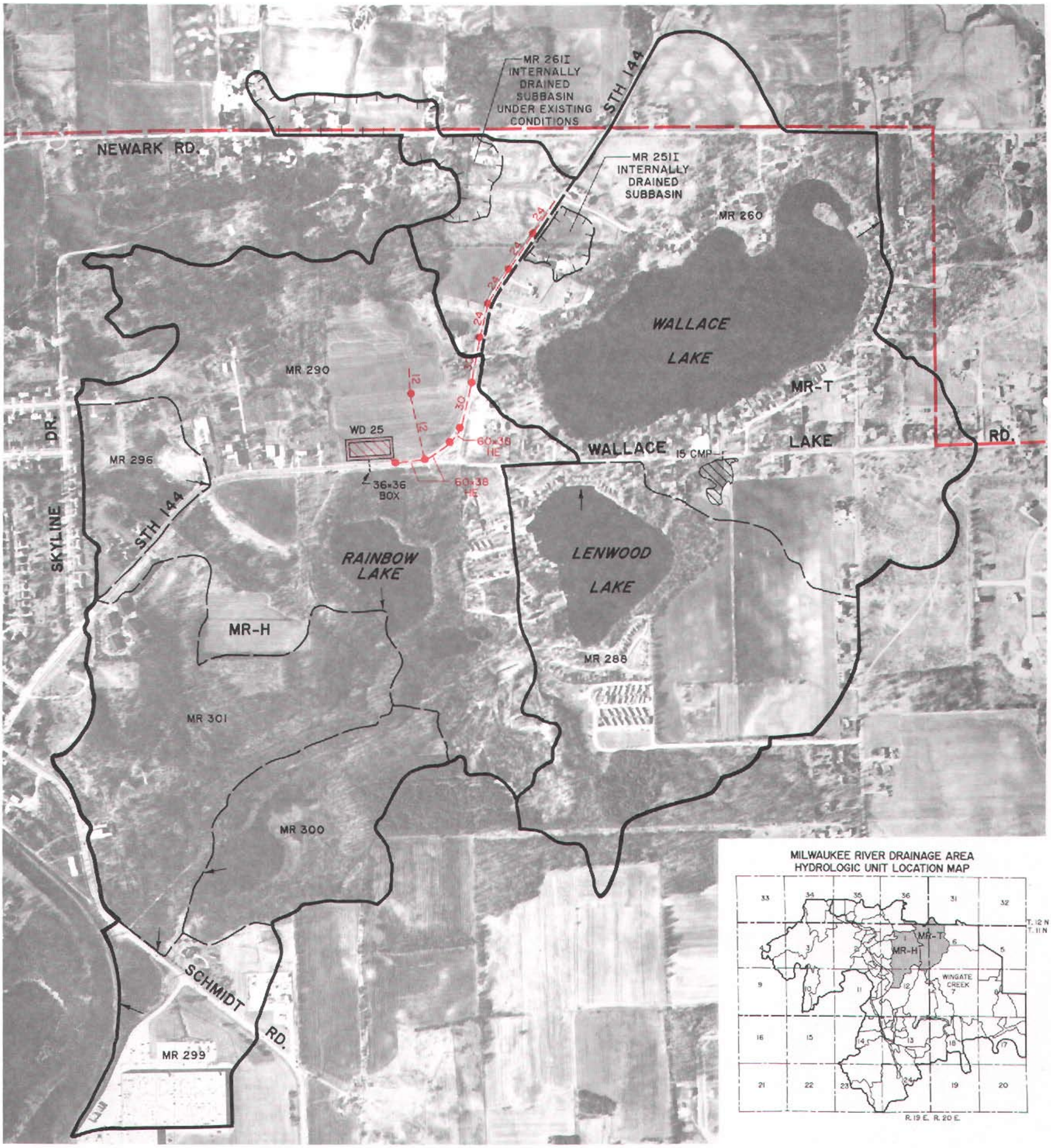
DATE OF PHOTOGRAPHY: MARCH 1990

MILWAUKEE RIVER DRAINAGE AREA HYDROLOGIC UNIT LOCATION MAP

Map 10 (continued)

STORM SEWER CONVEYANCE WITH CENTRALIZED DETENTION ALTERNATIVE PLAN FOR STORMWATER MANAGEMENT IN THE MILWAUKEE RIVER DRAINAGE AREA

HYDROLOGIC UNITS MR-H AND MR-T



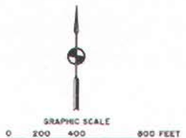
LEGEND

▬	HYDROLOGIC UNIT BOUNDARY UNDER EXISTING DRAINAGE CONDITIONS
— —	HYDROLOGIC UNIT BOUNDARY UNDER PLANNED DRAINAGE CONDITIONS
MR-H	HYDROLOGIC UNIT IDENTIFICATION
— —	SUBBASIN BOUNDARY
MR 300	SUBBASIN IDENTIFICATION
→	SUBBASIN OUTLET
— —	LIMITS OF PLANNED URBAN SERVICE AREA
_15_	EXISTING CULVERT (SIZE IN INCHES)
_24_	PROPOSED STORM SEWER (SIZE IN INCHES)
●	PROPOSED MANHOLE
WD 25 ▨	PERMANENT POND AREA OF PROPOSED WET DETENTION BASIN AND DESIGNATION
WD 25 ▨	PROPOSED DUAL-PURPOSE DETENTION BASIN AND DESIGNATION
▨	EXISTING NATURAL DETENTION OR RETENTION STORAGE AREA
HE	HORIZONTAL ELLIPTICAL REINFORCED CONCRETE PIPE

NOTE:

1.) PIPES ARE CONSTRUCTED OF REINFORCED CONCRETE.

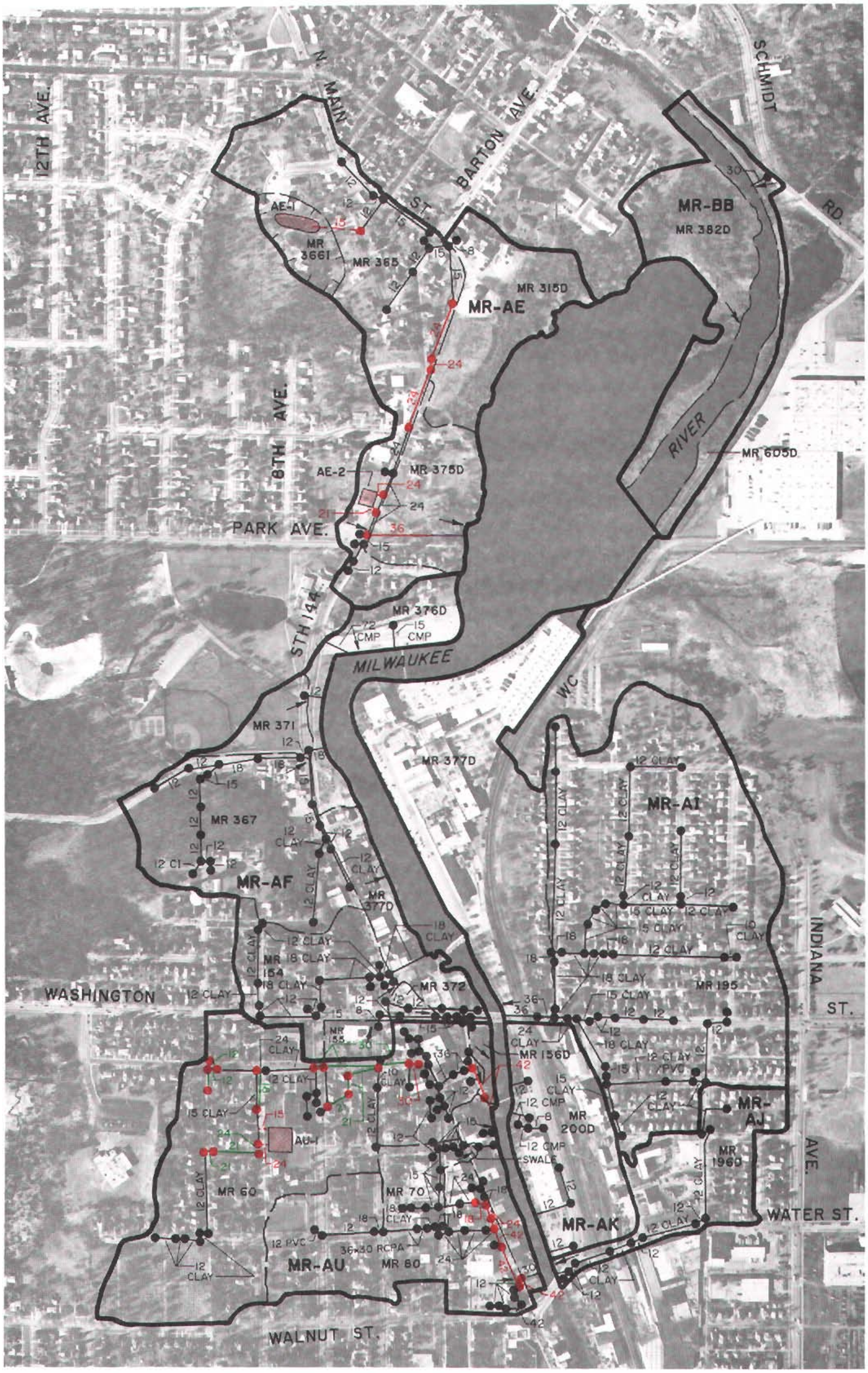
2.) THIS ALTERNATIVE WAS NOT DEVELOPED FOR HYDROLOGIC UNIT T. THEREFORE, THE EXISTING STORMWATER MANAGEMENT SYSTEM IS SHOWN FOR THAT UNIT.



Map 10 (continued)

STORM SEWER CONVEYANCE WITH CENTRALIZED DETENTION ALTERNATIVE PLAN FOR STORMWATER MANAGEMENT IN THE MILWAUKEE RIVER DRAINAGE AREA

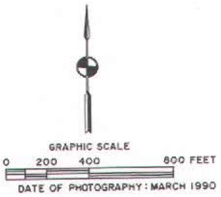
HYDROLOGIC UNITS MR-AE, MR-AF, MR-AI, MR-AJ, MR-AK, MR-AU, AND MR-BB



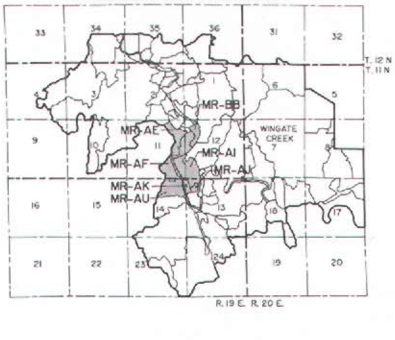
LEGEND

▬	HYDROLOGIC UNIT BOUNDARY UNDER EXISTING DRAINAGE CONDITIONS
MR-AE	HYDROLOGIC UNIT IDENTIFICATION
— —	SUBBASIN BOUNDARY
MR 365	SUBBASIN IDENTIFICATION
⟶	SUBBASIN OUTLET
24	EXISTING STORM SEWER TO BE RETAINED (SIZE IN INCHES)
●	EXISTING MANHOLE OR CATCHBASIN
24	PROPOSED REPLACEMENT STORM SEWER DESIGNED FOR 10-YEAR STORM (SIZE IN INCHES)
24	PROPOSED REPLACEMENT STORM SEWER DESIGNED FOR 100-YEAR STORM (SIZE IN INCHES)
24	PROPOSED STORM SEWER OR CULVERT (SIZE IN INCHES)
●	PROPOSED MANHOLE
—	PROPOSED OPEN CHANNEL
AE-2 ▨	PROPOSED DRY DETENTION BASIN AND DESIGNATION
CMP	CORRUGATED METAL PIPE
CLAY	CLAY PIPE
RCPA	REINFORCED CONCRETE PIPE ARCH
PVC	POLYVINYL CHLORIDE
CI	CAST IRON

NOTE:
1.) PIPES ARE CONSTRUCTED OF REINFORCED CONCRETE UNLESS DESIGNATED AS ABOVE.
2.) DUE TO MAP SCALE LIMITATIONS SOME STORM SEWER SIZES IN CONGESTED AREAS ARE NOT SHOWN.
3.) THIS ALTERNATIVE WAS NOT DEVELOPED FOR HYDROLOGIC UNITS MR-AF, MR-AI, MR-AJ, MR-AK, AND MR-BB. THEREFORE, THE EXISTING STORM SEWER SYSTEM IS SHOWN FOR THOSE UNITS.



MILWAUKEE RIVER DRAINAGE AREA HYDROLOGIC UNIT LOCATION MAP



Map 10 (continued)

STORM SEWER CONVEYANCE WITH CENTRALIZED DETENTION ALTERNATIVE PLAN FOR STORMWATER MANAGEMENT IN THE MILWAUKEE RIVER DRAINAGE AREA

HYDROLOGIC UNITS MR-J AND MR-K

LEGEND

▬	HYDROLOGIC UNIT BOUNDARY UNDER EXISTING DRAINAGE CONDITIONS
MR–J	HYDROLOGIC UNIT IDENTIFICATION
– –	SUBBASIN BOUNDARY
MR 4	SUBBASIN IDENTIFICATION
→	SUBBASIN OUTLET
12	EXISTING STORM SEWER TO BE RETAINED (SIZE IN INCHES)
●	EXISTING MANHOLE OR CATCHBASIN
27	PROPOSED REPLACEMENT STORM SEWER DESIGNED FOR 10-YEAR STORM (SIZE IN INCHES)
36	PROPOSED REPLACEMENT STORM SEWER DESIGNED FOR 100-YEAR STORM (SIZE IN INCHES)
🟥●	PROPOSED MANHOLE
▬	PROPOSED JUNCTION BOX

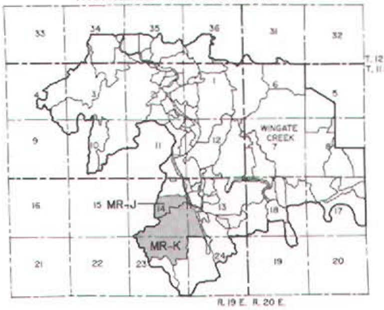
K 1 ▨	EXISTING NATURAL DETENTION OR RETENTION STORAGE AREA AND DESIGNATION
WD 4 ▨	PROPOSED DRY DETENTION BASIN AND DESIGNATION
CMP	CORRUGATED METAL PIPE
CMPA	CORRUGATED METAL PIPE ARCH
HE	HORIZONTAL ELLIPTICAL REINFORCED CONCRETE PIPE
CLAY	CLAY PIPE
CI	CAST IRON

NOTE:

1.) PIPES ARE CONSTRUCTED OF REINFORCED CONCRETE UNLESS DESIGNATED AS ABOVE.

2.) THIS ALTERNATIVE WAS NOT DEVELOPED FOR HYDROLOGIC UNIT MR-J. THEREFORE, THE EXISTING STORM SEWER SYSTEM IS SHOWN FOR THAT UNIT.

MILWAUKEE RIVER DRAINAGE AREA HYDROLOGIC UNIT LOCATION MAP



Map 10 (continued)

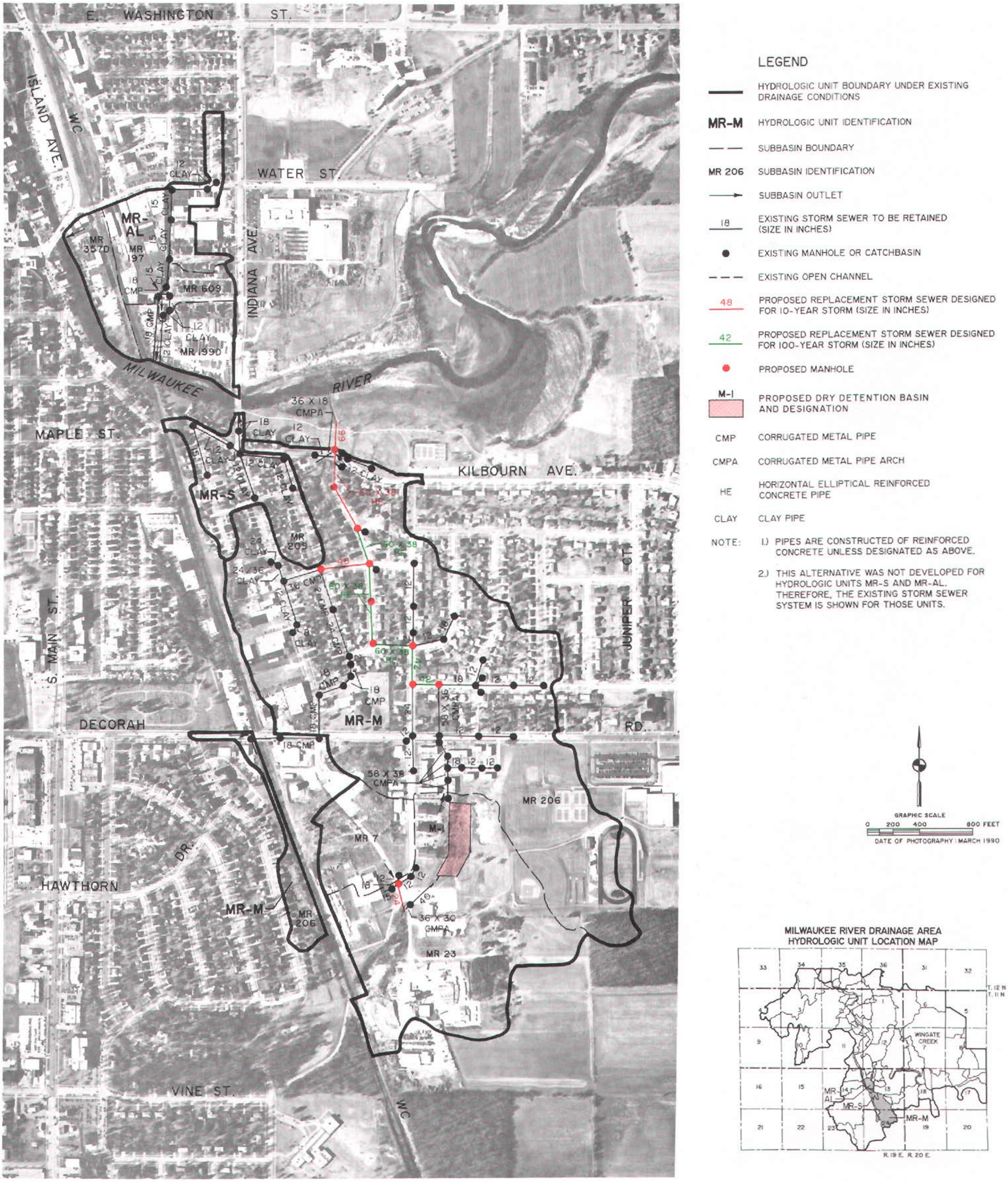
STORM SEWER CONVEYANCE WITH CENTRALIZED DETENTION ALTERNATIVE PLAN FOR STORMWATER MANAGEMENT IN THE MILWAUKEE RIVER DRAINAGE AREA

HYDROLOGIC UNITS MR-L AND MR-AV

Map 10 (continued)

STORM SEWER CONVEYANCE WITH CENTRALIZED DETENTION ALTERNATIVE PLAN FOR STORMWATER MANAGEMENT IN THE MILWAUKEE RIVER DRAINAGE AREA

HYDROLOGIC UNITS MR-M, MR-S, AND MR-AL



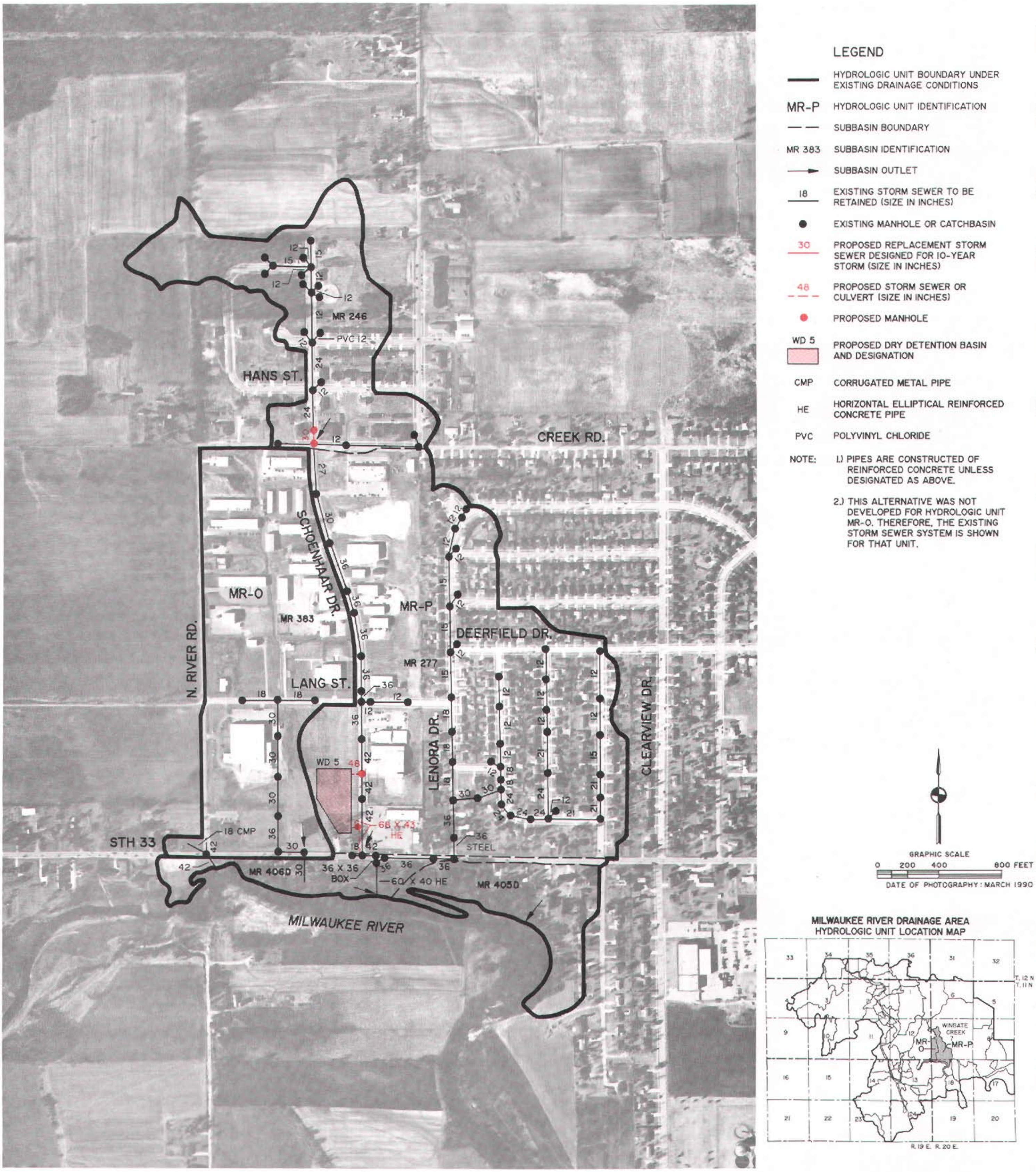
NOTE: 1.) PIPES ARE CONSTRUCTED OF REINFORCED CONCRETE UNLESS DESIGNATED AS ABOVE.

2.) THIS ALTERNATIVE WAS NOT DEVELOPED FOR HYDROLOGIC UNITS MR-S AND MR-AL. THEREFORE, THE EXISTING STORM SEWER SYSTEM IS SHOWN FOR THOSE UNITS.

Map 10 (continued)

STORM SEWER CONVEYANCE WITH CENTRALIZED DETENTION ALTERNATIVE PLAN FOR STORMWATER MANAGEMENT IN THE MILWAUKEE RIVER DRAINAGE AREA

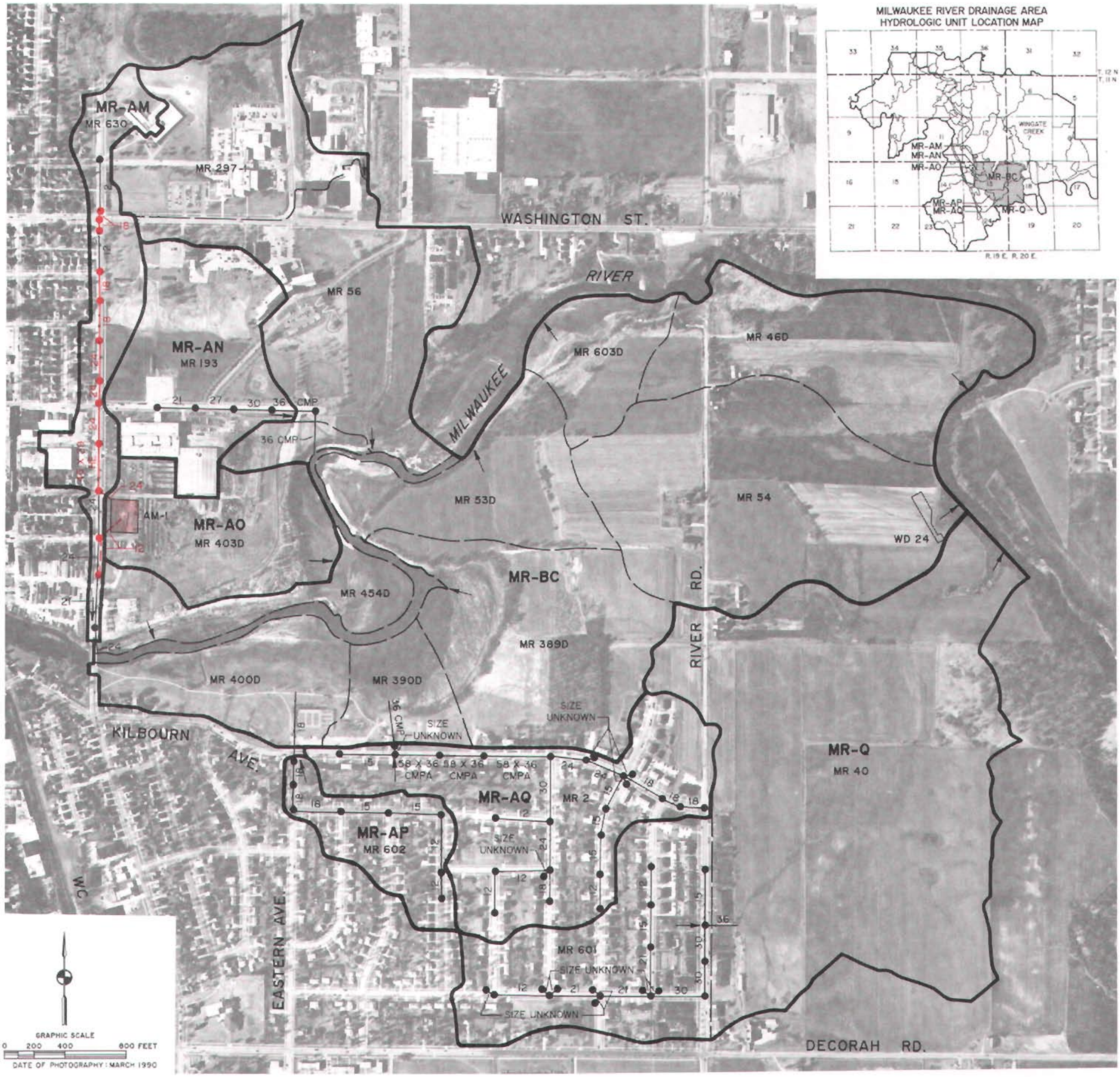
HYDROLOGIC UNITS MR-O AND MR-P



Map 10 (continued)

STORM SEWER CONVEYANCE WITH CENTRALIZED DETENTION ALTERNATIVE PLAN FOR STORMWATER MANAGEMENT IN THE MILWAUKEE RIVER DRAINAGE AREA

HYDROLOGIC UNITS MR-Q, MR-AM, MR-AN, MR-AO, MR-AP, MR-AQ, AND MR-BC



LEGEND

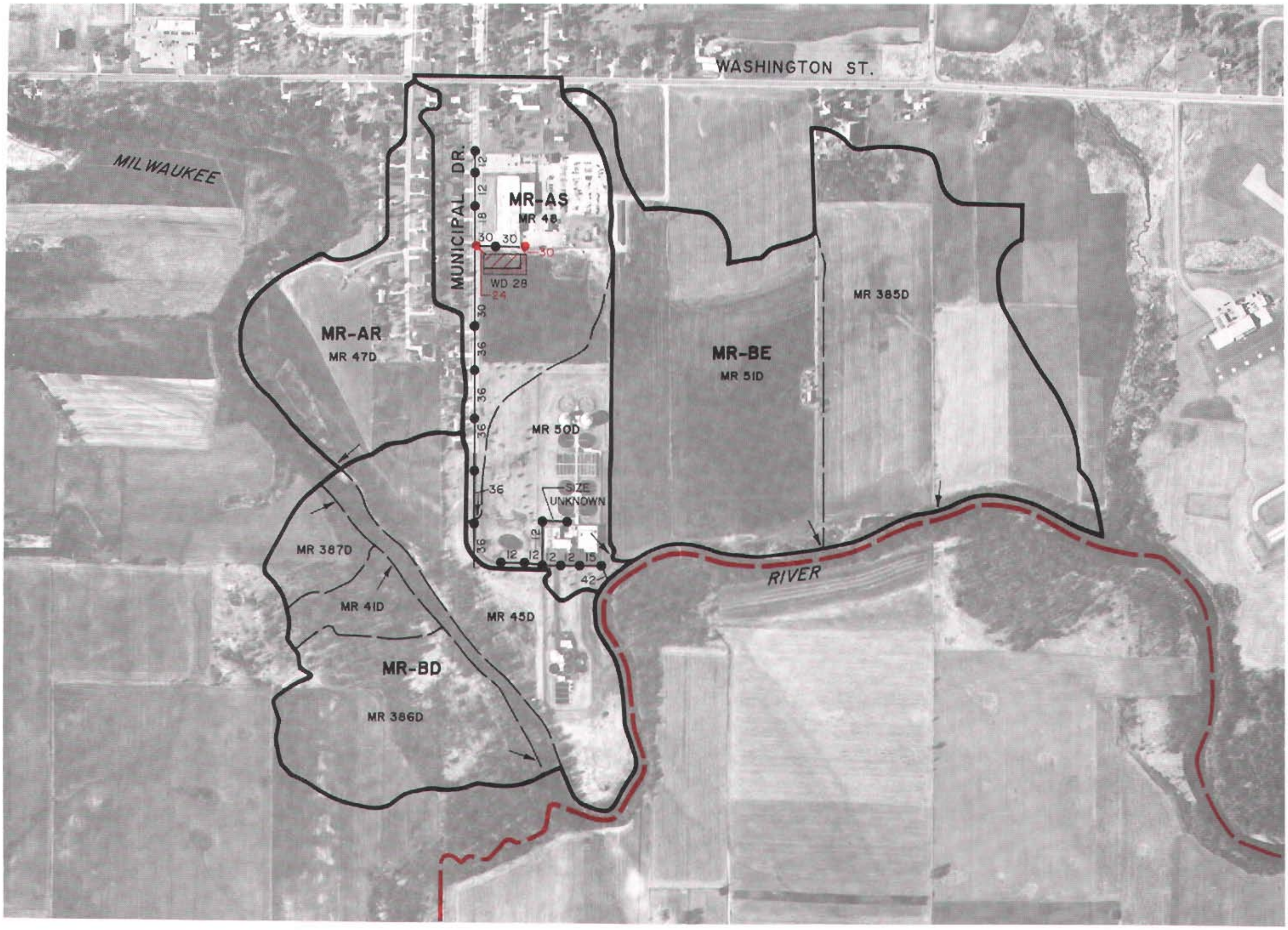
—	HYDROLOGIC UNIT BOUNDARY UNDER EXISTING DRAINAGE CONDITIONS
MR-Q	HYDROLOGIC UNIT IDENTIFICATION
— —	SUBBASIN BOUNDARY
MR 602	SUBBASIN IDENTIFICATION
——►	SUBBASIN OUTLET
12	EXISTING STORM SEWER TO BE RETAINED (SIZE IN INCHES)
●	EXISTING MANHOLE OR CATCHBASIN
24	PROPOSED REPLACEMENT STORM SEWER DESIGNED FOR 10-YEAR STORM (SIZE IN INCHES)
●	PROPOSED MANHOLE
24	PROPOSED STORM SEWER OR CULVERT (SIZE IN INCHES)
AM-1 🟥	PROPOSED DRY DETENTION BASIN AND DESIGNATION
CMP	CORRUGATED METAL PIPE
CMPA	CORRUGATED METAL PIPE ARCH
HE	HORIZONTAL ELLIPTICAL REINFORCED CONCRETE PIPE

NOTE:
1.) PIPES ARE CONSTRUCTED OF REINFORCED CONCRETE UNLESS DESIGNATED AS ABOVE.
2.) THIS ALTERNATIVE WAS NOT DEVELOPED FOR HYDROLOGIC UNITS MR-Q, MR-AN, MR-AO, MR-AP, MR-AQ, AND MR-BC. THEREFORE, THE EXISTING STORM SEWER SYSTEM IS SHOWN FOR THOSE UNITS.

Map 10 (continued)

STORM SEWER CONVEYANCE WITH CENTRALIZED DETENTION ALTERNATIVE PLAN FOR STORMWATER MANAGEMENT IN THE MILWAUKEE RIVER DRAINAGE AREA

HYDROLOGIC UNITS MR-AR, MR-AS, MR-BD, AND MR-BE



LEGEND

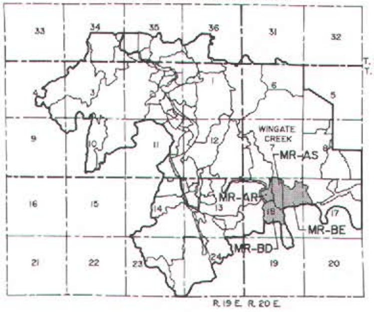
——	HYDROLOGIC UNIT BOUNDARY UNDER EXISTING DRAINAGE CONDITIONS
MR-AS	HYDROLOGIC UNIT IDENTIFICATION
— —	SUBBASIN BOUNDARY
MR 48	SUBBASIN IDENTIFICATION
→	SUBBASIN OUTLET
— —	LIMITS OF PLANNED URBAN SERVICE AREA
30	EXISTING STORM SEWER TO BE RETAINED (SIZE IN INCHES)
●	EXISTING MANHOLE OR CATCHBASIN
30	PROPOSED STORM SEWER (SIZE IN INCHES)
●	PROPOSED MANHOLE
WD 28 ▨	PERMANENT POND AREA OF PROPOSED WET DETENTION BASIN AND DESIGNATION
WD 28 ▨	PROPOSED DUAL-PURPOSE DETENTION BASIN AND DESIGNATION

NOTE: 1.) PIPES ARE CONSTRUCTED OF REINFORCED CONCRETE.

2.) THIS ALTERNATIVE WAS NOT DEVELOPED FOR HYDROLOGIC UNITS MR-AR, MR-BD, AND MR-BE.

DATE OF PHOTOGRAPHY: MARCH 1990

MILWAUKEE RIVER DRAINAGE AREA HYDROLOGIC UNIT LOCATION MAP



Source: SEWRPC.

Table 15

COMPARISON OF EXISTING AND PROPOSED FLOWS AND HYDRAULIC CAPACITIES OF STORM SEWERS: ALTERNATIVE F-2, STORM SEWER CONVEYANCE WITH CENTRALIZED DETENTION

Branch	Reach	Storm Sewer Location[a]	Existing Size[b] (inches)	Existing Capacity (cubic feet per second)	Planned Size[b] (inches)	Length (feet)	Planned Capacity (cubic feet per second)	Existing 10-Year Storm Flow (cubic feet per second)	Planned 10-Year Storm Flow (cubic feet per second)	Existing 100-Year Storm Flow (cubic feet per second)	Planned 100-Year Storm Flow (cubic feet per second)	Frequency Storm Used for Evaluation of Existing Storm Sewers and Replacement of Inadequate Storm Sewers (years)
1	0	In Skyline Drive north of Barbie Avenue and south of Barbie Drive (100)	21	8	38 by 24 HE	673	20	8	8	8[c]	15	100
1	2	In easement east of Acorn Road and west of Skyline Drive (100)	12	9	21	24	25	11	11	15	22	100
		In easement east of Acorn Road and west of Skyline Drive (100)	12 CMP	3	21	380	25	11	11	15	22	100
1	4	In Acorn Road between Parkfield Drive and Briar Drive (100)	21	29	38 by 24 HE	29	76	28	28	50	56	100
		In Acorn Road between Parkfield Drive and Briar Drive (100)	18	13	38 by 24 HE	329	52	28	28	50	56	10
2	0	In Briar Drive north of Acorn Road (100)	15	7	30 by 19 HE	308	23	15	15	29	29	10
1	6	In Acorn Road west of Parkfield Drive (100)	18[d]	6	24 at 1.38 percent	330	27	51	52	96	102	10
		In Acorn Road west of Parkfield Drive (100)	24[d]	25	Retain existing	320	25	51	52	96	102	10
1	8	In easement between Jackson Street and Hi-Mount Road west of Salisbury Road (101)	30	40	36 at 1.65 percent	390	86	62	63	115	121	10
1	10	In Stratford Road between Jackson Street and Hi-Mount Road (101)	30	46	36 at 1.65 percent	58	86	65	66	123	129	10
5	0	In easement north of Jackson Street and west of Salisbury Road	New sewer	New sewer	12	170	1.3	--	0.8	--	1.3	100
1	12	Abandoned under this alternative	--	--	--	--	--	--	--	--	--	--
1	14	In easement between Northwestern Avenue and Milwaukee River (101)	36	124	42	123	187	51	70	125	141	100
		In easement between Northwestern Avenue and Milwaukee River (101)	50 by 31 CMPA	82	42	168	185	51	70	125	141	100

Table 15 (continued)

Branch	Reach	Storm Sewer Location[a]	Existing Size[b] (inches)	Existing Capacity (cubic feet per second)	Planned Size[b] (inches)	Length (feet)	Planned Capacity (cubic feet per second)	Existing 10-Year Storm Flow (cubic feet per second)	Planned 10-Year Storm Flow (cubic feet per second)	Existing 100-Year Storm Flow (cubic feet per second)	Planned 100-Year Storm Flow (cubic feet per second)	Frequency Storm Used for Evaluation of Existing Storm Sewers and Replacement of Inadequate Storm Sewers (years)
4	0	In Northwestern Avenue and west of Northwestern Avenue (101)	24 CMP	5	18 at 0.87 percent	130	10	4	6	6	10	100
		In Northwestern Avenue and west of Northwestern Avenue (101)	24 CMP	18	18 at 0.87 percent	60	10	4	6	6	10	100
6	0	At the intersection of Hi-Mount Road and Stratford Road and in Northwestern Avenue north of Hi-Mount Road (101)	15	6	21 at 2.2 percent	196	24	14	14	21	21	100
6	2	At the intersection of Hi-Mount Road and Stratford Road and in Northwestern Avenue north of Hi-Mount Road (101)	15	12	21 at 2.2 percent	210	24	14	14	21	21	100

NOTE: The following abbreviations have been used: CMP = corrugated metal pipe; CMPA = corrugated metal pipe arch; HE = horizontal elliptical; and RCP = reinforced concrete pipe.

[a] *City storm sewer system plan sheet number in parentheses.*

[b] *Diameter of circular reinforced concrete pipe unless noted otherwise.*

[c] *Flow limited to storm sewer capacity.*

[d] *Branch 1, Reach 6 is an 18-inch-diameter RCP in parallel with a 24-inch-diameter RCP.*

Source: SEWRPC.

peak flows and existing and proposed storm sewer hydraulic capacities. Table 9 presents the salient characteristics and estimated costs of the new and replacement storm sewers comprising this alternative plan. The total present value cost of this alternative plan is $425,000, consisting of an estimated capital cost of $426,000 and an estimated annual operation and maintenance cost decrease of $60 compared to existing conditions.

Alternative Plan No. G-2, Storm Sewer Conveyance with Decentralized Detention: Because of the lack of available open space in which to construct detention storage facilities, the only possible site for such a facility would be on the site of a 5.5-acre area of planned high-density residential development within the hydrologic unit. It was found that the provision of such detention storage would not enable the downsizing of any proposed storm sewers and would, therefore, be more costly than Alternative G-1.

Evaluation of Alternative Stormwater Drainage Plans and Plan Recommendations: As outlined above, Alternative G-1, Storm Sewer Conveyance, is the preferable alternative and was selected for this hydrologic unit. The components and costs of the recommended plan are set forth in Table 9 and the approximate location, alignment, and configuration of the recommended facilities, along with the nonpoint source pollution control measures recommended in Chapter IV of this volume, are shown graphically on Map 14.

Hydrologic Unit MR-H

Evaluation of the Stormwater Management System: Hydrologic Unit MR-H is a 0.53-square-mile area located as shown on Map 1 in Chapter I of this volume. Under existing land use conditions, about 20 percent of the unit is developed in urban land uses. Under planned year 2010 conditions about 40 percent of the hydrologic unit would be developed in urban use,

Table 16

ALTERNATIVE F-2: COMPONENTS AND COSTS OF THE STORM SEWER CONVEYANCE WITH CENTRALIZED DETENTION STORMWATER DRAINAGE PLAN FOR WEST BEND HYDRAULIC UNIT MR-F

Hydrologic Unit	Project and Component Description[a]	Estimated Cost	
		Capital[b]	Annual Operation and Maintenance[c]
F	1. through 7. Same components as Storm Sewer Conveyance Alternative (see Table 14)	$288,000	$ 0
	8. Replace 390 feet of 30-inch storm sewer in easement between Jackson Street and Hi-Mount Road with 36-inch storm sewer	75,000	-70
	9. Replace 58 feet of 30-inch storm sewer in Stratford Road between Jackson Street and Hi-Mount Road with 36-inch storm sewer	11,000	-10
	10. 170 feet of 12-inch storm sewer in easement north of Jackson Street and west of Salisbury Road	8,000	70
	11. Replace 123 feet of 36-inch storm sewer in easement west of Northwestern Avenue into the Milwaukee River north of Hi-Mount Road with 48-inch storm sewer	28,000	0
	12. Replace 168 feet of 50-inch by 31-inch CMPA in easement west of Northwestern Avenue and into the Milwaukee River north of Hi-Mount Road with 48-inch storm sewer	38,000	0
	13. Replace 130 feet of 24-inch storm sewer in Northwestern Avenue and west of Northwestern Avenue with 18-inch storm sewer	11,000	0
	14. Replace 60 feet of 24-inch storm sewer in Northwestern Avenue and west of Northwestern Avenue with 18-inch storm sewer	5,000	0
	15. Replace 196 feet of 15-inch storm sewer at the intersection of Hi-Mount Road and Stratford Road and in Northwestern Avenue north of Hi-Mount Road with 21-inch storm sewer	19,000	0
	16. Replace 210 feet of 15-inch storm sewer at the intersection of Hi-Mount Road and Stratford Road and in Northwestern Avenue north of Hi-Mount Road with 21-inch storm sewer	20,000	0
	17. 0.34 acre-foot detention basin to serve planned development northwest of the intersection of Jackson Street and Salisbury Road (basin F-1)	71,000	900
	18. 1.0 acre-foot detention basin located between Northwestern Avenue and Stratford Road (basin F-2)	122,000	1,000
- -	Total	$696,000	$1,890

NOTE: The following abbreviation has been used: CMPA = corrugated metal pipe arch.

[a] *All new and replacement storm sewers are reinforced concrete pipe.*

[b] *Includes 35 percent for engineering, administration, and contingencies. Costs are for year 1991 with Engineering News-Record CCI = 5,015.*

[c] *Costs were noted to be zero when the alternative proposed replacement of a component with a component having similar operation and maintenance costs. Negative costs were noted when the replacement component was estimated to have a lower operation and maintenance cost than that of the existing facility.*

Source: SEWRPC.

Table 17

COMPARISON OF EXISTING AND PROPOSED FLOWS AND HYDRAULIC CAPACITIES OF STORM SEWERS: ALTERNATIVE G-1, STORM SEWER CONVEYANCE

Branch	Reach	Storm Sewer Location[a]	Existing Size[b] (inches)	Existing Capacity (cubic feet per second)	Planned Size[b] (inches)	Length (feet)	Planned Capacity (cubic feet per second)	Existing 10-Year Storm Flow (cubic feet per second)	Planned 10-Year Storm Flow (cubic feet per second)	Existing 100-Year Storm Flow (cubic feet per second)	Planned 100-Year Storm Flow (cubic feet per second)	Frequency Storm Used for Evaluation of Existing Storm Sewers and Replacement of Inadequate Storm Sewers (years)
1	2	In Sunset Ridge Road between Adams Street and Roosevelt Drive (101)	24	16	45 by 29 HE at 0.41 percent	208	43	16	16	31	31	100
		In Sunset Ridge Road between Adams Street and Roosevelt Drive (101)	24	8	36 at 0.41 percent	116	43	16	16	31	31	100
		In Sunset Ridge Road between Adams Street and Roosevelt Drive (101)	36 CMP	51	36 at 0.41 percent	21	43	16	16	31	31	100
3	0	In Sunset Ridge Road between Roosevelt Drive and Jefferson Street (101)	15	6	24 at 2.1 percent	131	33	13	13	22	22	100
		In Jefferson Street just east of Sunset Ridge Road (101)	15	10	24 at 2.1 percent	306	33	13	13	22	22	100
1	4	In Roosevelt Drive just west of Sunset Ridge Road (101)	18	10	38 by 24 HE at 3.0 percent	156	71	40	40	75	75	100
		In Roosevelt Drive between Sunset Ridge Road and Main Street (101)	18	16	38 by 24 HE at 1.6 percent	364	53	40	40	75	75	10
		In Roosevelt Drive between Sunset Ridge Road and Main Street (101)	18	15	38 by 24 HE at 1.6 percent	15	53	40	40	75	75	10
1	6	In Main Street just north of Roosevelt Drive (101)	18	10	38 by 24 HE at 1.6 percent	86	53	44	44	81	81	10
		In Main Street just north of Roosevelt Drive (101)	24 CMP	21	38 by 24 HE at 1.6 percent	43	53	44	44	81	81	10
1	8	In easement between Main Street and Fairview Drive, north of School Place (101)	24 CMP	31	38 by 24 HE at 5.5 percent	200	98	66	78	120	138	10
		In School Place between Fairview Drive and River Drive (101)	24 CMP	28	38 by 24 HE at 5.5 percent	224	98	66	78	120	138	10
		In School Place between Fairview Drive and River Drive (101)	24 CMP	28	38 by 24 HE at 5.5 percent	294	98	66	78	120	138	10
1	10	In River Drive north of School Place (101)	30 CMP	49	38 by 24 HE	380	92	77	89	142	161	10
		In River Drive north of School Place (101)	30 CMP	63	38 by 24 HE	62	118	77	89	142	161	10

NOTE: The following abbreviations have been used: CMP = corrugated metal pipe; and HE = horizontal elliptical.

[a] *City storm sewer system plan sheet number in parenthesis.*

[b] *Diameter of circular reinforced concrete pipe unless noted otherwise.*

Source: SEWRPC.

predominantly medium- and high-density residential and commercial uses. The remaining 60 percent would be devoted woodlands, wetlands, park and recreational areas, agricultural, and other open space uses. The existing stormwater management system consists of roadside swales and a system of interconnected natural ponds, lakes, and wetlands located within existing and planned portions of the City's Lac Lawrann Conservancy Area.

Owing to the relatively low development density of the hydrologic unit under existing conditions and the flood-attenuating effects of the natural drainage system, there are no known existing, significant stormwater drainage problems in the unit.

Alternative Stormwater Management Plans: The following two alternative stormwater management plans were developed for Hydrologic Unit H: 1) a storm sewer conveyance with centralized detention plan and 2) a storm sewer conveyance with decentralized detention plan. The primary reason for the provision of stormwater detention facilities is to maintain the water quality of Rainbow and Wallace Lakes and of the Lac Lawrann stream and wetland system through the provision of a high degree of control of nonpoint source pollution.

Wallace Lake and subbasin MR261I and the extreme northwestern portion of MR260 are located in Hydrologic Unit MR-T; however, under possible future conditions, runoff from those subbasins may be conveyed to either Hydrologic Unit MR-H or MR-T. Under existing conditions subbasin MR261I is internally drained; however, when the southern portion of that subbasin is developed in medium-density residential uses, it is likely that the site would be graded to enable the entire subbasin to drain into the northwest part of subbasin MR260. The northwest part of subbasin MR260 drains to a roadside ditch along the west side of STH 144 under existing conditions. The ditch conveys that runoff to the southwest, where lower flows are impounded by a private drive which crosses the ditch. That drive functions to divert runoff to an 18-inch-diameter corrugated metal pipe culvert under STH 144 and then to a swale leading to Wallace Lake. Under existing conditions the culvert outlet is almost completely blocked with sediment. Even with the culvert clear of sediment, flows in excess of its capacity would overtop the private drive and continue to the southwest into the STH 144 ditch in subbasin MR290, ultimately being conveyed under STH 144 to Rainbow Lake. Under planned conditions, it is possible that the private driveway which diverts low flows to Wallace Lake may be removed and, in the absence of another constructed control to divert runoff, all upstream runoff would be conveyed to Rainbow Lake. Thus, Alternative No. 1, the centralized detention alternative, was developed under the assumption that all runoff from MR261I and from the northwest portion of MR260 would be conveyed into subbasin MR290 in Hydrologic Unit MR-H and, ultimately, into Rainbow Lake. Alternative No. 2, the decentralized detention alternative, assumes that all runoff from MR261I and from the northwest portion of MR260 is conveyed across STH 144 into Hydrologic Unit MR-T to Wallace Lake.

Alternative Plan No. H-1, Storm Sewer Conveyance with Centralized Detention: This alternative plan calls for the provision of new storm sewers and a single, centralized detention basin to serve planned development effectively. This alternative includes 3,110 lineal feet of new storm sewer, ranging in size from 12-inch-diameter to 60-inch by 38-inch horizontal elliptical reinforced concrete pipe. The alternative also calls for the construction of wet detention basin WD25 on the north side of STH 144. That basin is intended primarily to reduce nonpoint source pollutant loadings to Rainbow Lake and Lac Lawrann; however, because of the excavation necessary to accommodate the existing outlet and the proposed inflowing storm sewer, the basin would also provide attenuation of peak flood flows with recurrence intervals up to, and including, 100 years. The peak 100-year flood outflow from the basin would be conveyed under STH 144 through the existing three-foot by three-foot concrete box culvert without overtopping the highway. Under planned conditions, with the wet basin in place, loadings of suspended solids and phosphorus from the tributary area would be reduced by 93 and 64 percent, respectively. Lead loadings, used as an indicator of heavy metals in general, would increase by about 220 percent, from 5.8 pounds per year under existing conditions to 13.0 pounds per year under planned conditions; however, uncontrolled planned loadings would be reduced

Table 18

ALTERNATIVE H-1: COMPONENTS AND COSTS OF THE STORM SEWER CONVEYANCE WITH CENTRALIZED DETENTION ALTERNATIVE STORMWATER DRAINAGE PLAN FOR WEST BEND HYDROLOGIC UNIT MR-H

Hydrologic Unit	Project and Component Description[a]	Estimated Cost	
		Capital[b]	Annual Operation and Maintenance
H	1. 660 feet of 12-inch storm sewer	$ 29,000	$ 260
	2. 1,135 feet of 24-inch storm sewer	127,000	450
	3. 705 feet of 30-inch storm sewer	106,000	280
	4. 610 feet of 60-inch by 38 inch concrete HE storm sewer	192,000	120
	5. Detention basin WD25 with a 100-year storm live storage volume of 4.4 acre-feet. Water quantity control cost	117,000	1,900
	6. Detention basin WD25 with a permanent pond area of 0.88 acre. Water quality control cost	134,000	2,600
- -	Total	$705,000	$5,610

NOTE: The following abbreviation has been used: HE = horizontal elliptical.

[a] *All new and replacement storm sewers are reinforced concrete pipe.*

[b] *Includes 35 percent for engineering, administration, and contingencies. Costs are for year 1991 with Engineering News-Record Construction Cost Index = 5,015.*

Source: SEWRPC.

by 57 percent.[2] Map 10 shows the approximate location and alignment of the new storm sewers and the detention basin proposed under this alternative. Table 18 presents the salient characteristics and estimated costs of the recommended facilities comprising this alternative plan. The total present value cost of this alternative plan is $793,000, consisting of an estimated capital cost of $705,000 and an estimated annual operation and maintenance cost increase of $5,610 over existing conditions.

Alternative Plan No. H-2, Storm Sewer Conveyance with Decentralized Detention: This alternative plan calls for the provision of new storm sewers and two decentralized detention basins to serve planned development effectively. The alternative includes 3,075 lineal feet of new storm sewer, ranging in size from 12-inch- to 24-inch-diameter reinforced concrete pipe. The alternative also calls for the construction of wet detention basin WD25 on the north side of STH 144 and wet basin WD26 on the west side of STH 144 at the location of the existing private drive which diverts runoff from the northwest part of MR260 to Wallace Lake. Under proposed conditions, all runoff from MR261I and the northwest part of MR260 would be treated by basin WD26 and then conveyed to Wallace Lake. The two wet basins are intended primarily to reduce nonpoint source pollutant loadings to Rainbow and Wallace Lakes and Lac Lawrann; however, because of the excavation necessary to accommodate the proposed inflowing storm sewers, the basins would also provide attenuation of peak flood flows with recurrence intervals up to, and including, 100 years. As under Alternative H-1, the peak 100-year flood outflow from basin WD25 would be conveyed under STH 144 through the existing culvert without overtopping the highway. A proposed storm sewer outlet from basin WD26 would convey the

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[2] *When land use in an area is converted from rural to urban, an increase in metal loadings under planned conditions in comparison to existing conditions is almost unavoidable even with treatment to the maximum extent practicable, as is provided in this case.*

peak 100-year flood flow from the basin under STH 144 to Wallace Lake. Under planned conditions, with the wet basins in place, the same degree of treatment of nonpoint source pollution would be provided as under Alternative H-1. Map 11 shows the approximate location and alignment of the new storm sewers and the detention basin proposed under this alternative. Table 19 presents the salient characteristics and estimated costs of the recommended facilities comprising this alternative plan. The total present value cost of this alternative plan is $753,000, consisting of an estimated capital cost of $636,000 and an estimated annual operation and maintenance cost increase of $7,430 over existing conditions.

Evaluation of Alternative Stormwater Management Plans: The foregoing information provides a basis for a comparative evaluation of the two alternative stormwater drainage plans. Each alternative was designed to serve anticipated future development within the hydrologic unit. Each alternative achieves the same net level of abatement of nonpoint source pollution; however, the distribution of the pollutants to receiving waters differs between the two alternatives. Thus, the principal criteria for the comparative evaluation are cost, implementability, and the distribution of pollutant loads.

Alternative H-2 has lower capital and present value costs than Alternative H-1. Although annual operation and maintenance costs of the two alternatives are similar, the additional detention basin called for under Alternative H-2 results in a somewhat higher annual operation and maintenance cost. Alternative H-2 may be somewhat more difficult to implement since it may involve obtaining an easement for the construction of the outlet pipe for basin WD26. Alternative H-2 minimizes nonpoint source pollutant loadings to Rainbow Lake and the Lac Lawrann Conservancy Area, while Alternative H-1 eliminates the contribution of nonpoint source loadings to Wallace Lake from subbasins MR261I and the northwest part of MR260. Because the planned, uncontrolled unit pollutant loadings to Wallace Lake from its entire watershed would be lower than those to Rainbow Lake and Lac Lawrann and because of the anticipated higher assimilative capacity of Wallace Lake, Alternative H-2, which minimizes loadings to Rainbow Lake and Lac Lawrann, would be preferred from the standpoint of nonpoint source pollution control.

Recommended Stormwater Management Plan: On the basis of a comparative evaluation of the two alternative plans, Alternative H-2, Storm Sewer Conveyance with Decentralized Detention, is recommended for adoption in this hydrologic unit. The recommended stormwater management plan, including nonpoint source pollution control measures, is summarized in graphic form on Map 14. The minor and major system components and costs of the recommended plan are set forth in Table 9.

Hydrologic Unit MR-I

Evaluation of the Stormwater Management System: Hydrologic Unit MR-I is a 0.31-square-mile area located as shown on Map 1 in Chapter I of this volume. Under existing land use conditions, about 21 percent of the hydrologic unit is developed in urban land uses. Under planned year 2010 conditions, the hydrologic unit would be about 57 percent developed in urban uses, predominantly industrial, but would also include medium- and high-density residential and government and institutional uses. The remaining 43 percent would be devoted to woodlands, wetlands, park and recreational areas, and other open space uses. The existing stormwater management system consists of roadway curbs and gutters, storm sewer inlets, storm sewers, roadside swales, and a dry detention basin. The existing facilities discharge to an area which is in the Milwaukee River 100-year recurrence interval floodplain located southwest of the intersection of Schmidt Road and Brown Lane. That area is currently in wetland and agricultural uses, and it would remain in wetland and open space uses under planned land use conditions.

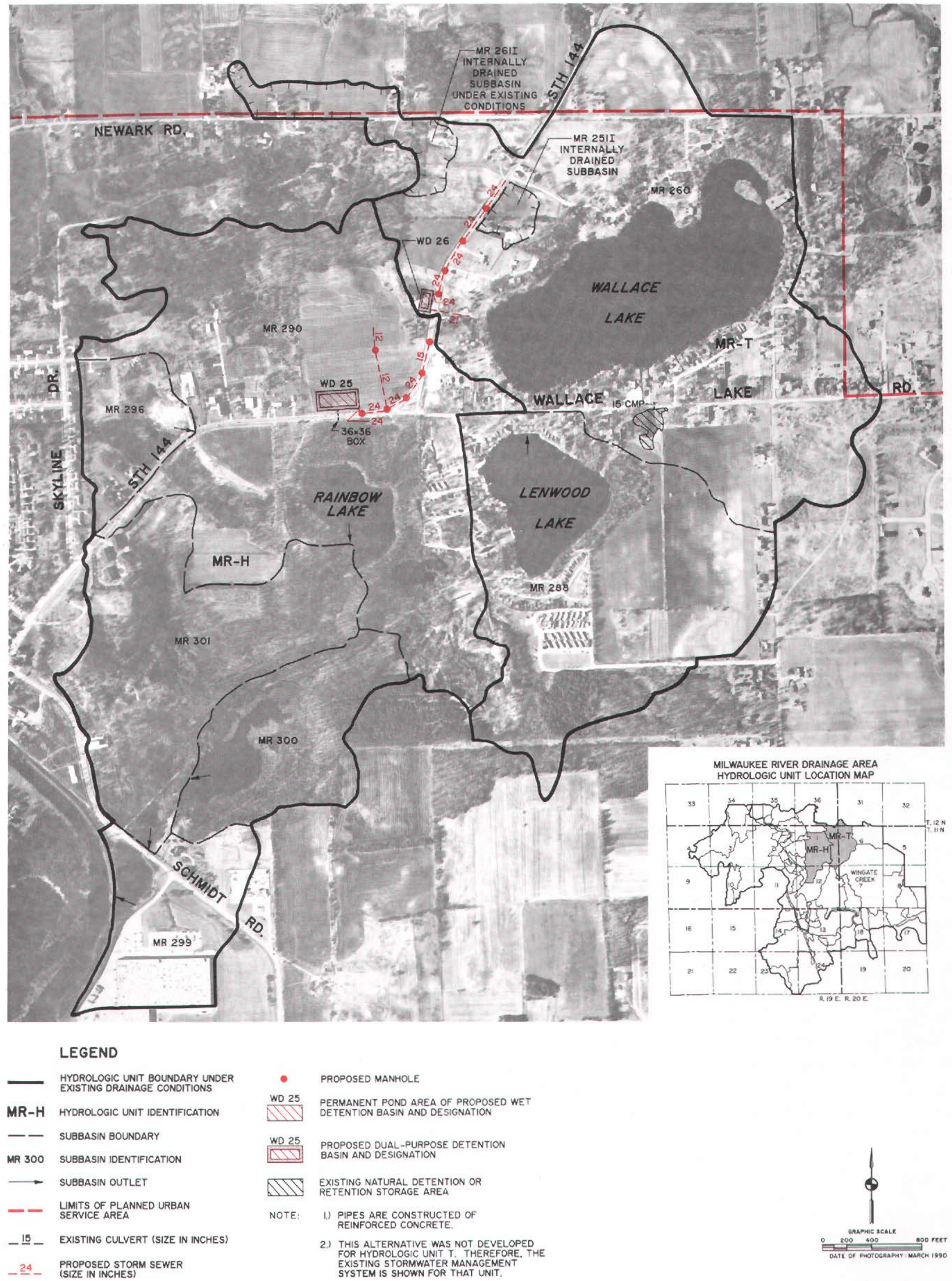
Under existing conditions, there is a potential problem with flooding of Brown Lane west of Schmidt Road. That problem is due to the lack of facilities to convey runoff from the area north of Brown Lane across Brown Lane.

Alternative Stormwater Drainage Plans: Because much of the hydrologic unit is to remain in wetland, park, or open space uses; because the subbasins in the unit have several separate outlets to the Milwaukee River floodplain; and because detention storage has already been

Map 11

STORM SEWER CONVEYANCE WITH DECENTRALIZED DETENTION ALTERNATIVE PLAN FOR STORMWATER MANAGEMENT IN THE MILWAUKEE RIVER DRAINAGE AREA

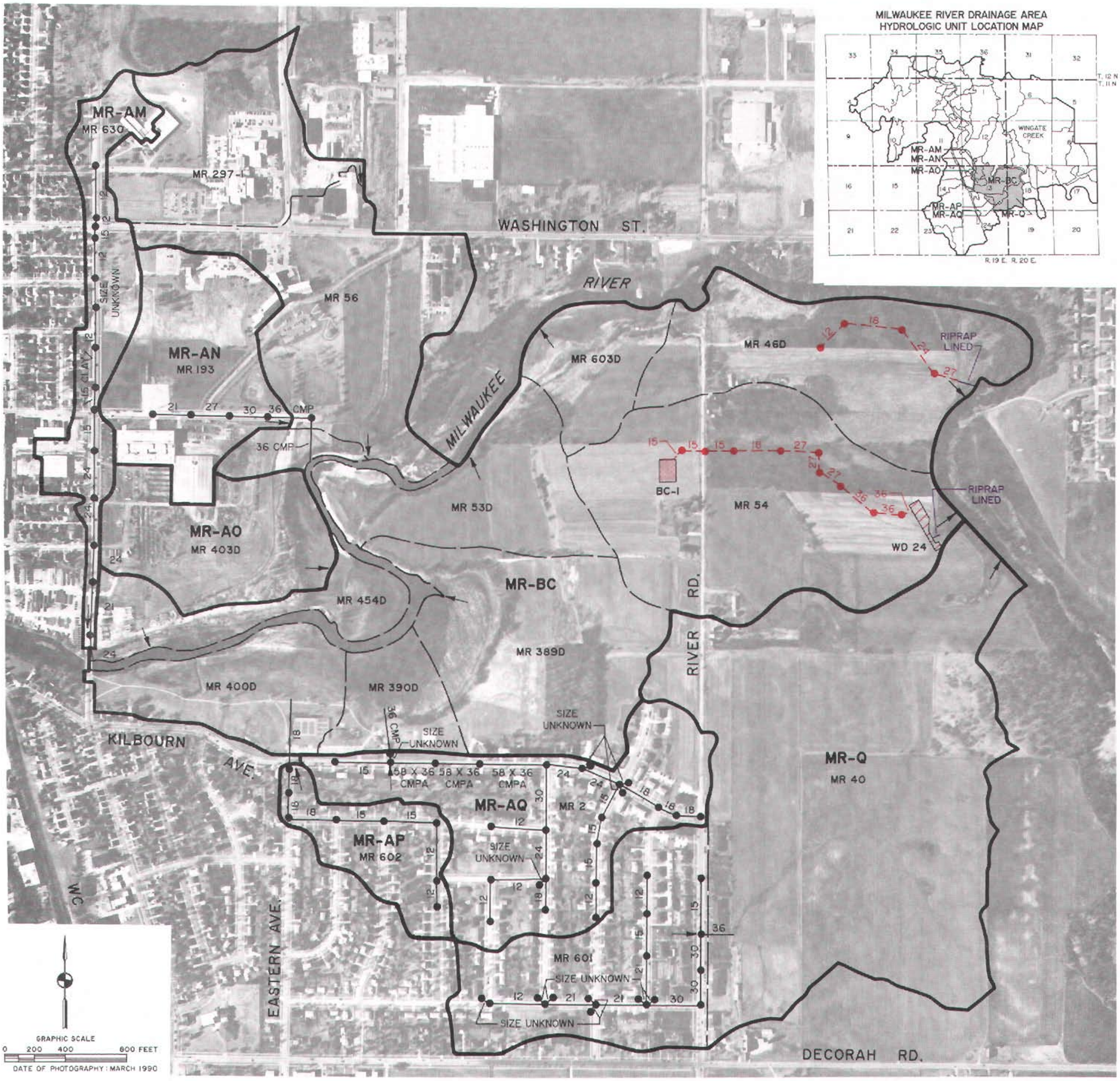
HYDROLOGIC UNITS MR-H AND MR-T



Map 11 (continued)

STORM SEWER CONVEYANCE WITH DECENTRALIZED DETENTION ALTERNATIVE PLAN FOR STORMWATER MANAGEMENT IN THE MILWAUKEE RIVER DRAINAGE AREA

HYDROLOGIC UNITS MR-Q, MR-AM, MR-AN, MR-AO, MR-AP, MR-AQ, AND MR-BC



LEGEND

——	HYDROLOGIC UNIT BOUNDARY UNDER EXISTING DRAINAGE CONDITIONS
MR-Q	HYDROLOGIC UNIT IDENTIFICATION
— —	SUBBASIN BOUNDARY
MR 602	SUBBASIN IDENTIFICATION
——►	SUBBASIN OUTLET
12	EXISTING STORM SEWER TO BE RETAINED (SIZE IN INCHES)
●	EXISTING MANHOLE OR CATCHBASIN
27	PROPOSED STORM SEWER OR CULVERT (SIZE IN INCHES)
●	PROPOSED MANHOLE
——	PROPOSED OPEN CHANNEL
▨	PERMANENT POND AREA OF PROPOSED WET DETENTION BASIN AND DESIGNATION
BC-I	PROPOSED DRY DETENTION BASIN AND DESIGNATION
CMP	CORRUGATED METAL PIPE
CMPA	CORRUGATED METAL PIPE ARCH
CLAY	CLAY PIPE

NOTE:

1.) PIPES ARE CONSTRUCTED OF REINFORCED CONCRETE UNLESS DESIGNATED AS ABOVE.

2.) THIS ALTERNATIVE WAS NOT DEVELOPED FOR HYDROLOGIC UNITS MR-Q, MR-AM, MR-AN, MR-AO, MR-AP, AND MR-AQ. THEREFORE, THE EXISTING STORM SEWER SYSTEM IS SHOWN FOR THOSE UNITS.

Source: SEWRPC.

Table 19

ALTERNATIVE H-2: COMPONENTS AND COSTS OF THE STORM SEWER CONVEYANCE WITH DECENTRALIZED DETENTION STORMWATER DRAINAGE PLAN FOR WEST BEND HYDROLOGIC UNIT MR-H

Hydrologic Unit	Project and Component Description[a]	Estimated Cost	
		Capital[b]	Annual Operation and Maintenance
H	1. 660 feet of 12-inch storm sewer	$ 29,000	$ 260
	2. 250 feet of 15-inch storm sewer	16,000	100
	3. 330 feet of 21-inch storm sewer	58,000	240
	4. 1,835 feet of 24-inch storm sewer	206,000	730
	5. Detention basin WD25 with a 100-year storm live storage volume of 3.2 acre-feet. Water quantity control cost	102,000	1,700
	6. Detention basin WD25 with a permanent pond area of 0.68 acre. Water quality control cost	128,000	2,600
	7. Detention basin WD26 with a 100-year storm live storage volume of 0.5 acre-feet. Water quantity control cost	26,000	300
	8. Detention basin WD26 with a permanent pond area of 0.25 acre. Water quality control cost	71,000	1,500
- -	Total	$636,000	$7,430

[a] *All new and replacement storm sewers are reinforced concrete pipe.*

[b] *Includes 35 percent for engineering, administration, and contingencies. Costs are for year 1991 with Engineering News-Record Construction Cost Index = 5,015.*

Source: SEWRPC

provided in a location where it will serve both existing and planned development, the only stormwater drainage measures required in this hydrologic unit are storm sewers to serve planned multi-family residential uses and medium-density, single-family residential uses.

Recommended Stormwater Management Plan: The recommended plan calls for the provision of 260 lineal feet of 24-inch-diameter and 370 lineal feet of 27-inch-diameter reinforced concrete storm sewer to serve areas of planned residential development. The existing dry detention basin, located southeast of the intersection of Schmidt Road and North Oakfield Street, with its associated 27-inch-diameter outlet, is adequate to store and convey the runoff from a 100-year recurrence interval storm occurring under planned land use conditions. That basin intercepts and reroutes much of the runoff which may have overtopped Brown Lane in the past. It is recommended that the runoff to Brown Lane which is not intercepted by the basin be conveyed in an 1,100-foot-long roadside swale and in two 50-foot-long, 18-inch-diameter reinforced concrete culverts under Brown Lane. The components and costs of the recommended plan are set forth in Table 9. The approximate location, alignment, and configuration of the recommended facilities, including nonpoint source pollution control measures, are shown graphically on Map 14. The total capital cost of this plan is about $74,000 and the estimated annual operation and maintenance cost increase is $730.

Hydrologic Unit MR-J

Evaluation of the Stormwater Management System: Hydrologic Unit MR-J is a 0.13-square-mile area located as shown on Map 1 in Chapter I of this volume. Under existing land use conditions, the hydrologic unit is completely developed in urban land uses, which are predominantly two-family residential, but also include government and institutional and commercial uses. The existing stormwater management system consists of roadway curbs and gutters, storm sewer inlets, and storm sewers. There are no identified intermittent or perennial streams within the hydrologic unit and the storm sewers discharge directly to the Milwaukee River.

Problems with both inadequate minor and major system hydraulic capacities were identified in parts of this hydrologic unit. As seen in Table 20, a comparison of the existing 10-year recurrence interval storm flows with the capacities of the existing storm sewers shows that many sewers have inadequate capacities to meet the minor system requirement of passing the peak rate of runoff from a 10-year storm. Major system capacity problems were identified at two locations where ponding in mid-block sags in the road could result in overland flow and flooding of buildings: 1) in 11th Avenue between Poplar and Walnut Streets and 2) in Poplar Street west of 6th Avenue. Additional major system problems were identified along Summit Drive south of Chestnut Street, where the buildings on the east side of the street are located at elevations below the street grade, and at a depression at the intersection of 10th Avenue and Poplar Street.

Alternative Stormwater Drainage Plans: Because of the lack of available open space in which to construct detention storage facilities, the only practicable solution to the stormwater drainage problems of this hydrologic unit is to upgrade the storm sewer conveyance system.

Recommended Stormwater Management Plan: The recommended storm sewer conveyance plan calls for the provision of replacement storm sewers to abate existing stormwater runoff problems. This plan includes 4,230 lineal feet of replacement storm sewer, ranging in size from 18-inch- to 66-inch-diameter reinforced concrete pipe. Table 20 presents a comparison of peak flows and existing and proposed storm sewer hydraulic capacities. The components and costs of the recommended plan are set forth in Table 9. The approximate location, alignment, and configuration of the recommended facilities, including nonpoint source pollution control measures, are shown graphically on Map 14. The total present value cost of this plan is $797,000, consisting of an estimated capital cost of $800,000 and an estimated annual operation and maintenance cost decrease of $210.

Hydrologic Unit MR-K

Evaluation of the Stormwater Management System: Hydrologic Unit MR-K is a 0.69-square-mile area located as shown on Map 1 in Chapter I of this volume. Under existing land use conditions, 91 percent of the hydrologic unit is developed in urban land uses. Under planned year 2010 conditions the hydrologic unit would essentially be completely developed in urban uses, predominantly medium-density residential, but would also include two-family residential, government and institutional, and commercial uses. The existing stormwater management system consists of roadway curbs and gutters, storm sewer inlets, and storm sewers. There are no identified intermittent or perennial streams within the hydrologic unit and the storm sewers discharge directly to the Milwaukee River.

Problems with both inadequate minor and major system hydraulic capacities were identified in parts of this hydrologic unit. As seen in Table 21, a comparison of the existing 10-year recurrence interval storm flows with the capacities of the existing storm sewers shows that many sewers have inadequate capacities to meet the minor system requirement of passing the peak rate of runoff from a 10-year storm. In addition, major system capacity problems were identified at seven locations: 1) in the vicinity of Highland View Drive and Bobolink Lane, where runoff from large storms would collect in backyard depressions with no outlets, 2) northwest of the intersection of Decorah Road and Highland View Drive, where an inadequate overland flow path could result in the flooding of buildings during a 100-year storm, 3) in Highland View Drive between Pine Drive and Evergreen Street, where ponding at a mid-block sag could result in flooding of houses on the east side of the street, 4) 5th Avenue between Hawthorn Drive and Decorah Road, where ponding in a mid-block sag could result in flooding of adjacent buildings, 5) northwest of the intersection of Main Street and Maple Street, where major system overflow through backyards could result in flooding of buildings, 6) in Main Street between Maple and Chestnut Streets, where ponding in a mid-block sag could result in overflow from the street and flooding of buildings to the east, and 7) northeast of the intersection of Kilbourn and Chestnut Streets, where an inadequate overland flow path to the Milwaukee River could result in flooding of buildings.

Table 20

COMPARISON OF EXISTING AND PROPOSED FLOWS AND HYDRAULIC CAPACITIES OF STORM SEWERS: ALTERNATIVE J-1, STORM SEWER CONVEYANCE

Branch	Reach	Storm Sewer Location[a]	Existing Size[b] (inches)	Existing Capacity (cubic feet per second)	Planned Size[b] (inches)	Length (feet)	Planned Capacity (cubic feet per second)	Existing 10-Year Storm Flow (cubic feet per second)	Planned 10-Year Storm Flow (cubic feet per second)	Existing 100-Year Storm Flow (cubic feet per second)	Planned 100-Year Storm Flow (cubic feet per second)	Frequency Storm Used for Evaluation of Existing Storm Sewers and Replacement of Inadequate Storm Sewers (years)
1	0	In Summit Drive south of Chestnut Street (173)	18 clay	13	30	225	50	21	21	35	35	100
1	2	In Chestnut Drive west of Summit Drive (173)	18 clay	23	21	410	35	27	27	46	46	10
1	4	In Chestnut Street west of 10th Avenue (173)	18 clay	8	30	195	32	28	28	49	49	10
		Intersection of Chestnut Street and 10th Avenue (152)	18 clay	14	30	46	52	44	44	76	76	10
1	6	In 10th Avenue between Chestnut Street and Poplar Street (152)	18 clay	6	42	364	59	44	44	76	76	10
3	0	In 11th Avenue north of Poplar Street (152)	12 clay	3	24	263	18	9	9	14	14	100
		In intersection of 11th Avenue and Poplar Street (152)	12 clay	4	24	57	27	9	9	14	14	100
3	2	In Poplar Street east of 11th Avenue (151)	12 clay	7	18	364	20	10	10	18	18	100
3	4	In Poplar Street west of 10th Avenue (152)	12 clay	7	21	297	29	11	11	21	21	100
1	8	In Poplar Street between 9th Avenue and 10th Avenue (152)	24	20	48	17	130	65	65	116	116	100
		In Poplar Street between 9th Avenue and 10th Avenue (152)	30	39	48	308	135	65	65	116	116	100
1	10	In Poplar Street between 8th Avenue and 9th Avenue (152)	30[c]	43	Retain existing	305	43	73	73	132	132	100
		In Poplar Street between 8th Avenue and 9th Avenue (152)	15[c]	10	36	309	104	73	73	132	132	100
1	12	In Poplar Street between 7th Avenue and 8th Avenue (152)	30[d]	75	Retain existing	340	75	83	83	151	151	100
		In Poplar Street between 6th Avenue and 7th Avenue (152)	15[d]	7	36	333	77	83	83	151	151	100
		In intersection of 7th Avenue and Poplar Street (152)	30	55	42 at 2.8 percent	32	168	83	83	151	151	100

Table 20 (continued)

Branch	Reach	Storm Sewer Location[a]	Existing Size[b] (inches)	Existing Capacity (cubic feet per second)	Planned Size[b] (inches)	Length (feet)	Planned Capacity (cubic feet per second)	Existing 10-Year Storm Flow (cubic feet per second)	Planned 10-Year Storm Flow (cubic feet per second)	Existing 100-Year Storm Flow (cubic feet per second)	Planned 100-Year Storm Flow (cubic feet per second)	Frequency Storm Used for Evaluation of Existing Storm Sewers and Replacement of Inadequate Storm Sewers (years)
1	14	In Poplar Street east of 7th Avenue (152)	30	73	48 at 2.8 percent	131	168	96	96	178	178	100
		In intersection of Poplar Street and alley between 6th and 7th Avenues (152)	30	56	48	36	196	96	96	178	178	100
		In alley between 6th and 7th Avenues north of Poplar Street (152)	30	44	54	159	209	96	96	178	178	100
		In alley between 6th and 7th Avenues and Poplar and Walnut Streets (152)	30	41	54	108	195	96	96	178	178	100
1	16	In Walnut Street and alley between 6th and 7th Avenues (152)	30	42	54	320	203	100	100	187	187	100
1	18	In intersection of 6th Avenue and Walnut Street (152)	30	28	66	17	228	108	108	204	204	100
1	20	In intersection of Walnut Street and 6th Avenue (152)	30	86	36	36	139	117	117	219	219	10
		In Walnut Street between 6th Avenue and alley east of 6th Avenue (152)	30	95	36	139	153	117	117	219	219	10
1	22	Outfall from intersection of Walnut Street and Main Street to Milwaukee River (152)	42	106	48	61	151	131	131	243	243	10

[a] City storm sewer system plan sheet number in parentheses.

[b] Diameter of circular reinforced concrete pipe unless noted otherwise.

[c] The two storm sewers designated Branch 1, Reach 10, are parallel to one another.

[d] These two storm sewers are parallel to one another.

Source: SEWRPC.

Table 21

COMPARISON OF EXISTING AND PROPOSED FLOWS AND HYDRAULIC CAPACITIES OF STORM SEWERS: ALTERNATIVE K-1, STORM SEWER CONVEYANCE

Branch	Reach	Storm Sewer Location[a]	Existing Size[b] (inches)	Existing Capacity (cubic feet per second)	Planned Size[b] (inches)	Length (feet)	Planned Capacity (cubic feet per second)	Existing 10-Year Storm Flow (cubic feet per second)	Planned 10-Year Storm Flow (cubic feet per second)	Existing 100-Year Storm Flow (cubic feet per second)	Planned 100-Year Storm Flow (cubic feet per second)	Frequency Storm Used for Evaluation of Existing Storm Sewers and Replacement of Inadequate Storm Sewers (years)
1	0[c]	In Silverbrook Drive between Hawthorn Drive and Chapel Hill Place (187)	15	7	- -	- -	- -	7[d]	11	7[d]	20	10
1	15	In Hawthorn Drive at intersection with 5th Avenue (188)	58 by 36 CMPA	68	53 by 34 HE	92	104	44	46	68	92	100
1	16	In 5th Avenue north of Hawthorn Drive (188)	58 by 36 CMPA	29	Two 60 by 38 HE	2 times 864 equals 1,728	132	29[d]	71	29[d]	137	100
1	18	In 5th Avenue south of Decorah Road (188)	58 by 36 CMPA	33	Two 68 by 43 HE	2 times 326 equals 752	190	33[d]	103	33[d]	179	100
2	0	In Chestnut Street between Western Avenue and Summit Drive	10	3	21	649	21	3[d]	14	- -	21	100
9	0	In Orchard Street between 6th Avenue and 7th Avenue (188)	15	8	18	281	13	8[d]	11	8[d]	21	10
9	2	In 6th Avenue between Orchard Street and Spring Drive (188)	18	6	38 by 24 HE	299	18	6[d]	14	6[d]	28	10
10	6	In 6th Avenue between Spring Drive and Decorah Road (188)	30 CMP	13	36	710	38	13[d]	32	13[d]	64	10
10	8	In Decorah Road between 5th and 6th Avenues (188)	30 CMP	31	27	305	44	21	40	27	78	10
3	0	In Decorah Road between 5th and 6th Avenues (188)	12 clay	6	15	353	11	6[d]	8	6[d]	11[d]	10
30	0	In Highland View Drive from Silverbrook Drive to Bobolink Lane (187)	18	5	54	514	88	- -	41	15	71	100
4	0	In Bobolink Lane between Highland View Drive and Silverbrook Drive (187)	15	4	27	475	19	4[d]	16	4[d]	32	10
		In Bobolink Lane between Highland View Drive and Silverbrook Drive (187)	15	4	30	236	32	4[d]	16	4[d]	32	100
4	2	In Highland View Drive east of Bobolink Lane (187)	18	7	54	159	143	7[d]	79	7[d]	138	100
4	4	Along easement between Highland View Drive and Decorah Road (187)	18	3	54	426	143	3[d]	80	3[d]	144	100
4	6	Along easement between Decorah Road and Evergreen Street (173)	15 CMP	3	60	513	189	3[c]	94	3[d]	169	100
5	0	In Evergreen Street east of Silverbrook Drive (174)	15 and 18	7	30	234	53	7[d]	25	7[d]	48	100

Table 21 (continued)

Branch	Reach	Storm Sewer Location[a]	Existing Size[b] (inches)	Existing Capacity (cubic feet per second)	Planned Size[b] (inches)	Length (feet)	Planned Capacity (cubic feet per second)	Existing 10-Year Storm Flow (cubic feet per second)	Planned 10-Year Storm Flow (cubic feet per second)	Existing 100-Year Storm Flow (cubic feet per second)	Planned 100-Year Storm Flow (cubic feet per second)	Frequency Storm Used for Evaluation of Existing Storm Sewers and Replacement of Inadequate Storm Sewers (years)
5	2	In Evergreen Street east of Highland View Drive (173)	18	16	60	203	266	16[d]	119	16[d]	222	100
5	4	In Highland View Drive south of Pine Drive (173)	36	42	60	559	266	31	135	42[d]	251	100
5	6	In Pine Drive at Highland View Drive (173)	36	60	60	232	266	34	137	49	257	100
5	8	In Pine Drive between Highland View Drive and 8th Avenue (173)	27	47	60	596	266	39	141	47[d]	266	100
5	10	In Pine Drive west of 6th Avenue, to 8th Avenue (173)	30	49	48	884	260	41	142	49[d]	271	100
5	12	In 6th Avenue north of Pine Drive (173)	36	114	60	134	300	62	159	101	320	100
5	14	Between 5th and 6th Avenues south of Oak Street (173)	52 by 36 CMPA	80	60	511	300	55[d]	162	55[d]	324	100
		Between 5th and 6th Avenues south of Oak Street (173)	50 by 31 CMPA	55	76 by 48 HE	246	300	55[d]	162	55[d]	324	100
		Between 5th and 6th Avenues south of Oak Street (173)	30	60	76 by 48 HE	92	300	55[d]	162	55[d]	324	100
1	20	In 5th Avenue between Oak Street and Decorah Road	60 by 36 CMPA	65	76 by 48 HE	1,754	227[e]	62	146	65[d]	265	100
3	4	Just west of 5th Avenue between Maple Street and Oak Street (173)	40	--	98 by 63 HE	466	620[f]	144	327	164	624	100
14	0[c]	In Oak Street at 8th Avenue (173)	18 clay	15	24	204	32	15[d]	24	15[d]	44	10
14	2[c]	In Oak Street between 7th and 8th Avenues (173)	18 clay	16	27	332	46	16[d]	36	16[d]	67	10
14	4[c]	In Oak Street between 5th and 7th Avenues (173)	24	37	27	640	50	30	49	37[d]	92	10
14	6	In 5th Avenue between Maple Street and Chestnut Street (173)	30	52	53 by 34 HE	423	127	40	59	52[d]	111	100
14	8	In Maple Street west of 5th Avenue (173)	30	59	53 by 34 HE	110	144	45	64	59[d]	120	100
15	0[c]	In 6th Avenue between Chestnut Street and Maple Street (173)	12	4	15	477	8	4[d]	7	4[d]	15	10
15	2	In Maple Street and 5th Avenue (173)	18 clay	17	27	468	51	17[d]	20	17[d]	44	100
3	6	In alley and easement between 5th Avenue and Main Street north of Maple Street (173)	82 by 63 SPPA	200	106 by 68 HE at 1.83 percent[g]	368	866	200[d]	405	257	795	100
17	2	In Main Street north of Maple Street (172)	24	39	30	276	71	29	30	39[d]	56	100

Table 21 (continued)

Branch	Reach	Storm Sewer Location[a]	Existing Size[b] (inches)	Existing Capacity (cubic feet per second)	Planned Size[b] (inches)	Length (feet)	Planned Capacity (cubic feet per second)	Existing 10-Year Storm Flow (cubic feet per second)	Planned 10-Year Storm Flow (cubic feet per second)	Existing 100-Year Storm Flow (cubic feet per second)	Planned 100-Year Storm Flow (cubic feet per second)	Frequency Storm Used for Evaluation of Existing Storm Sewers and Replacement of Inadequate Storm Sewers (years)
3	8	In Main Street between Chestnut Street and Maple Street (172)	Cut stone, 5.5 feet high, 5.0 feet wide at base, 3.5 feet wide at top. Top is an arch with radius of 2.5 feet	90	113 by 72 HE at 1.33 percent[h]	486	887	246	442	312	861	100
20	0	In 3rd Avenue between Oak Street and Locust Street (172)	15	10	24	539	35	10[d]	24	10[d]	35	100
20	4	In 3rd Avenue south of Kilbourn Street (172)	21	- -	30	234	86	25	39	28[d]	66	100
		In 3rd Avenue south of Kilbourn Street (172)	24	28	45 by 29 HE	132	101	25	39	28[d]	102	100
21	2	In 2nd Avenue from Oak Street to Kilbourn Street and in Kilbourn Street between 2nd and 3rd Avenues (172)	12 clay	3	38 by 24 HE	1,292	36	3[d]	29	3[d]	36	100
20	6	East of intersection of Chestnut and Kilbourn Streets (153)	24	23	45 by 29 HE	75	167	23[d]	89	23[d]	141	100
18	0	In Chestnut Street between Main Street and Kilbourn Street (153)	12	8	18	212	25	8[d]	11	8[d]	19	100
19	0	In Kilbourn Street north of Chestnut Street (153)	12	3	18	348	9	3[d]	5	3[d]	8	100
3	10	Outfall from Kilbourn Street to Milwaukee River (153)	75 by 61.5 concrete box	1,430	113 by 72 HE at 1.85 percent[i]	103	1,046	280	530	346	1,016	100

NOTE: The following abbreviations have been used: CMP = corrugated metal pipe; CMPA = corrugated metal pipe arch; HE = horizontal elliptical; and SPPA = structural plate pipe arch.

[a] *City storm sewer system plan sheet number in parentheses.*

[b] *Diameter of circular reinforced concrete pipe unless noted otherwise.*

[c] *Do not replace. Combined hydraulic capacity of existing storm sewer and street satisfies Objective 1, Standard 3 in Chapter IV of Volume One of this report.*

[d] *Flow limited to storm sewer capacity.*

[e] *Design capacity of 227 cubic feet per second is somewhat less than the 100-year recurrence interval peak flow of 265 cubic feet per second. The excess 100-year flow would be conveyed overland in the athletic fields and open areas west of Badger Middle School to the southwest corner of the intersection of Oak Street and 5th Avenue, where additional stormwater inlets would be provided. Those inlets would discharge to the downstream 92-foot-long segment of Branch 5, Reach 14 and would have a capacity of about 40 cubic feet per second.*

[f] *An additional 60 cubic feet per second would be conveyed in the parallel 494-foot-long, 58-inch by 36-inch CMPA located in the alley between 5th Avenue and Main Street and north of Oak Street. Therefore, the total capacity would be about 680 cubic feet per second.*

[g] *Downstream invert lowered to elevation 887.46 feet National Geodetic Vertical Datum.*

[h] *Upstream invert lowered to elevation 887.46 feet National Geodetic Vertical Datum. Downstream invert lowered to elevation 881.0 feet National Geodetic Vertical Datum.*

[i] *Upstream invert lowered to elevation 881.0 feet National Geodetic Vertical Datum.*

Source: SEWRPC.

Alternative Stormwater Drainage Plans: The following two alternative stormwater management plans were developed for Hydrologic Unit K: 1) a storm sewer conveyance plan and 2) a storm sewer conveyance with centralized detention plan.

Alternative Plan No. K-1, Storm Sewer Conveyance: The storm sewer conveyance alternative plan calls for the provision of replacement storm sewers to abate existing stormwater runoff problems and to serve planned new urban development effectively. This alternative includes 18,500 lineal feet of replacement storm sewer, ranging in size from 15-inch-diameter reinforced concrete pipe to 113-inch-wide by 72-inch-high horizontal elliptical reinforced concrete pipe. Map 9 shows the approximate location and alignment of the replacement storm sewers proposed under this alternative. Table 21 presents a comparison of peak flows and existing and proposed storm sewer hydraulic capacities. Table 22 presents the salient characteristics and estimated costs of the replacement storm sewers comprising this alternative plan. The total present value cost of this alternative plan is $5,551,000, consisting of an estimated capital cost of $5,566,000 and an estimated annual operation and maintenance cost decrease of $930.

Alternative Plan No. K-2, Storm Sewer Conveyance with Centralized Detention: Map 10 shows the approximate location, alignment, and configuration of the facilities called for under this alternative. Because of the reduction in peak 100-year recurrence interval flood flows achieved through the provision of detention storage, this alternative enables the downsizing of 6,820 lineal feet of replacement storm sewers and the retention of an additional 1,470 lineal feet of existing storm sewer which would be replaced under Alternative K-1. In addition, 560 lineal feet of existing storm sewer which would be replaced under Alternative K-1 are located at a proposed detention basin site and would, therefore, be eliminated under Alternative K-2. Also, 430 lineal feet of existing storm sewer adjacent to proposed detention basin K-2 would be abandoned. This alternative calls for 15,300 lineal feet of replacement storm sewers ranging in size from 15-inch-diameter reinforced concrete pipe to 98-inch-wide by 63-inch-high horizontal elliptical reinforced concrete pipe.

Basin K-1, which is to be located on private property southwest of the intersection of Highland View and Silverbrook Drives, would utilize the existing storage volume of a 1.8-acre nonshoreland wetland identified on the State wetland inventory maps and the 1990 Regional Planning Commission land use inventory maps. That wetland, which is not located near a navigable waterway, serves as a natural detention area under existing conditions. The wetland is classified as an emergent marsh wetland with narrow-leaved vegetation on wet soils (E2K). Wildlife habitat at the site is classified a Type III, or of good quality. Under this alternative, the existing wetland might experience minor, localized disturbance along its north boundary. Its function as a natural detention area would be preserved, eliminating the need for replacement of the storm sewers located immediately downstream. The storm sewers in Highland View Drive would be retrofitted to discharge to basin K-1 and a short 170-foot-long open swale and a 170-foot-long, 15-inch-diameter reinforced concrete outlet pipe would be installed to convey outflow from basin K-1 to the existing 24-inch-diameter storm sewer in the intersection of Silverbrook and Highland View Drives. A Federal permit and State water quality certification may be required for the proposed diversion of the Highland Drive storm sewer and the minor swale construction, although there would be only minor disturbance of the wetland.

Basin K-2, which is proposed to be located in Decorah Hills City Park, could be either a wet basin with a permanent pond for the control of nonpoint source pollution, or a dry basin, depending on whether the City Park, Recreation and Forestry Commission decides that a permanent pond could be a desirable addition to the park.

Basin K-3, which is located on property owned by St. John's Lutheran School, could contain athletic fields and play areas. This basin would be a dry detention basin, which would drain completely between storms, minimizing disruption of use of the school athletic fields.

In Chapter IV of this volume, basin WD4 is recommended to be constructed on Badger Middle School property as a dual-purpose wet detention basin with a 2.6-acre permanent pond for the control of nonpoint source pollution. Surcharge storage above the permanent pond would be used for water quantity control.

Table 22

ALTERNATIVE K-1: COMPONENTS AND COSTS OF THE STORM SEWER CONVEYANCE STORMWATER DRAINAGE PLAN FOR WEST BEND HYDROLOGIC UNIT MR-K

Hydrologic Unit	Project and Component Description[a]	Estimated Cost Capital[b]	Estimated Cost Annual Operation and Maintenance[c]
K	1. Replace 92 feet of 58-inch by 36-inch CMPA storm sewer at intersection of Hawthorn Drive and 5th Avenue with 53-inch by 34-inch HE storm sewer	$ 24,000	$ 0
	2. Replace 864 feet of 58-inch by 36-inch CMPA storm sewer in 5th Avenue north of Hawthorn Drive with 1,728 feet of double 60-inch by 38-inch HE storm sewer	544,000	160
	3. Replace 326 feet of 58-inch by 36-inch CMPA storm sewer in 5th Avenue south of Decorah Road with 752 feet of double 68-inch by 43-inch HE storm sewer	273,000	70
	4. Replace 649 feet of 10-inch storm sewer along easement in 5th Avenue extended south of Hawthorn Drive with 21-inch storm sewer	62,000	0
	5. Replace 281 feet of 15-inch storm sewer in Orchard Street between 6th Avenue and 7th Avenue with 18-inch storm sewer	23,000	0
	6. Replace 299 feet of 18-inch storm sewer in 6th Avenue between Orchard Street and Spring Drive with 38-inch by 24-inch HE storm sewer	50,000	0
	7. Replace 710 feet of 30-inch CMP storm sewer in 6th Avenue between Orchard Street and Decorah Road with 36-inch storm sewer	137,000	-130
	8. Replace 305 feet of 30-inch CMP storm sewer in Decorah Road between 5th and 6th Avenues with 27-inch storm sewer	39,000	0
	9. Replace 353 feet of 12-inch clay storm sewer in Decorah Road between 5th and 6th Avenues with 15-inch storm sewer	23,000	0
	10. Replace 514 feet of 18-inch storm sewer in Highland View Drive from Silverbrook Drive to Bobolink Lane with 54-inch storm sewer	177,000	-100
	11. Replace 475 feet of 15-inch storm sewer in Bobolink Lane between Highland View Drive and Silverbrook Drive with 27-inch storm sewer	61,000	0
	12. Replace 236 feet of 15-inch storm sewer in Bobolink Lane between Highland View Drive and Silverbrook Drive with 30-inch storm sewer	35,000	0
	13. Replace 159 feet of 18-inch storm sewer in Highland View Drive east of Bobolink Lane with 54-inch storm sewer	55,000	-30
	14. Replace 426 feet of 18-inch storm sewer along easement between Highland View Drive and Decorah Road with 54-inch storm sewer	147,000	-80
	15. Replace 513 feet of 15-inch CMP storm sewer along easement between Decorah Road and Evergreen Street with 60-inch storm sewer	215,000	-100
	16. Replace 234 feet of 15-inch and 18-inch storm sewer in Evergreen Street east of Silverbrook Drive with 30-inch storm sewer	35,000	0

Table 22 (continued)

Hydrologic Unit	Project and Component Description[a]	Estimated Cost	
		Capital[b]	Annual Operation and Maintenance[c]
K (continued)	17. Replace 203 feet of 18-inch storm sewer in Evergreen Street west of Highland View Drive with 60-inch storm sewer	$ 85,000	$ -40
	18. Replace 559 feet of 36-inch storm sewer in Highland View Drive south of Pine Drive with 60-inch storm sewer	235,000	0
	19. Replace 232 feet of 36-inch storm sewer in Pine Drive at Highland View Drive with 60-inch storm sewer	97,000	0
	20. Replace 596 feet of 27-inch storm sewer in Pine Drive between Highland View Drive and 8th Avenue with 60-inch storm sewer	250,000	-110
	21. Replace 884 feet of 30-inch storm sewer in Pine Drive west of 6th Avenue to 8th Avenue with 48-inch storm sewer	226,000	-170
	22. Replace 134 feet of 36-inch storm sewer in 6th Avenue north of Pine Drive angled northeast with 60-inch storm sewer	56,000	0
	23. Replace 511 feet of 52-inch by 36-inch CMPA storm sewer between 5th and 6th Avenues south of Oak Street with 60-inch storm sewer	215,000	-100
	24. Replace 246 feet of 50-inch by 31-inch CMPA storm sewer between 5th and 6th Avenues south of Oak Street with 76-inch by 48-inch HE storm sewer	107,000	-50
	25. Replace 92 feet of 30-inch storm sewer between 5th and 6th Avenues south of Oak Street with 76-inch by 48-inch HE storm sewer	40,000	-20
	26. Replace 1754 feet of 60-inch by 36-inch CMPA storm sewer in 5th Avenue between Oak Street and Decorah Road with 76-inch by 48-inch HE storm sewer	762,000	0
	27. Replace 466 feet of 40-inch storm sewer just east of 5th Avenue between Maple and Oak Street with 98-inch by 63-inch HE storm sewer	285,000	0
	28. Replace 423 feet 30-inch storm sewer in 5th Avenue between Maple Street and Oak Street with 53-inch by 34-inch HE storm sewer	110,000	-80
	29. Replace 110 feet 30-inch storm sewer in Maple Street east of 5th Avenue with 53-inch by 34-inch HE storm sewer	29,000	-20
	30. Replace 468 feet of 15-inch and 18-inch clay storm sewer in Maple Street and 5th Avenue east of 5th Avenue with 27-inch storm sewer	60,000	0
	31. Replace 368 feet of 82-inch by 63-inch SPPA storm sewer in alley and easement between 5th Avenue and Main Street north of Maple Street with 106-inch by 68-inch HE storm sewer	252,000	0
	32. Replace 276 feet of 24-inch storm sewer in Main Street north of Maple Street with 30-inch storm sewer	41,000	0

Table 22 (continued)

Hydrologic Unit	Project and Component Description[a]	Estimated Cost	
		Capital[b]	Annual Operation and Maintenance[c]
K (continued)	33. Replace 486 feet of cut stone pipe that is 5.5 feet high, 5.0 feet wide at the base, and 3.5 feet wide at the top (top is an arch with a radius of 2.5 feet) in Main Street between Chestnut Street and Maple Street with 113-inch by 72-inch HE storm sewer	$ 342,000	$ -90
	34. Replace 103 feet of 75-inch by 61.5-inch concrete box at outfall from Kilbourn Street to Milwaukee River with 113-inch by 72-inch HE storm sewer	72,000	0
	35. Replace 539 feet of 15-inch storm sewer in 3rd Avenue between Oak Street and Locust Street with 24-inch storm sewer	60,000	0
	36. Replace 234 feet of 21-inch storm sewer in intersection of Kilbourn Street and 3rd Avenue and in 3rd Avenue south of Kilbourn Street with 30-inch storm sewer	35,000	0
	37. Replace 132 feet of 24-inch storm sewer in intersection of Kilbourn Street and 3rd Avenue and in 3rd Avenue south of Kilbourn Street with 45-inch by 29-inch HE storm sewer	27,000	-30
	38. Replace 1,292 feet of 12-inch clay storm sewer in 2nd Avenue from Oak Street to Kilbourn Street and in Kilbourn Street to 3rd Avenue with 38-inch by 24-inch HE storm sewer	218,000	0
	39. Replace 75 feet of 24-inch storm sewer just east of intersection of Chestnut Street and Kilbourn Street with 45-inch by 29-inch HE storm sewer	6,000	-10
	40. Replace 212 feet of 12-inch storm sewer in Chestnut Street between Main Street and Kilbourn Street with 18-inch storm sewer	17,000	0
	41. Replace 348 feet of 12-inch storm sewer in Kilbourn Street north of Chestnut Street with 18-inch storm sewer	29,000	0
- -	Total	$5,566,000	$-930

NOTE: The following abbreviations have been used: CMP = corrugated metal pipe; CMPA = corrugated metal pipe arch; HE = horizontal elliptical; and SPPA = structural plate pipe arch.

[a] *All new and replacement storm sewers are reinforced concrete pipe.*

[b] *Includes 35 percent for engineering, administration, and contingencies. Costs are for year 1991 with Engineering News-Record CCI = 5,015.*

[c] *Costs were noted to be zero when the alternative proposed replacement of a component with a component having similar operation and maintenance costs. Negative costs were noted when the replacement component was estimated to have a lower operation and maintenance cost than that of the existing facility.*

Source: SEWRPC.

Table 23 presents a comparison of peak flows and existing and proposed storm sewer hydraulic capacities. Table 24 presents the salient characteristics and estimated costs of the components of this alternative, including new and replacement storm sewers and the four detention basins ranging in size from 2.3 to 4.2 acre-feet. The total present value cost of this alternative plan is $3,714,000, consisting of an estimated capital cost of $3,639,000, including land acquisition for the detention basins, and an estimated annual operation and maintenance cost increase of $4,740.

Evaluation of Alternative Stormwater Drainage Plans: The foregoing information provides a basis for a comparative evaluation of the two alternative stormwater drainage plans. Each alternative was designed to resolve the identified existing drainage problems as well as to serve anticipated future development within the hydrologic unit. Each, when expanded to include the nonpoint source pollution control measures recommended in Chapter IV of this volume, would achieve essentially the same degree of abatement of nonpoint source pollution. Thus, the principal criteria for the comparative evaluation were reduced to cost and implementability.

Alternative K-2 is less costly than Alternative K-1, but Alternative K-1 would be more easily implemented since it would involve replacement of storm sewers which are generally within existing rights-of-way and easements and it would not require purchasing land or easements for the provision of detention basins. Basin K-1 would utilize the storage in an existing wetland with no significant disturbance of that wetland. Proposed detention basins K-2 and K-3 can be adapted to their sites without eliminating the present uses at those sites, possibly making them more acceptable to the property owners involved. Also, the flexibility to construct basin K-2 as either a wet or a dry basin may make it more satisfactory to the City Park, Recreation and Forestry Commission. Detention basin K-3 would be a dry basin, enabling continued use of the site as athletic fields and play areas. That feature should make the basin more acceptable to the St. John's Lutheran School administration. Dual-purpose detention basin WD4, which is proposed to be located on Badger Middle School property, would have a 2.6-acre permanent pond which would require the removal of several large trees. This would reduce the available dry-land recreational open space adjacent to the school and neighborhood.

Recommended Stormwater Management Plan: Because of the considerably lower cost of Alternative K-2, Storm Sewer Conveyance with Centralized Detention, and because of the possibility of maintaining three of the four proposed detention basin sites in existing or enhanced uses under that alternative plan, Alternative K-2 is recommended for adoption in this hydrologic unit. At the request of City staff, the recommended plan was refined. That refinement is described in the next section of this chapter. The components and costs of the refined recommended plan are set forth in Table 9. The approximate location, alignment, and configuration of the refined recommended facilities, including nonpoint source pollution control measures, are shown graphically on Map 14.

Hydrologic Unit MR-L

Evaluation of the Stormwater Management System: Hydrologic Unit MR-L is a 0.50-square-mile area located as shown on Map 1 of Chapter I of this volume. Under existing land use conditions, about 89 percent of the hydrologic unit is developed in urban land uses. Under planned year 2010 conditions, the hydrologic unit would essentially be completely developed in urban uses, predominantly medium-density residential, but would also include considerable commercial uses and some two-family residential and government and institutional uses. The existing stormwater management system consists of roadway curbs and gutters, storm sewer inlets, storm sewers, and an open channel. An unnamed intermittent tributary to the Milwaukee River flows through Ziegler Park for a distance of about 800 feet. The tributary is enclosed in storm sewers upstream and downstream of the 800-foot-long reach of open channel. This reach of stream was realigned and the invert was paved with concrete in the early 1980s.

Problems with both inadequate minor and major system hydraulic capacities were identified in parts of this hydrologic unit. As seen in Table 25, a comparison of the existing 10-year recurrence interval storm flows with the capacities of the existing storm sewers shows that many sewers have inadequate capacities to meet the minor system requirement of passing the peak rate of runoff from a 10-year storm. In addition, major system capacity problems were

Table 23

COMPARISON OF EXISTING AND PROPOSED FLOWS AND HYDRAULIC CAPACITIES OF STORM SEWERS: ALTERNATIVE K-2, STORM SEWER CONVEYANCE WITH CENTRALIZED DETENTION

Branch	Reach	Storm Sewer Location[a]	Existing Size[b] (inches)	Existing Capacity (cubic feet per second)	Planned Size[b] (inches)	Length (feet)	Planned Capacity (cubic feet per second)	Existing 10-Year Storm Flow (cubic feet per second)	Planned 10-Year Storm Flow (cubic feet per second)	Existing 100-Year Storm Flow (cubic feet per second)	Planned 100-Year Storm Flow (cubic feet per second)	Frequency Storm Used for Evaluation of Existing Storm Sewers and Replacement of Inadequate Storm Sewers (years)
1	0[c]	In Silverbrook Drive between Hawthorn Drive and Chapel Hill Place (187)	15	7	21	465	16	7[d]	11	7[d]	20	10
1	15	In Hawthorn Drive at intersection with 5th Avenue (188)	58 by 36 CMPA	68	53 by 34 HE	92	104	44	46	68	92	100
Basin K-3	Inlet	--	--	--	53 by 34 HE	90	98	--	46	--	92	100
Basin K-3	Outlet	--	--	--	24	100	12	--	1	--	10	100
1	16	In 5th Avenue north of Hawthorn Drive (188)	58 by 36 CMPA	29	Retain existing	864	29	29[d]	1	29[d]	10	100
1	18	In 5th Avenue south of Decorah Road (188)	58 by 36 CMPA	33	48	326	67	33[d]	35	33[d]	54	100
2	0	In Chestnut Street between Western Avenue and Summit Drive	10	3	21	649	21	3[d]	14	--	21	100
9	0	In Orchard Street between 6th Avenue and 7th Avenue (188)	15	8	18	281	13	8[d]	11	8[d]	21	10
9	2	In 6th Avenue between Orchard Street and Spring Drive (188)	18	6	38 by 24 HE	299	18	6[d]	14	6[d]	28	10
10	6	In 6th Avenue between Spring Drive and Decorah Road (188)	30 CMP	13	36	710	38	13[d]	32	13[d]	54	10
10	8	In Decorah Road between 5th and 6th Avenues	30 CMP	31	27	305	44	21	40	27	68	10
3	0	In Decorah Road between 5th and 6th Avenues	12 clay	6	15	353	11	6[d]	8	6[d]	11[d]	10
30	0	In Highland View Drive from Silverbrook Drive to Bobolink Lane (187)	18	5	*Retain existing*	--	5	--	2	--	4	100
4	0	In Bobolink Lane between Highland View Drive and Silverbrook Drive (187)	15	4	27	475	19	4[d]	16	4[d]	32	10
		In Bobolink Lane between Highland View Drive and Silverbrook Drive (187)	15	4	30	236	32	4[d]	16	4[d]	32	100
4	2	In Highland View Drive east of Bobolink Lane (187)	18	7	Two 38 by 24	318	80	7[d]	38	7[d]	68	100
Basin K-2	Inlet	--	18	3	Two 38 by 24	144	80	3[d]	38	3[d]	74	100
Basin K-2	Outlet	--	18	3	15	70	4	3[d]	1	3[d]	2	100
4	6	Along easement between Decorah Road and Evergreen Street (173)	15 CMP	3	30	513	33	3[d]	14	3[d]	26	100

Table 23 (continued)

Branch	Reach	Storm Sewer Location[a]	Existing Size[b] (inches)	Existing Capacity (cubic feet per second)	Planned Size[b] (inches)	Length (feet)	Planned Capacity (cubic feet per second)	Existing 10-Year Storm Flow (cubic feet per second)	Planned 10-Year Storm Flow (cubic feet per second)	Existing 100-Year Storm Flow (cubic feet per second)	Planned 100-Year Storm Flow (cubic feet per second)	Frequency Storm Used for Evaluation of Existing Storm Sewers and Replacement of Inadequate Storm Sewers (years)
5	0	In Evergreen Street east of Silverbrook Drive (174)	15 and 18	7	38 by 24 HE at 1.7 percent	234	53	7[d]	25	7[d]	48	100
5	2	In Evergreen Street east of Highland View Drive (173)	18	16	42	203	112	16	40	16[d]	78	100
5	4	In Highland View Drive south of Pine Drive (173)	36	42	42	559	112	31	57	42[d]	108	100
5	6	In Pine Drive at Highland View Drive (173)	36	60	48	232	153	34	60	49	114	100
5	8	In Pine Drive between Highland View Drive and 8th Avenue (173)	27	47	48	596	153	39	64	47[d]	123	100
5	10	In Pine Drive west of 6th Avenue to 8th Avenue (173)	30	49	42	884	179	41	66	49[d]	129	100
5	12	In 6th Avenue north of Pine Drive (173)	36	114	48	134	226	62	86	101	180	100
5	14	Between 5th and 6th Avenues south of Oak Street (173)	52 by 36 CMPA	80	54	200	226	55	89	55[d]	185	100
		Basin K-4 outlet	30	60	Retain existing	92	60	55	23	55[d]	59	100
1	20	In 5th Avenue between Oak Street and Decorah Road	60 by 36 CMPA	65	53 by 34 HE	1,754	116	62	75	65[d]	107	100
3	4	Just west of 5th Avenue between Maple Street and Oak Street (173)	40	- -	42	466	119[e]	144	107	164	178	100
14	0[c]	In Oak Street at 8th Avenue (173)	18 clay	15	Retain existing	204	15	15[d]	24	15[d]	44	10
14	2[c]	In Oak Street between 7th and 8th Avenues (173)	18 clay	16	Retain existing	332	16	16[d]	36	16[d]	67	10
14	4[c]	In Oak Street between 5th and 7th Avenues (173)	24	37	Retain existing	640	37	30	49	37[d]	92	10
14	6	In 5th Avenue between Maple Street and Chestnut Street (173)	30	52	53 by 34 HE	423	127	40	59	52[d]	111	100
14	8	In Maple Street west of 5th Avenue (173)	30	59	53 by 34 HE	110	144	45	64	59[d]	120	100
15	0[c]	In 6th Avenue between Chestnut Street and Maple Street (173)	12	4	15	477	8	4[d]	7	4[d]	15	10
15	2	In Maple Street and 5th Avenue (173)	18 clay	17	27	468	51	17[d]	20	17[d]	44	100
3	6	In alley and easement between 5th Avenue and Main Street north of Maple Street (173)	82 by 63 SPPA	200	83 by 53 HE	368	396	226[d]	190	257	339	100
17	2	In Main Street north of Maple Street (172)	24	39	30	276	71	29	30	39[d]	56	100

Table 23 (continued)

Branch	Reach	Storm Sewer Location[a]	Existing Size[b] (inches)	Existing Capacity (cubic feet per second)	Planned Size[b] (inches)	Length (feet)	Planned Capacity (cubic feet per second)	Existing 10-Year Storm Flow (cubic feet per second)	Planned 10-Year Storm Flow (cubic feet per second)	Existing 100-Year Storm Flow (cubic feet per second)	Planned 100-Year Storm Flow (cubic feet per second)	Frequency Storm Used for Evaluation of Existing Storm Sewers and Replacement of Inadequate Storm Sewers (years)
3	8	In Main Street between Chestnut Street and Maple Street	Cut stone, 5.5 feet high, 5.0 feet wide at base, 3.5 feet wide at top. Top is an arch with a radius of 2.5 feet	90	72 at 1.33 percent[f]	486	488	246	232	312	407	100
20	0	In 3rd Avenue between Oak Street and Locust Street (172)	15	10	24	539	35	10[d]	24	10[d]	35	100
20	4	In 3rd Avenue south of Kilbourn Street (172)	21	- -	30	234	86	25	39	28[d]	66	100
20	4	In 3rd Avenue south of Kilbourn Street (172)	24	28	45 by 29 HE	132	101	25	39	28[d]	102	100
21	2	In 2nd Avenue from Oak Street to Kilbourn Street and in Kilbourn Street between 2nd and 3rd Avenues (172)	12 clay	3	38 by 24 HE	1,292	36	3[d]	29	3[d]	36	100
20	6	East of intersection of Chestnut and Kilbourn Streets (153)	24	23	45 by 29 HE	75	167	23[d]	89	23[d]	141	100
18	0	In Chestnut Street between Main Street and Kilbourn Street (153)	12	8	18	212	25	8[d]	11	8[d]	19	100
19	0	In Kilbourn Street north of Chestnut Street (153)	12	3	18	348	9	3[d]	5	3[d]	8	100
3	10	Outfall from Kilbourn Street to Milwaukee River (153)	75 by 61.5 concrete box	1,430	98 by 63 HE at 1.37 percent[g]	103	615	280	329	346	567	100

NOTE: The following abbreviations have been used: CMP = corrugated metal pipe; CMPA = corrugated metal pipe arch; HE = horizontal elliptical; and SPPA = structural plate pipe arch.

[a] *City storm sewer system plan sheet number in parentheses.*

[b] *Diameter of circular reinforced concrete pipe unless noted otherwise.*

[c] *Do not replace. Combined hydraulic capacity of existing storm sewer and street satisfies Objective 1, Standard 3 in Chapter IV of Volume One of this report.*

[d] *Flow limited to storm sewer capacity.*

[e] *An additional 60 cubic feet per second would be conveyed in the parallel 494-foot-long, 48-inch by 36-inch CMPA located in the alley between 5th Avenue and Main Street and north of Oak Street. Therefore, the total capacity would be about 180 cubic feet per second.*

[f] *Downstream invert elevation of Branch 3, Reach 6 not changed. Lower upstream invert of Branch 3, Reach 8 to elevation 887.46 feet National Geodetic Vertical Datum, Lower Branch 3, Reach 8 downstream invert to elevation 881.0 feet National Geodetic Vertical Datum.*

[g] *Lower upstream invert elevation to 880.5 feet National Geodetic Vertical Datum.*

Source: SEWRPC.

Table 24

ALTERNATIVE K-2: COMPONENTS AND COSTS OF THE STORM SEWER CONVEYANCE WITH CENTRALIZED DETENTION STORMWATER DRAINAGE PLAN FOR WEST BEND HYDROLOGIC UNIT MR-K

Hydrologic Unit	Project and Component Description[a]	Estimated Cost	
		Capital[b]	Annual Operation and Maintenance[c]
K	1. Replace 92 feet of 58-inch by 36-inch CMPA storm sewer at intersection of Hawthorn Drive and 5th Avenue with 53-inch by 34-inch HE storm sewer	$ 24,000	$ 0
	2. Basin K-3 inlet, 90 feet	17,000	20
	3. Basin K-3 outlet, 100 feet	11,000	40
	4. Replace 326 feet of 58-inch by 36-inch CMPA in 5th Avenue, south of Decorah Road with 48-inch storm sewer	83,000	0
	5. Replace 649 feet of 10-inch storm sewer along easement in 5th Avenue extended south of Hawthorn Drive with 21-inch storm sewer	62,000	0
	6. Replace 281 feet of 15-inch storm sewer in Orchard Street between 6th Avenue and 7th Avenue with 18-inch storm sewer	23,000	0
	7. Replace 299 feet of 18-inch storm sewer in 6th Avenue between Orchard Street and Spring Drive with 38-inch by 24-inch HE storm sewer	50,000	0
	8. Replace 710 feet of 30-inch CMP storm sewer in 6th Avenue between Orchard Street and Decorah Road with 36-inch storm sewer	137,000	-130
	9. Replace 305 feet of 30-inch CMP storm sewer in Decorah Road between 5th and 6th Avenues with 27-inch storm sewer	39,000	0
	10. Replace 353 feet of 12-inch clay storm sewer in Decorah Road between 5th and 6th Avenues with 15-inch storm sewer	23,000	0
	11. Replace 475 feet of 15-inch storm sewer in Bobolink Lane between Highland View Drive and Silverbrook Drive with 27-inch storm sewer	61,000	0
	12. Replace 236 feet of 15-inch storm sewer in Bobolink Lane between Highland View Drive and Silverbrook Drive with 30-inch storm sewer	35,000	0
	13. Replace 159 feet of 18-inch storm sewer in Highland View Drive east of Bobolink Lane with 318 feet of double 38-inch by 24-inch HE storm sewer . . .	54,000	0
	14. Basin K-2 inlet, 144 feet	24,000	0
	15. Basin K-2 outlet, 70 feet	5,000	-100
	16. Replace 513 feet of 15-inch CMP storm sewer along easement between Decorah Road and Evergreen Street with 30-inch storm sewer	77,000	0
	17. Replace 234 feet of 15-inch and 18-inch storm sewer in Evergreen Street east of Silverbrook Drive with 38-inch by 24-inch HE storm sewer	39,000	0
	18. Replace 203 feet of 18-inch storm sewer in Evergreen Street east of Highland View Drive with 42-inch storm sewer	45,000	-40
	19. Replace 559 feet of 36-inch storm sewer in Highland View Drive south of Pine Drive with 42-inch storm sewer	125,000	0
	20. Replace 232 feet of 36-inch storm sewer in Pine Drive at Highland View Drive with 48-inch storm sewer . . .	59,000	0

Table 24 (continued)

Hydrologic Unit	Project and Component Description[a]	Estimated Cost	
		Capital[b]	Annual Operation and Maintenance[c]
K (continued)	21. Replace 596 feet of 27-inch storm sewer in Pine Drive between Highland View Drive and 8th Avenue with 48-inch storm sewer	$ 152,000	$ -110
	22. Replace 884 feet of 30-inch storm sewer in Pine Drive west of 6th Avenue to 8th Avenue with 42-inch storm sewer	198,000	-170
	23. Replace 134 feet of 36-inch storm sewer in 6th Avenue north of Pine Drive angled northeast with 48-inch storm sewer	34,000	0
	24. Replace 200 feet of 52-inch by 36-inch CMP storm sewer between 5th and 6th Avenues south of Oak Street with 54-inch storm sewer	69,000	-40
	25. Replace 1,754 feet 60-inch by 36-inch CMPA storm sewer in 5th Avenue between Oak Street and Decorah Road with 53-inch by 34-inch HE storm	457,000	0
	26. Replace 466 feet of 40-inch storm sewer just east of 5th Avenue between Maple and Oak Street with 42-inch storm sewer	104,000	0
	27. Replace 423 feet 30-inch storm sewer in 5th Avenue between Maple Street and Oak Street with 53-inch by 34-inch HE storm sewer	110,000	-80
	28. Replace 110 feet 30-inch storm sewer in Maple Street west of 5th Avenue with 53-inch by 34-inch HE storm sewer	29,000	-20
	29. Replace 468 feet of 15-inch and 18-inch clay storm sewer in Maple Street and 5th Avenue east of 5th Avenue with 27-inch storm sewer	60,000	0
	30. Replace 368 feet of 82-inch by 63-inch SPPA storm sewer in alley and easement between 5th Avenue and Main Street north of Maple Street with 83-inch by 53-inch HE storm sewer	171,000	0
	31. Replace 276 feet of 24-inch storm sewer in Main Street north of Maple Street with 30-inch storm sewer	41,000	0
	32. Replace 486 feet of cut stone pipe that is 5.5 feet high, 5.0 feet wide at the base, and 3.5 feet wide at the top (top is an arch with a radius of 2.5 feet) in Main Street between Chestnut Street and Maple Street with 72-inch storm sewer	255,000	-90
	33. Replace 103 feet of 75-inch by 61.5-inch concrete box at outfall from Kilbourn Street to Milwaukee River with 98-inch by 63-inch HE storm sewer	63,000	0
	34. through 40. Same components as Storm Sewer Conveyance Alternative items 35 through 41 (see Table 22)	402,000	-40
	Storm Sewer Subtotal	$3,138,000	$ -660
	41. 2.3 acre-foot detention basin located southwest of the intersection Highland View and Silverbrook Drives. T11N, R19E, northwest quarter, Section 23 (basin K-1)	$ 68,000	$1,300

Table 24 (continued)

Hydrologic Unit	Project and Component Description[a]	Estimated Cost	
		Capital[b]	Annual Operation and Maintenance[c]
K (continued)	42. 3.3 acre-foot detention basin located in Decorah Hills Park between Decorah Road and Highland View Drive extended. T11N, R19E, northeast quarter, Section 23 (basin K-2)	$ 112,000	$1,400
	43. 3.9 acre-foot detention basin located north of Hawthorn Drive between 5th and 6th Avenues. T11N, R19E, northeast quarter, Section 23 (basin K-3)	277,000	1,700
	44. 4.2 acre-foot detention basin located on Badger School grounds southeast of the intersection of 6th Avenue and Oak Street. T11N, R19E, southeast quarter, Section 14 (basin WD4)	44,000	1,100
- -	Total	$3,639,000	$4,740

NOTE: The following abbreviations have been used: CMP = corrugated metal pipe; CMPA = corrugated metal pipe arch; HE = horizontal elliptical; and SPPA = structural plate pipe arch.

[a] *All new and replacement storm sewers are reinforced concrete pipe.*

[b] *Includes 35 percent for engineering, administration, and contingencies. Costs are for year 1991 with Engineering News-Record CCI = 5,015.*

[c] *Costs were noted to be zero when the alternative proposed replacement of a component with a component having similar operation and maintenance costs. Negative costs were noted when the replacement component was estimated to have a lower operation and maintenance cost than that of the existing facility.*

Source: SEWRPC.

identified at five locations: 1) in Butternut Street between Main Street and Eder Lane, where ponding at a mid-block sag could overflow to the north creating the potential for flooding of buildings and potentially overloading the downstream drainage system, 2) at the intersection of Main and Vine Streets, where, during a 100-year recurrence interval storm, the flow in excess of the existing storm sewer capacity would be conveyed in streets to the north, would enter Hydrologic Unit MR-K, and would exacerbate the existing ponding and flooding problem in Unit MR-K in 5th Avenue between Hawthorn Drive and Decorah Road, 3) in Hawthorn Drive west of Sunset Drive, where the storm sewer slope is the opposite of the street slope and excess runoff in the street from a 100-year storm would flow to the west into Hydrologic Unit MR-K, where it would aggravate the existing ponding and flooding problem in 5th Avenue, 4) in Main Street between Decorah Road and Hawthorn Drive, where the street slope is very flat, and 5) at the T intersection of Birchwood and Hawthorn Drives, where runoff would pond and could overflow through yards, possibly flooding buildings.

Alternative Stormwater Drainage Plans: The following two alternative stormwater management plans were developed for Hydrologic Unit L: 1) a storm sewer conveyance plan and 2) a storm sewer conveyance with centralized detention plan.

Alternative Plan No. L-1, Storm Sewer Conveyance: The storm sewer conveyance alternative plan calls for the provision of replacement storm sewers to abate existing stormwater runoff

Table 25

COMPARISON OF EXISTING AND PROPOSED FLOWS AND HYDRAULIC CAPACITIES OF STORM SEWERS: ALTERNATIVE L-1, STORM SEWER CONVEYANCE

Branch	Reach	Storm Sewer Location[a]	Existing Size[b] (inches)	Existing Capacity (cubic feet per second)	Planned Size[b] (inches)	Length (feet)	Planned Capacity (cubic feet per second)	Existing 10-Year Storm Flow (cubic feet per second)	Planned 10-Year Storm Flow (cubic feet per second)	Existing 100-Year Storm Flow (cubic feet per second)	Planned 100-Year Storm Flow (cubic feet per second)	Frequency Storm Used for Evaluation of Existing Storm Sewers and Replacement of Inadequate Storm Sewers (years)
2	0	In Butternut Street between Main Street and Eder Lane (208)	15	12	38 by 24 HE at 3.07 percent	287	72	44	44	66	66	100
		In Main Street north of Butternut Street (208)	21	26[c]	42 at 0.93 percent	661	97	63	63	95	95	100
1	4	In Main Street between Butternut Street and Vine Street (208)	42	113	76 by 48 HE	226	301	146	146	255	255	100
1	6	In Main Street between Butternut Street and Vine Street (208)	42	112	76 by 48 HE	471	299	164	164	282	282	100
1	8	In Vine Street between Main Street and Eder Lane (208)	60 by 38 HE	167	76 by 48 HE[d]	289	311	180	180	314	314	100
		In Vine Street between Eder Lane and Sylvan Way (208)	60 by 38 HE	127	Two 68 by 43 HE[d]	2 times 278 equals 556	2 times 178 equals 356	180	180	314	314	10
		In Vine Street between Eder Lane and Sylvan Way (208)	60 by 38 HE	142	68 by 43 HE	680	194	180	180	314	314	10
1	10	In Vine Street between Eder Lane and Sylvan Way (208)	60 by 38 HE	143	76 by 48 HE at 0.86 percent	319	248	198	198	345	345	10
		In Vine Street between Eder Lane and Sylvan Way (208)	76 by 48 HE	46	76 by 48 HE at 0.86 percent	32	248	198	198	345	345	10
4	2	In Green Valley Place between Sandra Lane and Sylvan Way (208)	50 by 31 CMPA	29	53 by 34 HE	377	67	54	54	94	94	10
4	4	In Green Valley Place between Sandra Lane and Sylvan Way (208)	50 by 31 CMPA	29	53 by 34 HE	377	67	54	54	94	94	10
4	8	In Sylvan Way between Vine Street and Green Valley Place (208)	50 by 31 CMPA	20	60 by 38 HE	247	68	54	54	97	97	10
5	6	In easement on east side of Sylvan Way (208)	24	19	30	392	34	33	33	48	48	10
8	2	In Eder Lane and Terra Drive between Vine Street and Lincoln Drive East (189)	18	7	36	1,068	46	29	29	46	46	100

Table 25 (continued)

Branch	Reach	Storm Sewer Location[a]	Existing Size[b] (inches)	Existing Capacity (cubic feet per second)	Planned Size[b] (inches)	Length (feet)	Planned Capacity (cubic feet per second)	Existing 10-Year Storm Flow (cubic feet per second)	Planned 10-Year Storm Flow (cubic feet per second)	Existing 100-Year Storm Flow (cubic feet per second)	Planned 100-Year Storm Flow (cubic feet per second)	Frequency Storm Used for Evaluation of Existing Storm Sewers and Replacement of Inadequate Storm Sewers (years)
8	4	In Terrace Drive between Lincoln Drive East and Birchwood Drive (189)	24	13	42 at 0.55 percent	250	75	58	58	103	103	10
		In easement south of Birchwood Drive and west of railroad tracks (189)	24	14	53 by 34 HE at 0.55 percent	356	77	58	58	103	103	10
8	6	In easement south of Birchwood Drive and west of railroad tracks (189)	36 by 23 RCPA	50	53 by 34 at 0.55 percent	60	77	71	71	127	127	10
1	20	Along railroad right-of-way south of Decorah Road (189)	54	124	Existing 54 with parallel 54	1,902	248	124[e]	162	124[e]	233	100
9	0	In Main Street between Hawthorn Drive and Vine Street (189)	15	10	30 at 1.0 percent	56	44	10[e]	23	10[e]	38	100
		In Main Street between Hawthorn Drive and Vine Street (189)	21	18	30 at 1.0 percent	56	44	10[e]	23	10[e]	38	100
9	1	In Main Street between Hawthorn Drive and Vine Street (189)	12 and 15 in series parallel to a 21 and 27 in series	21	42 at 1.0 percent[f]	300	109	21[e]	59	21[e]	95	100
		In Main Street between Hawthorn Drive and Vine Street (189)	12 and 15 in series parallel to a 21 and 27 in series	21	48 at 0.51 percent[f]	544	103	21[e]	59	21[e]	95	100
10	0	In Main Street between Decorah Road and Hawthorn Drive (189)	18	5	38 by 24 HE at 0.68 percent[g]	585	50	2[e]	33	2[e]	50	100
		In Main Street between Decorah Road and Hawthorn Drive (189)	18	2	38 by 24 HE at 0.68 percent[g]	585	50	2[e]	33	2[e]	50	100
		In Main Street between Decorah Road and Hawthorn Drive (189)	15	3	38 by 24 HE at 0.68 percent[g]	585	50	2[e]	33	2[e]	50	100
		In Main Street between Decorah Road and Hawthorn Drive (189)	15	3	38 by 24 HE at 0.68 percent[g]	585	50	2[e]	33	2[e]	50	100
9	2	In Hawthorn Drive between Main Street and Lincoln Drive West (189)	44 by 27 RCPA	48	48 at 0.85 percent	152	132	26[e]	83	26[e]	131	100
		In Hawthorn Drive between Main Street and Lincoln Drive West (189)	36	48	48 at 0.85 percent	199	132	26[e]	83	26[e]	131	100

Table 25 (continued)

Branch	Reach	Storm Sewer Location[a]	Existing Size[b] (inches)	Existing Capacity (cubic feet per second)	Planned Size[b] (inches)	Length (feet)	Planned Capacity (cubic feet per second)	Existing 10-Year Storm Flow (cubic feet per second)	Planned 10-Year Storm Flow (cubic feet per second)	Existing 100-Year Storm Flow (cubic feet per second)	Planned 100-Year Storm Flow (cubic feet per second)	Frequency Storm Used for Evaluation of Existing Storm Sewers and Replacement of Inadequate Storm Sewers (years)
9	4	In Hawthorn Drive between Lincoln Drive West and Birchwood Drive (189)	42	25	54 at 0.86 percent	928	182	25[e]	97	25[e]	156	100
9	6	In Hawthorn Drive between Lincoln Drive West and Birchwood Drive (189)	42	114	54 at 1.0 percent	273	213	41	108	54	180	100
9	8	In easement east of railroad right-of-way (172, 189)	42	106	60 at 1.0 percent	456	282	71	131	105	225	100
1	22	In easement east of railroad right-of-way and north and south of Decorah Road (172,189)	60	147	Existing with parallel 66 at 0.87 percent	2,452	461	147[e]	306	147[e]	460	100
1	24	In easement east of railroad right-of-way north of Kilbourn Street (172)	60	193	Existing with parallel 72	574	507	147	306	161	460	100

NOTE: The following abbreviations have been used: CMPA = corrugated metal pipe arch; HE = horizontal elliptical; and RCPA = reinforced concrete pipe arch.

[a] *City storm sewer system plan sheet number in parentheses.*

[b] *Diameter of circular reinforced concrete pipe unless noted otherwise.*

[c] *Includes 10 cubic feet per second capacity of parallel 24-inch sewer in Main Street.*

[d] *To avoid overflow to north in Main Street and eventual ponding at Branch 1, Reach 16 in MR1, Hydrologic Unit MR-K.*

[e] *Flow limited to storm sewer capacity.*

[f] *The 21-inch and 27-inch pipes would be replaced. The parallel 12-inch and 15-inch pipes would remain to collect local runoff from Main Street.*

[g] *The replacement pipes are parallel to 132 feet of existing 29-inch by 18-inch RCPA, 297 feet of existing 24-inch, and 163 feet of existing 27-inch with a capacity of 22 cubic feet per second.*

Source: SEWRPC.

problems and to serve planned new urban development effectively. This alternative includes 15,080 lineal feet of replacement storm sewer, ranging in size from 30-inch- to 72-inch-diameter reinforced concrete pipe. The alternative utilizes the existing detention storage available in Ziegler Park. In order to prevent overflow from this hydrologic unit into the adjacent Hydrologic Unit M during a 100-year recurrence interval storm, it would be necessary to raise the grade under the railroad bridge at the outlet from Ziegler Park a maximum of 2.7 feet. That raised grade would provide one foot of freeboard between the 100-year flood stage in the park and the low point under the bridge and about 2.5 feet of freeboard between the low point under the bridge and the approximate low upstream house grade. Thus, during storms larger than a 100-year storm, when ponded water levels could rise up to or exceed the elevation of the low point under the bridge, overflow through the bridge and then to the east would limit upstream ponding to levels which would not flood houses.

An alternative which would not involve raising the grade under the railroad bridge and which would permit overflow into Hydrologic Unit

MR-M was also investigated. It was found that the amount of runoff which would overflow into MR-M would not cause enough reduction in peak flows to enable any reduction in the size of the storm sewers recommended to be installed in Hydrologic Unit MR-L. The facilities required to be constructed in Unit MR-M could be more costly because of the need to handle the additional runoff which would overflow from MR-L. Thus, the option which would permit overflow from MR-L into MR-M would produce no cost savings and could be more costly than Alternative Plan No. L-1. As a result, the overflow option was not considered further.

Map 9 shows the approximate location and alignment of the stormwater drainage measures proposed under Alternative Plan L-1. Table 25 presents a comparison of peak flows and existing and proposed storm sewer hydraulic capacities. Table 26 presents the salient characteristics and estimated costs of the replacement storm sewers comprising this alternative plan. The total present value cost of this alternative plan is $5,005,000, consisting of an estimated capital cost of $5,000,000 and an estimated annual operation and maintenance cost increase of $320.

Alternative Plan No. L-2, Storm Sewer Conveyance with Centralized Detention: This alternative calls for an additional 5.7 acre-feet of detention storage in Ziegler Park to control the runoff from a 100-year recurrence interval storm. This detention storage enables the downsizing of 1,900 lineal feet of replacement storm sewers. In order to prevent overflow from this hydrologic unit into the adjacent Hydrologic Unit M during a 100-year recurrence interval storm, it would be necessary to raise the grade under the railroad bridge at the outlet from Ziegler Park a maximum of 2.7 feet. That raised grade would provide two feet of freeboard between the 100-year flood stage in the park and the low point under the bridge and about 2.5 feet of freeboard between the low point under the bridge and the approximate low upstream house grade. A portion of the proposed expanded detention storage area is located in a wetland, as identified on the State wetland inventory. Aside from the features discussed above, this alternative is identical to Alternative L-1. Map 10 shows the approximate location, alignment, and configuration of the facilities called for under this alternative. Table 27 presents a comparison of peak flows and existing and proposed storm sewer hydraulic capacities. Table 28 presents the salient characteristics and estimated costs of the components of this alternative. The total present value cost of this alternative plan is $4,975,000, consisting of an estimated capital cost of $4,937,000, and an estimated annual operation and maintenance cost increase of $320.

Evaluation of Alternative Stormwater Drainage Plans: The foregoing information provides a basis for a comparative evaluation of the two alternative stormwater drainage plans. Each alternative was designed to resolve the identified existing drainage problems as well as to serve anticipated future development within the hydrologic unit. Each, when expanded to include the nonpoint source pollution control measures recommended in Chapter IV of this volume, would achieve the same degree of abatement of nonpoint source pollution. Thus, the principal criteria for the comparative evaluation were reduced to cost and implementability.

The two alternative plans have essentially equal present value costs. Alternative L-1 would be more implementable than Alternative L-2 because it would not require significant disturbance of Ziegler Park and would avoid wetland disturbance.

Recommended Stormwater Management Plan: Because the present value costs of the two alternatives are essentially the same and because Alternative L-1 would be more readily implementable on stormwater drainage considerations alone, Alternative L-1, Storm Sewer Conveyance, is recommended for adoption in this hydrologic unit. If the provision of wet detention storage in basin WD2 in Ziegler Park, as called for in Chapter IV of this volume, is unacceptable to City staff and officials in view of factors such as the loss of the baseball diamond and much of the playground in the park, the wet detention component could be eliminated and stormwater drainage Alternative L-1 would still function as intended. If basin WD2 were eliminated, the potential water quality benefits to the Milwaukee River provided by the basin would be eliminated. Some of the loss of that benefit could be offset through the implementation of infiltration of commercial and government and institutional parking lot runoff. The components and costs of the recommended plan are set forth in Table 9. The approximate location, alignment, and configura-

Table 26

ALTERNATIVE L-1: COMPONENTS AND COSTS OF THE STORM SEWER CONVEYANCE STORMWATER DRAINAGE PLAN FOR THE WEST BEND HYDROLOGIC UNIT MR-L

Hydrologic Unit	Project and Component Description[a]	Estimated Cost	
		Capital[b]	Annual Operation and Maintenance[c]
L	1. Replace 287 feet of 15-inch storm sewer in Butternut Street between Main Street and Eder Lane with 38-inch by 24-inch HE storm sewer	$48,000	$0
	2. Replace 661 feet of 21-inch storm sewer in Main Street north of Butternut Street with 42-inch storm sewer	148,000	-130
	3. Replace 226 feet of 42-inch storm sewer in Main Street between Butternut Street and Vine Street with 76-inch by 48-inch HE storm sewer	98,000	0
	4. Replace 471 feet of 42-inch storm sewer in Main Street between Butternut Street and Vine Street with 76-inch by 48-inch HE storm sewer	205,000	0
	5. Replace 289 feet of 60-inch by 38-inch storm sewer in Vine Street between Main Street and Eder Lane with 76-inch by 48-inch HE storm sewer	126,000	0
	6. Replace 278 feet of 60-inch by 38-inch storm sewer in Vine Street between Eder Lane and Sylvan Way with 556 feet of double 68-inch by 43-inch HE storm sewer	202,000	0
	7. Replace 680 feet of 60-inch by 38-inch storm sewer in Vine Street between Eder Lane and Sylvan Way with 68-inch by 43-inch HE storm sewer	247,000	0
	8. Replace 319 feet of 60-inch by 38-inch storm sewer in Vine Street between Eder Lane and Sylvan Way with 76-inch by 48-inch HE storm sewer	139,000	0
	9. Replace 32 feet of 76-inch by 48-inch storm sewer at 0.03 percent slope in Vine Street between Eder Lane and Sylvan Way with 76-inch by 48-inch HE storm sewer at 0.86 percent slope	14,000	0
	10. Replace 393 feet of 50-inch by 31-inch CMPA storm sewer in Green Valley Place between Sandra Lane and Sylvan Way with 53-inch by 34-inch HE storm sewer	102,000	0
	11. Replace 377 feet of 50-inch by 31-inch CMPA storm sewer in Green Valley Place between Sandra Lane and Sylvan Way with 53-inch by 34-inch HE storm sewer	98,000	0
	12. Replace 247 feet of 50-inch by 31-inch CMPA storm sewer in Sylvan Way between Vine Street and Green Valley Place with 60-inch by 38-inch HE storm sewer	78,000	0
	13. Replace 392 feet of 24-inch storm sewer in easement on east side of Sylvan Way with 36-inch storm sewer	59,000	0
	14. Replace 1,068 feet of 18-inch storm sewer in Eder Lane and Terrace Drive between Vine Street and Lincoln Drive East with 36-inch storm sewer	206,000	-200
	15. Replace 250 feet of 24-inch storm sewer in Terrace Drive between Lincoln Drive East and Birchwood Drive with 42-inch storm sewer	56,000	-50
	16. Replace 356 feet of 24-inch storm sewer in easement south of Birchwood Drive and west of railroad tracks with 53-inch by 34-inch HE storm sewer	93,000	-70

Table 26 (continued)

Hydrologic Unit	Project and Component Description[a]	Estimated Cost	
		Capital[b]	Annual Operation and Maintenance[c]
L (continued)	17. Replace 60 feet of 36-inch by 23-inch RCPA in easement south of Birchwood Drive and west of railroad tracks with 53-inch by 34-inch storm sewer	16,000	-10
	18. Install 1,902 feet of 54-inch storm sewer parallel to existing 54-inch storm sewer along railroad right-of-way south of Decorah Road	655,000	360
	19. Replace 56 feet of 15-inch and 21-inch storm sewer in Main Street between Hawthorn Drive and Vine Street with 30-inch storm sewer	8,000	0
	20. Replace 300 feet of 21-inch storm sewer in Main Street between Hawthorn Drive and Vine Street with 42-inch storm sewer	67,000	-60
	21. Replace 544 feet of 27-inch storm sewer in Main Street between Hawthorn Drive and Vine Street with 48-inch storm sewer	139,000	-100
	22. Replace 585 feet of 15-inch and 18-inch storm sewer in Main Street between Decorah Road and Hawthorn Drive with 38-inch by 24-inch HE storm sewer	99,000	0
	23. Replace 152 feet of 44-inch by 27-inch RCPA in Hawthorn Drive between Main Street and Lincoln Drive West with 48-inch storm sewer	39,000	0
	24. Replace 199 feet of 36-inch storm sewer in Hawthorn Drive between Main Street and Lincoln Drive West with 48-inch storm sewer	51,000	0
	25. Replace 928 feet of 42-inch storm sewer in Hawthorn Drive between Lincoln Drive West and Birchwood Drive with 54-inch storm sewer	319,000	0
	26. Replace 273 feet of 42-inch storm sewer in Hawthorn Drive between Lincoln Drive West and Birchwood Drive with 54-inch storm sewer	94,000	0
	27. Replace 456 feet of 42-inch storm sewer in easement east of Birchwood Drive to railroad tracks (south of Decorah Road) with 60-inch storm sewer	191,000	0
	28. Install 2,452 feet of 66-inch storm sewer at a slope of 0.87 percent parallel to existing 60-inch storm sewer in easement east of railroad right-of-way located north and south of Decorah Road	1,102,000	470
	29. Install 574 feet of 72-inch storm sewer parallel to existing 60-inch storm sewer in easement east of railroad right-of-way north of Kilbourn Street	301,000	110
- -	Total	$5,000,000	$320

NOTE: The following abbreviations have been used: CMPA = corrugated metal pipe arch; HE = horizontal elliptical; and RCPA = reinforced concrete pipe arch.

[a] *All new and replacement storm sewers are reinforced concrete pipe.*

[b] *Includes 35 percent for engineering, administration, and contingencies. Costs are for year 1991 with Engineering News-Record CCI = 5,015.*

[c] *Costs were noted to be zero when the alternative proposed replacement of a component with a component having similar operation and maintenance costs. Negative costs were noted when the replacement component was estimated to have a lower operation and maintenance cost than that of the existing facility.*

Source: SEWRPC.

Table 27

COMPARISON OF EXISTING AND PROPOSED FLOWS AND HYDRAULIC CAPACITIES OF STORM SEWERS: ALTERNATIVE L-2, STORM SEWER CONVEYANCE WITH CENTRALIZED DETENTION

Branch	Reach	Storm Sewer Location[a]	Existing Size[b] (inches)	Existing Capacity (cubic feet per second)	Planned Size[b] (inches)	Length (feet)	Planned Capacity (cubic feet per second)	Existing 10-Year Storm Flow (cubic feet per second)	Planned 10-Year Storm Flow (cubic feet per second)	Existing 100-Year Storm Flow (cubic feet per second)	Planned 100-Year Storm Flow (cubic feet per second)	Frequency Storm Used for Evaluation of Existing Storm Sewers and Replacement of Inadequate Storm Sewers (years)
Same as Alternative L-1 from Branch 2, Reach 0 through Branch 8, Reach 6												
1	20	Along railroad right-of-way south of Decorah Road (189)	54	124	Existing 54 with parallel 48	1,902	215	124[c]	162	124[c]	207	100
Same as Alternative L-1 from Branch 9, Reach 0 through Branch 9, Reach 8												
1	22	In easement east of railroad right-of-way and north and south of Decorah Road (172, 189)	60	147	Existing with parallel 66 at 0.87 percent	2,452	461	147[c]	266	147[c]	435	100
1	24	In easement east of railroad right-of-way north of Kilbourn Street (172)	60	193	Existing with parallel 72	574	507	147	266	161	437	100

[a] *City storm sewer system plan sheet number in parentheses.*

[b] *Diameter of circular reinforced concrete pipe unless noted otherwise.*

[c] *Flow limited to storm sewer capacity.*

Source: SEWRPC.

Table 28

ALTERNATIVE L-2: COMPONENTS AND COSTS OF THE STORM SEWER CONVEYANCE WITH CENTRALIZED DETENTION STORMWATER DRAINAGE PLAN FOR WEST BEND HYDROLOGIC UNIT MR-L

Hydrologic Unit	Project and Component Description[a]	Estimated Cost Capital[b]	Estimated Cost Annual Operation and Maintenance[c]
L	1. through 17. Same components as Storm Sewer Conveyance Alternative (see Table 26)	$1,935,000	$ -460
	18. Install 1,902 feet of 48-inch storm sewer parallel to existing 54-inch storm sewer along railroad right-of-way south of Decorah Road	485,000	360
	19. through 29. Same components as Storm Sewer Conveyance Alternative (see Table 26)	2,410,000	420
	Storm Sewer Subtotal	$4,830,000	$ 320
	30. 5.7 acre-feet of additional detention storage in Ziegler Park, T11N, R19E, northwest quarter, Section 24 (basin L-1)	$ 107,000	$2,100
- -	Total	$4,937,000	$2,420

[a] *All new and replacement storm sewers are reinforced concrete pipe.*

[b] *Includes 35 percent for engineering, administration, and contingencies. Costs are for year 1991 with Engineering News-Record CCI = 5,015.*

[c] *Costs were noted to be zero when the alternative proposed replacement of a component with a component having similar operation and maintenance costs. Negative costs were noted when the replacement component was estimated to have a lower operation and maintenance cost than that of the existing facility.*

Source: SEWRPC.

tion of the recommended facilities, including nonpoint source pollution control measures, are shown graphically on Map 14.

Hydrologic Unit MR-M

Evaluation of the Stormwater Management System: Hydrologic Unit MR-M is a 0.28-square-mile area located as shown on Map 1 in Chapter I of this volume. Under existing land use conditions, 95 percent of the hydrologic unit is developed in urban land uses. Under planned year 2010 conditions the hydrologic unit would essentially be completely developed in urban uses, predominantly medium-density residential and industrial, but would also include some high-density residential, commercial, and government and institutional uses. The existing stormwater management system consists of roadway curbs and gutters, storm sewer inlets, storm sewers, and an open channel. A 1,700-foot-long reach of an intermittent tributary to the Milwaukee River flows from the Wisconsin Central Transportation Corporation embankment on the east side of Ziegler Park to a storm sewer located southeast of the intersection of Decorah Road and Eastern Avenue. The channel is enclosed in a storm sewer from that location to the Milwaukee River.

Problems with inadequacies in both minor and major system hydraulic capacities were identified in parts of this hydrologic unit. As seen in Table 29, a comparison of the existing 10-year recurrence interval storm flows with the capacities of the existing storm sewers shows that several sewers have inadequate capacities to meet the minor system requirement of passing the peak rate of runoff from a 10-year storm. In addition, major system capacity problems were identified at two locations: 1) in Decorah Road between Eastern and Madison Avenues, where ponding in a mid-block sag could result in overflow to the north and south and flooding of buildings and 2) west of the T intersection of Eastern Avenue and Pleasant Drive, where flooding of buildings could occur because of overflow through the yards to the west.

Alternative Stormwater Drainage Plans: The following two alternative stormwater management plans were developed for Hydrologic Unit M: 1) a storm sewer conveyance plan and 2) a storm sewer conveyance with centralized detention plan.

Alternative Plan No. M-1, Storm Sewer Conveyance: The storm sewer conveyance alternative plan calls for the provision of replacement storm sewers to abate existing stormwater runoff problems and to serve planned new urban development effectively. This alternative includes 3,830 lineal feet of replacement storm sewer, ranging in size from 24-inch- to 66-inch-diameter reinforced concrete pipe. The alternative also utilizes the existing detention storage available along the unnamed tributary to the Milwaukee River. Map 9 shows the approximate location and alignment of the replacement storm sewers proposed under this alternative. Table 29 presents a comparison of peak flows and existing and proposed storm sewer hydraulic capacities. Table 30 presents the salient characteristics and estimated costs of the replacement storm sewers comprising this alternative plan. The total present value cost of this alternative plan is $1,249,000, consisting of an estimated capital cost of $1,250,000 and an estimated annual operation and maintenance cost decrease of $70.

Alternative Plan No. M-2, Storm Sewer Conveyance with Centralized Detention: In addition to replacement storm sewers, this alternative calls for the control of the runoff from a 100-year recurrence interval storm through the provision of 4.6 acre-feet of detention storage in detention basin M-1, located along the unnamed tributary to the Milwaukee River. The detention storage enables the retention of 840 lineal feet of existing storm sewer which would be replaced under Alternative M-1 and the downsizing of 2,280 lineal feet of replacement storm sewers.

The western one-third of detention basin M-1 is located along the unnamed tributary in an isolated 0.75-acre wetland. A systems-level wetlands evaluation and alternatives analysis, which concludes that construction of the basin as proposed is the only practicable alternative, is presented in Appendix A of this volume.

Map 10 shows the approximate location, alignment, and configuration of the facilities called for under this alternative. Table 31 presents a comparison of peak flows and existing and proposed storm sewer hydraulic capacities. Table 32 presents the salient characteristics and estimated costs of the components of this alternative. The total present value cost of this alternative plan is $1,111,000, consisting of an

Table 29

COMPARISON OF EXISTING AND PROPOSED FLOWS AND HYDRAULIC CAPACITIES OF STORM SEWERS: ALTERNATIVE M-1, STORM SEWER CONVEYANCE

Branch	Reach	Storm Sewer Location[a]	Existing Size[b] (inches)	Existing Capacity (cubic feet per second)	Planned Size[b] (inches)	Length (feet)	Planned Capacity (cubic feet per second)	Existing 10-Year Storm Flow (cubic feet per second)	Planned 10-Year Storm Flow (cubic feet per second)	Existing 100-Year Storm Flow (cubic feet per second)	Planned 100-Year Storm Flow (cubic feet per second)	Frequency Storm Used for Evaluation of Existing Storm Sewers and Replacement of Inadequate Storm Sewers (years)
50	0	In Indiana Avenue south of Eastern Avenue (189)	18	10	24	181	20	18	18	30	30	10
50	2	In easement south of Decorah Road and east of Eastern Avenue (189)	58 by 36 CMPA	52	42	4	80	39	54	154	66	100
50	4	In easement south of Decorah Road and east of Eastern Avenue (189)	58 by 36 CMPA	52	42	223	80	39	54	154	76	100
50	6	In easement north of Decorah Road and east of Eastern Avenue (189)	58 by 36 CMPA	51	60 by 38 HE	200	115	44	60	154	94	100
50	8	In easement north of Decorah Road between Madison Avenue and Eastern Avenue (171)	58 by 36 CMPA	93	60 by 38 HE	413	111	45	64	92	105	100
50	10	In Redwood Street between Eastern Avenue and Madison Avenue (171)	58 by 36 CMPA	41	60 by 38 HE at 0.82 percent	200	130	32	71	95	127	100
50	12	In Eastern Avenue between Pleasant Drive and Redwood Street (171)	58 by 36 CMPA	70	68 by 43 HE at 0.82 percent	289	183	48	79	99	154	100
50	14	In easement just west of Pleasant Drive between Locust Street and Decorah Road	58 by 36 CMPA	26	68 by 43 HE at 0.89 percent	324	191	26[c]	83	26[c,d]	176	100
		In easement just west of Pleasant Drive between Locust Street and Decorah Road	58 by 36 CMPA	96	68 by 43 HE at 0.89 percent	217	191	26[c]	83	26[c,d]	176	100
		In Riverview Drive between Locust Street and Decorah Road (172)	58 by 36 CMPA	56	68 by 43 HE at 0.89 percent	276	191	26[c]	83	26[c,d]	176	100
56	6	In Locust Street between Pennsylvania Avenue and Riverview Drive (172)	30 CMP	13	48	358	81	61	61	79	79	10
50	16	In Riverview Drive between Riverview Place and Locust Street (172)	72 by 44 CMPA	161	68 by 43 HE	260	278	101	157	177	285	100
		In Riverview Drive between Riverview Place and Kilbourn Avenue (172)	72 by 44 CMPA	111	68 by 43 HE	711	192	101	157	177	285	10
50	18	In easement north of the intersection of Kilbourn Avenue and Riverview Drive (172)	72 by 44 CMPA	62	66	174	181	114	169	191	307	10

NOTE: The following abbreviations have been used: CMP = corrugated metal pipe; CMPA = corrugated metal pipe arch; and HE = horizontal elliptical.

[a] *City storm sewer system plan sheet number in parentheses.*

[b] *Diameter of circular reinforced concrete pipe unless noted otherwise.*

[c] *Flow limited to storm sewer capacity.*

[d] *An additional 89 cubic feet per second peak flow travels through the backyards of the buildings between Riverview Drive and Eastern Avenue and south of Locust Street.*

Source: SEWRPC.

Table 30

ALTERNATIVE M-1: COMPONENTS AND COSTS OF THE STORM SEWER CONVEYANCE ALTERNATIVE STORMWATER DRAINAGE PLAN FOR WEST BEND HYDROLOGIC UNIT MR-M

Hydrologic Unit	Project and Component Description[a]	Estimated Cost	
		Capital[b]	Annual Operation and Maintenance[c]
M	1. Replace 181 feet of 18-inch storm sewer in Indiana Avenue south of Eastern Avenue with 24-inch storm sewer	$ 20,000	$ 0
	2. Replace 4 feet of 58-inch by 36-inch CMPA storm sewer in easement south of Decorah Road and east of Eastern Avenue with 42-inch storm sewer	1,000	0
	3. Replace 223 feet of 58-inch by 36-inch CMPA storm sewer in easement south of Decorah Road and east of Eastern Avenue with 42-inch storm sewer	50,000	0
	4. Replace 200 feet of 58-inch by 36-inch CMPA storm sewer in easement south of Decorah Road and east of Eastern Avenue with 60-inch by 38-inch HE storm sewer	63,000	0
	5. Replace 413 feet of 58-inch by 36-inch CMPA storm sewer in easement north of Decorah Road between Madison Avenue and Eastern Avenue with 60-inch by 38-inch HE storm sewer	130,000	0
	6. Replace 200 feet of 58-inch by 36-inch CMPA storm sewer in Redwood Street between Eastern Avenue and Madison Avenue with 60-inch by 38-inch HE storm sewer	63,000	0
	7. Replace 289 feet of 58-inch by 36-inch CMPA storm sewer in Eastern Avenue between Pleasant Drive and Redwood Street with 68-inch by 43-inch HE storm sewer	105,000	0
	8. Replace 324 feet of 58-inch by 36-inch CMPA storm sewer in easement just west of Pleasant Drive between Locust Drive and Decorah Road with 68-inch by 43-inch HE storm sewer	118,000	0
	9. Replace 217 feet of 58-inch by 36-inch CMPA storm sewer in Riverview Drive between Locust Drive and Decorah Road with 68-inch by 43-inch HE storm sewer	79,000	0
	10. Replace 276 feet of 58-inch by 36-inch CMPA storm sewer in Riverview Drive between Locust Drive and Decorah Road with 68-inch by 43-inch HE storm sewer	100,000	0
	11. Replace 358 feet of 30-inch CMP storm sewer in Locust Street between Pennsylvania Avenue and Riverview Drive with 48-inch storm sewer	91,000	-70
	12. Replace 260 feet of 72-inch by 44-inch CMPA storm sewer in Riverview Drive between Riverview Place and Locust Street with 68-inch by 43-inch HE storm sewer	94,000	0

Table 30 (continued)

Hydrologic Unit	Project and Component Description[a]	Estimated Cost	
		Capital[b]	Annual Operation and Maintenance[c]
M (continued)	13. Replace 711 feet of 72-inch by 44-inch CMPA storm sewer in Riverview Drive between Riverview Place and Kilbourn Avenue with 68-inch by 43-inch HE storm sewer	$ 258,000	$ 0
	14. Replace 174 feet of 72-inch by 44-inch CMPA storm sewer in easement north of the intersection of Kilbourn Avenue and Riverview Drive with 66-inch storm sewer	78,000	0
- -	Total	$1,250,000	$-70

NOTE: The following abbreviations have been used: CMP = corrugated metal pipe; CMPA = corrugated metal pipe arch; and HE = horizontal elliptical.

[a] *All new and replacement storm sewers are reinforce concrete pipe.*

[b] *Includes 35 percent for engineering, administration, and contingencies. Costs are for year 1991 with* *__Engineering News-Record__* *CCI = 5,015.*

[c] *Costs were noted to be zero when the alternative proposed replacement of a component with a component having similar operation and maintenance costs. Negative costs were noted when the replacement component was estimated to have a lower operation and maintenance cost than that of the existing facility.*

Source: SEWRPC.

estimated capital cost of $1,081,000, including land acquisition for the detention basin, and an estimated annual operation and maintenance cost increase of $1,930.

__Evaluation of Alternative Stormwater Drainage Plans__: The foregoing information provides a basis for a comparative evaluation of the two alternative stormwater drainage plans. Each alternative was designed to resolve the identified existing drainage problems and to serve anticipated future development within the hydrologic unit. Each, when expanded to include the nonpoint source pollution control measures recommended in Chapter IV of this volume, would achieve the same degree of abatement of nonpoint source pollution. Thus, the principal criteria for the comparative evaluation were reduced to cost and implementability.

Alternative M-2 is less costly than Alternative M-1, but Alternative M-1 would be more easily implemented since it would involve replacement of storm sewers which are generally within existing rights-of-way and easements and it would not require purchasing land or easements for the provision of detention basins. The possible location of a portion of detention basin M-1 in a wetland could hinder implementation of Alternative M-2 if it were determined that wetland water quality evaluation were required under Chapter NR 103 of the State Administrative Code.

__Recommended Stormwater Management Plan__: Because of the lower cost of Alternative M-2, Storm Sewer Conveyance with Centralized Detention, it is recommended for adoption in this hydrologic unit. The components and costs of the recommended plan are set forth in Table 9 and the approximate location, alignment, and configuration of the recommended facilities, including nonpoint source pollution control measures, are shown graphically on Map 14.

Table 31

COMPARISON OF EXISTING AND PROPOSED FLOWS AND HYDRAULIC CAPACITIES OF STORM SEWERS: ALTERNATIVE M-2, STORM SEWER CONVEYANCE WITH CENTRALIZED DETENTION

Branch	Reach	Storm Sewer Location[a]	Existing Size[b] (inches)	Existing Capacity (cubic feet per second)	Planned Size[b] (inches)	Length (feet)	Planned Capacity (cubic feet per second)	Existing 10-Year Storm Flow (cubic feet per second)	Planned 10-Year Storm Flow (cubic feet per second)	Existing 100-Year Storm Flow (cubic feet per second)	Planned 100-Year Storm Flow (cubic feet per second)	Frequency Storm Used for Evaluation of Existing Storm Sewers and Replacement of Inadequate Storm Sewers (years)
50	0	In Indiana Avenue south of Eastern Avenue (189)	18	10	24	181	20	18	18	30	30	10
50	2	In easement south of Decorah Road and east of Eastern Avenue (189)	58 by 36 CMPA	52	Retain existing	4	52	39	16	154	40	100
50	4	In easement south of Decorah Road and east of Eastern Avenue (189)	58 by 36 CMPA	52	Retain existing	223	52	39	16	154	40	100
50	6	In easement north of Decorah Road and east of Eastern Avenue (189)	58 by 36 CMPA	51	Retain existing	200	51	44	20	154	47	100
50	8	In easement north of Decorah Road between Madison Avenue and Eastern Avenue (171)	58 by 36 CMPA	93	Retain existing	413	93	45	21	92	48	100
50	10	In Redwood Street between Eastern Avenue and Madison Avenue (171)	58 by 36 CMPA	41	42	200	62	32	32	95	62	100
50	12	In Eastern Avenue between Pleasant Drive and Redwood Street (171)	58 by 36 CMPA	70	42	289	107	48	48	99	88	100
50	14	In easement just west of Pleasant Drive between Locust Street and Decorah Road	58 by 36 CMPA	26	60 by 38 HE at 0.89 percent	324	140	26[c]	62	26[c,d]	113	100
		In easement just west of Pleasant Drive between Locust Street and Decorah Road	58 by 36 CMPA	96	60 by 38 HE at 0.89 percent	217	140	26[c]	62	26[c,d]	113	100
		In Riverview Drive between Locust Street and Decorah Road (172)	58 by 36 CMPA	56	60 by 38 HE at 0.89 percent	276	140	26[c]	62	26[c,d]	113	100
56	6	In Locust Street between Pennsylvania Avenue and Riverview Drive (172)	30 CMP	13	48	358	81	61	61	79	79	10
50	16	In Riverview Drive between Riverview Place and Locust Avenue (172)	72 by 44 CMPA	161	60 by 38 HE	260	210	101	137	177	219	100
		In Riverview Drive between Riverview Place and Kilbourn Avenue (172)	72 by 44 CMPA	111	60 by 38 HE	711	145	101	137	177	219	10
50	18	In easement north of the intersection of Kilbourn Avenue and Riverview Drive (172)	72 by 44 CMPA	62	66	174	181	114	169	191	307	10

NOTE: The following abbreviations have been used: CMP = corrugated metal pipe; CMPA = corrugated metal pipe arch; and HE = horizontal elliptical.

[a] *City storm sewer system plan sheet number in parentheses.*

[b] *Diameter of circular reinforced concrete pipe unless noted otherwise.*

[c] *Flow limited to storm sewer capacity.*

[d] *An additional 89 cubic feet per second peak flow travels through the backyards of the buildings between Riverview Drive and Eastern Avenue and south of Locust Street.*

Source: SEWRPC.

Table 32

ALTERNATIVE M-2: COMPONENTS AND COSTS OF THE STORM SEWER CONVEYANCE WITH CENTRALIZED DETENTION STORMWATER DRAINAGE PLAN FOR WEST BEND HYDROLOGIC UNIT MR-M

Hydrologic Unit	Project and Component Description[a]	Estimated Cost	
		Capital[b]	Annual Operation and Maintenance[c]
M	1. Replace 181 feet of 18-inch storm sewer in Indiana Avenue south Eastern Avenue with 24-inch storm sewer	$ 20,000	$ 0
	2. Replace 200 feet of 58-inch by 36-inch CMPA storm sewer in Redwood Street between Eastern Avenue and Madison Avenue with 42-inch storm sewer	45,000	0
	3. Replace 289 feet of 58-inch by 36-inch CMPA storm sewer in Eastern Avenue between Pleasant Drive and Redwood Street with 42-inch storm sewer	65,000	0
	4. Replace 324 feet of 58-inch by 36-inch CMPA storm sewer in easement just west of Pleasant Drive between Locust Street and Decorah Road with 60-inch by 38-inch HE storm sewer	102,000	0
	5. Replace 217 feet of 58-inch by 36-inch CMPA storm sewer in Riverview Drive between Locust Street and Decorah Road with 60-inch by 38-inch HE storm sewer	68,000	0
	6. Replace 276 feet of 58-inch by 36-inch CMPA storm sewer in Riverview Drive between Locust Street and Decorah Road with 60-inch by 38-inch HE storm sewer	87,000	0
	7. Replace 358 feet of 30-inch CMP storm sewer in Locust Street between Pennsylvania Avenue and Riverview Drive with 48-inch storm sewer	91,000	-70
	8. Replace 260 feet of 72-inch by 44-inch CMPA storm sewer in Riverview Drive between Riverview Place and Locust Street with 60-inch by 38-inch HE storm sewer	82,000	0
	9. Replace 711 feet of 72-inch by 44-inch CMPA storm sewer in Riverview Drive between Riverview Place and Kilbourn Avenue with 60-inch by 38-inch HE storm sewer	224,000	0
	10. Replace 174 feet of 72-inch by 44-inch CMPA storm sewer in easement north of the intersection of Kilbourn Avenue and Riverview Drive with 66-inch storm sewer	78,000	0
	Storm Sewer Subtotal	$ 862,000	$ -70
	11. 4.6 acre-foot detention basin located southeast of the intersection of Eastern Avenue and Decorah Road, T11N, R19E, northeast quarter, Section 24 (basin M-1)	$ 219,000	$2,000
- -	Total	$1,081,000	$1,930

NOTE: The following abbreviations have been used: CMP = corrugated metal pipe; CMPA = corrugated metal pipe arch; and HE = horizontal elliptical.

[a] *All new and replacement storm sewers are reinforced concrete pipe.*

[b] *Includes 35 percent for engineering, administration, and contingencies. Costs are for year 1991 with Engineering News-Record CCI = 5,015.*

[c] *Costs were noted to be zero when the alternative proposed replacement of a component with a component having similar operation and maintenance costs. Negative costs were noted when the replacement component was estimated to have a lower operation and maintenance cost than that of the existing facility.*

Source: SEWRPC.

Table 33

COMPARISON OF EXISTING AND PROPOSED FLOWS AND HYDRAULIC CAPACITIES OF STORM SEWERS: ALTERNATIVE N-1, STORM SEWER AND OPEN CHANNEL CONVEYANCE; ALTERNATIVE N-2, STORM SEWER AND OPEN CHANNEL CONVEYANCE WITH CENTRALIZED DETENTION; ALTERNATIVE N-3, STORM SEWER AND OPEN CHANNEL CONVEYANCE WITH STORM SEWERS IN RIVER ROAD

Branch	Reach	Storm Sewer Location[a]	Existing Size[b] (inches)	Existing Capacity (cubic feet per second)	Planned Size[b] (inches)	Length (feet)	Planned Capacity (cubic feet per second)	Planned 10-Year Storm Flow (cubic feet per second)	Planned 100-Year Storm Flow (cubic feet per second)	Frequency Storm Used for Evaluation of Existing Storm Sewers and Replacement of Inadequate Storm Sewers (years)
- -	- -	Lang Street east of Rolfs Avenue (135)	72 by 48 CMPA	38	68 by 43 HE	280	67	50	100	10

NOTE: The following abbreviations have been used: CMPA = corrugated metal pipe arch and HE = horizontal elliptical.

[a] *City storm sewer system plan sheet number in parentheses.*

[b] *Diameter of circular reinforced concrete pipe unless noted otherwise.*

Source: SEWRPC.

Hydrologic Unit MR-N

Evaluation of the Stormwater Management System: Hydrologic Unit MR-N is a 0.41-square-mile area located as shown on Map 1 in Chapter I of this volume. Under existing land use conditions, 24 percent of the hydrologic unit is developed in urban land uses. Under planned year 2010 conditions the hydrologic unit would be about 98 percent developed in urban uses, predominantly medium-density residential and industrial, but would also include some commercial and two-family residential uses. The existing stormwater management system consists of roadway curbs and gutters, storm sewer inlets, storm sewers, roadside swales, a decentralized detention basin in the Woodside Manor subdivision, and an open-channel drainageway. A 1.3-mile-long agricultural drainageway flows from near the hydrologic unit topographic divide to the Milwaukee River. The drainageway is not classified as an intermittent or perennial stream on existing large-scale topographic maps prepared by the Regional Planning Commission for the City of West Bend in 1988 nor on the 7.5-minute-quadrangle map of the area prepared by the U. S. Geological Survey.

Problems with inadequate minor system hydraulic capacities were identified in parts of this hydrologic unit. As seen in Table 33, a comparison of the existing 10-year recurrence interval storm flow in Lang Street with the capacity of a segment of existing storm sewer shows that the storm sewer has inadequate capacity to meet the minor system requirement of passing the peak rate of runoff from a 10-year storm.

Alternative Stormwater Drainage Plans: The following three alternative stormwater management plans were considered for Hydrologic Unit N: 1) a storm sewer and open channel conveyance plan with centralized detention for water quality control, 2) a storm sewer and open channel conveyance plan with centralized detention for water quality and quantity control, and 3) a storm sewer and open channel conveyance plan with storm sewers in River Road and centralized detention for water quality control. The wet detention basin for water quality control which is recommended in Chapter IV of this volume, is considered here because construction of that basin would also provide some quantity control benefits as well. Those benefits would enable reducing the size of the proposed storm sewers downstream of the basin. Thus, the total costs for stormwater drainage and nonpoint source pollution control must be compared in order to adequately evaluate the relative merits of the alternative plans.

Alternative Plan No. N-1, Storm Sewer and Open Channel Conveyance with Centralized Detention for Water Quality Control: Under planned land use conditions, this alternative plan would convey runoff through the provision of 8,730 lineal feet of new reinforced concrete storm sewer, ranging in size from 18-inch-diameter to 83-inch-wide by 53-inch-high horizontal elliptical pipe; 1,905 lineal feet of 2.5- to 5.5-foot-deep roadside swale; and a 60-foot-long, 68-inch-wide by 43-inch-high horizontal elliptical reinforced concrete culvert under Lang Street. This alternative also calls for the modification of the agricultural drainageway south of Lang Street. The proposed 160-foot-long channel is sized to convey the runoff from a 100-year recurrence interval storm. The channel would be lined with riprap, would have average side slopes of one vertical on four horizontal, or other equivalent shape, and would have an average flood control channel bottom width of about fifteen feet. A small, meandering low-flow channel could be provided to improve the aesthetic character of the channel. The channel would discharge to a 15-acre-foot wet detention basin, designated as WD3 in Chapter IV of this volume. Outflow from the wet basin would enter a proposed 48-inch-diameter reinforced concrete storm sewer which would convey flows with recurrence intervals up to, and including, 100 years to the Milwaukee River. Under this alternative, basin WD3 is sized and configured mainly to provide water quality control. However, the need to excavate to such a depth that the permanent pond can adequately receive runoff from upstream areas results in the provision of surcharge storage above the permanent pond which allows reducing the basin outlet from a 78-inch-diameter pipe to the proposed 48-inch diameter.

This alternative calls for the provision of curb cuts along the north and south sides of Lang Street west of its intersection with River Road. Those curb cuts would enable runoff which would be conveyed in Lang Street during storms with recurrence intervals in excess of 10 years to be conveyed to detention basin WD3. The overflow along the north side of the street would be conveyed to the detention basin through a 68-inch-wide by 43-inch-high horizontal elliptical culvert at the intersection of Lang Street and River Road. The overflow along the south side of the street would be conveyed directly to the detention basin through overland flow.

Map 7 shows the approximate location and alignment of the stormwater drainage facilities proposed under this alternative. Table 33 presents a comparison of peak flows and existing and proposed storm sewer hydraulic capacities. Table 34 presents the salient characteristics and estimated costs of the components of this alternative plan. The total present value cost of this alternative plan is $2,567,000, consisting of an estimated capital cost of $2,416,000 and an estimated annual operation and maintenance cost increase of $9,580.

<u>*Alternative Plan No. N-2, Storm Sewer and Open Channel Conveyance with Centralized Detention for Water Quality and Quantity Control*</u>: Under planned land use conditions, this alternative plan calls for runoff to be conveyed through the provision of 8,660 lineal feet of new 18-inch-diameter to 83-inch-wide by 53-inch-high horizontal elliptical reinforced concrete storm sewer, 1,905 lineal feet of 2.5- to 5.5-foot-deep roadside swale, and a 60-foot-long 68-inch-wide by 43-inch-high horizontal elliptical reinforced concrete culvert under Lang Street. At, and upstream of, Lang Street, this plan is identical to Alternative N-1. Downstream of Lang Street, this alternative calls for the construction of dual-purpose detention basin WD3 to provide control of both water quantity and quality. As described in Chapter IV of this volume, basin WD3 would have a permanent pond area of approximately 3.2 acres. In addition to the permanent pond, this alternative calls for 24.1 acre-feet of surcharge storage to control runoff from storms with recurrence intervals up to, and including, 100 years. The basin outlet is proposed to be a 720-foot-long, 42-inch-diameter concrete pipe running from the basin through Washington Street (STH 33) to a 200-foot-long trapezoidal channel similar to that called for under Alternative No. N-1.

This alternative also calls for the provision of curb cuts along the north and south side of Lang Street west of its intersection with River Road. Those curb cuts would enable runoff which would be conveyed in Lang Street during storms with recurrence intervals in excess of 10 years to be conveyed to detention basin WD3.

Map 8 shows the approximate location and alignment of the stormwater drainage facilities proposed under this alternative. The comparison of peak flows and existing and proposed storm sewer hydraulic capacities presented in Table 33 is also applicable to this alternative. Table 35 presents the salient characteristics and estimated costs of the components of this alternative plan. The total present value cost of this alternative plan is $2,783,000, consisting of an

Table 34

ALTERNATIVE N-1: COMPONENTS AND COSTS OF THE STORM SEWER AND OPEN CHANNEL CONVEYANCE STORMWATER DRAINAGE PLAN FOR WEST BEND HYDROLOGIC UNIT MR-N

Hydrologic Unit	Project and Component Description[a]	Estimated Cost	
		Capital[b]	Annual Operation and Maintenance[c]
N	1. Install 485 feet of new 18-inch storm sewer	$ 30,000	$ 190
	2. Install 575 feet of new 24-inch storm sewer	47,000	230
	3. Install 1,715 feet of new 30-inch storm sewer	180,000	690
	4. Install 1,690 feet of new 42-inch storm sewer	267,000	320
	5. Install 335 feet of new 48-inch storm sewer	65,000	60
	6. Install 1,310 feet of new 54-inch storm sewer	294,000	250
	7. Install 800 feet of new 60-inch storm sewer	207,000	150
	8. Install 790 feet of new 48-inch storm sewer	202,000	150
	9. Install 750 feet of new 83-inch-wide by 53-inch-high HE storm sewer	263,000	100
	10. Replace 280 feet of 72-inch-wide by 48-inch-high CMPA storm sewer in Lang Street with 68-inch-wide by 43-inch-high HE storm sewer	102,000	0
	11. Construct 160-foot-long open channel south of Lang Street	35,000	100
	12. Construct 190-foot-long, 3.0- to 5.5-foot-deep riprap-lined roadside swale along west side of River Road	9,000	80
	13. Construct 480-foot-long, 3-foot-wide turf-lined roadside swale along west side of River Road	8,000	200
	14. Construct 820-foot-long, 2.5- to 4-foot-deep turf-lined roadside swale along west side of River Road	7,000	300
	15. Construct 415-foot-long, 3-foot-deep riprap-lined roadside swale along west side of River Road	22,000	160
	16. Install one 60-foot-long, 63-inch-wide by 43-inch-high HE culvert under Lang Street just west of River Road	14,000	0
	17. Construct 200-foot-long riprap-lined open channel from proposed 48-inch-diameter storm sewer outfall to the Milwaukee River	20,000	100
	Subtotal	$1,772,000	$3,080
	18. Wet detention basin WD3[d]	$ 644,000	$6,500
- -	Total	$2,416,000	$9,580

NOTE: The following abbreviations have been used: CMPA = corrugated metal pipe arch and HE = horizontal elliptical.

[a] *All new and replacement storm sewers are reinforced concrete pipe.*

[b] *Includes 35 percent for engineering, administration, and contingencies. Costs are for year 1991 with Engineering News-Record Construction Cost Index = 5,015.*

[c] *Costs were noted to be zero when the alternative proposed replacement of a component with a component having similar operation and maintenance cost. Negative costs were noted when the replacement component was estimated to have a lower operation and maintenance cost than that of the existing facility.*

[d] *The capital cost is the total to construct the detention basin which is recommended for water quality control in Chapter IV of this volume. Because the basin would provide some water quantity control as well, the capital cost is presented here to enable comparison of the three alternative plans on a consistent basis.*

Source: SEWRPC.

Table 35

ALTERNATIVE N-2: COMPONENTS AND COSTS OF THE STORM SEWER AND OPEN CHANNEL CONVEYANCE WITH CENTRALIZED DETENTION STORMWATER DRAINAGE PLAN FOR WEST BEND HYDROLOGIC UNIT MR-N

Hydrologic Unit	Project and Component Description[a]	Estimated Cost	
		Capital[b]	Annual Operation and Maintenance[c]
N	1. through 7. Same components as Storm Sewer and Open Channel Conveyance Alternative (see Table 34)	$1,090,000	$ 1,890
	8. Install 750 feet of new 83-inch-wide by 53-inch-high HE storm sewer	263,000	100
	9. Replace 280 feet of 72-inch-wide by 48-inch-high CMPA storm sewer in Lang Street with 68-inch-wide by 43-inch-high HE storm sewer	102,000	0
	10. Same components as items 12. through 16. Storm Sewer and Open Channel Conveyance Alternative (see Table 34)	60,000	740
	11. Detention basin WD3 with a 100-year storm live storage volume of 24.1 acre-feet	146,000	12,000
	12. Construct 720 feet of 42-inch-diameter storm sewer for basin WD3 outlet	120,000	140
	13. Construct 200-foot-long riprap-lined open channel from proposed 42-inch-diameter storm sewer outfall to the Milwaukee River	20,000	100
	Subtotal	$1,801,000	$14,970
	14. Wet detention basin WD3 water quality control component[d]	$ 644,000	$ 6,500
- -	Total	$2,445,000	$21,470

NOTE: The following abbreviations have been used: CMPA = corrugated metal pipe arch and HE = horizontal elliptical.

[a] *All new and replacement storm sewers are reinforced concrete pipe.*

[b] *Includes 35 percent for engineering, administration, and contingencies. Costs are for year 1991 with Engineering News-Record Construction Cost Index = 5,015.*

[c] *Costs were noted to be zero when the alternative proposed replacement of a component with a component having similar operation and maintenance cost. Negative costs were noted when the replacement component was estimated to have a lower operation and maintenance cost than that of the existing facility.*

[d] *The capital cost reflects the apportionment of basin construction costs between water quality and quantity control. Under the apportionment procedure, the basin cost in excess of that for construction of the permanent pond alone is assigned to quantity control under Item 11.*

Source: SEWRPC.

estimated capital cost of $2,445,000 and an estimated annual operation and maintenance cost increase of $21,470.

Alternative Plan No. N-3, Storm Sewer and Open Channel Conveyance with Storm Sewers in River Road and Centralized Detention for Water Quality Control: This alternative was considered because the provision of an urban street cross-section with storm sewers for River Road is consistent with the recommendations of the transportation system plan which the Commission has prepared in conjunction with the City of West Bend. This alternative is the same as Alternative N-1 with the exception that a total of about 1,910 lineal feet of reinforced concrete storm sewers, ranging in diameter from 15 to 36 inches, would be substituted for the roadside swales and the Lang Street culvert which are proposed to be located along the west side of

River Road under Alternative N-1. Those storm sewers would convey runoff from tributary areas of Hydrologic Unit MR-N as well as from lands located along River Road in Hydrologic Unit MR-O. As under Alternatives N-1 and N-2, this alternative calls for curb cuts along the north and south sides of Lang Street west of River Road to convey runoff to detention basin WD3.

Map 12 shows the approximate location and alignment of the stormwater drainage facilities proposed under this alternative. Table 33 presents a comparison of peak flows and existing and proposed storm sewer hydraulic capacities. Table 36 presents the salient characteristics and estimated costs of the components of this alternative plan. The total present value cost of this alternative plan is $2,704,000, consisting of an estimated capital cost of $2,555,000 and an estimated annual operation and maintenance cost increase of $9,480.

Evaluation of Alternative Stormwater Drainage Plans and Plan Recommendations: The foregoing information provides a basis for a comparative evaluation of the three alternative stormwater drainage plans. Each alternative was designed to resolve the identified existing drainage problems as well as to serve anticipated future development within the hydrologic unit. Thus, the principal criteria for the comparative evaluation were reduced to cost, implementability, and ability to control nonpoint source pollution.

Alternative N-1 is less costly than Alternative N-2 and would be more easily implemented than Alternative N-2 since the proposed open channel and detention basin for water quality control would require the purchase of less land than would the expanded detention basin. Thus, implementation of Alternative N-1 would allow industrial development of more land than under Alternative N-2.

Alternatives N-1 and N-3 are comparable except that the present value cost of Alternative N-3 is about 5 percent greater than that of Alternative N-1 because of the substitution of storm sewers for roadside swales along River Road. The present value cost of Alternative N-3 is about 3 percent less than that of Alternative N-2.

Alternatives N-1 and N-2 call for roadside swales along River Road, while Alternative N-3 calls for storm sewers in that location. In general, swales would enhance the ability of the stormwater management system to control nonpoint source pollution in comparison to a system utilizing storm sewers. However, all three alternatives call for the provision of wet detention basin WD3 downstream of the area where swales are substituted for storm sewers. Because of the relatively high degree of nonpoint source pollution control to be achieved by basin WD3, it is concluded that the additional control provided through the use of roadside swales along River Road would be insignificant. Thus, Alternatives N-1 and N-2 would not provide a significantly higher level of control of nonpoint source pollution than would Alternative No. N-3.

Under Alternatives N-1 and N-3 the peak 100-year recurrence interval flood flow into the Milwaukee River at the outlet from the hydrologic unit would be increased from 80 cubic feet per second (cfs) under existing land use and drainage conditions to about 100 cfs under planned land use and drainage conditions. Under Alternative N-2, the 100-year recurrence interval flood flow from the hydrologic unit would remain 80 cfs. However, the 100-year flow from the hydrologic unit is quite small in comparison to the 100-year flow in the Milwaukee River. Also, the post-development Hydrologic Unit MR-N flood peaks would be expected to occur sooner than flood peaks on the Milwaukee River. Thus, the increase in the peak flood flows from the hydrologic unit under Alternative N-1 or N-3 would not be expected to increase peak flood flows on the Milwaukee River.

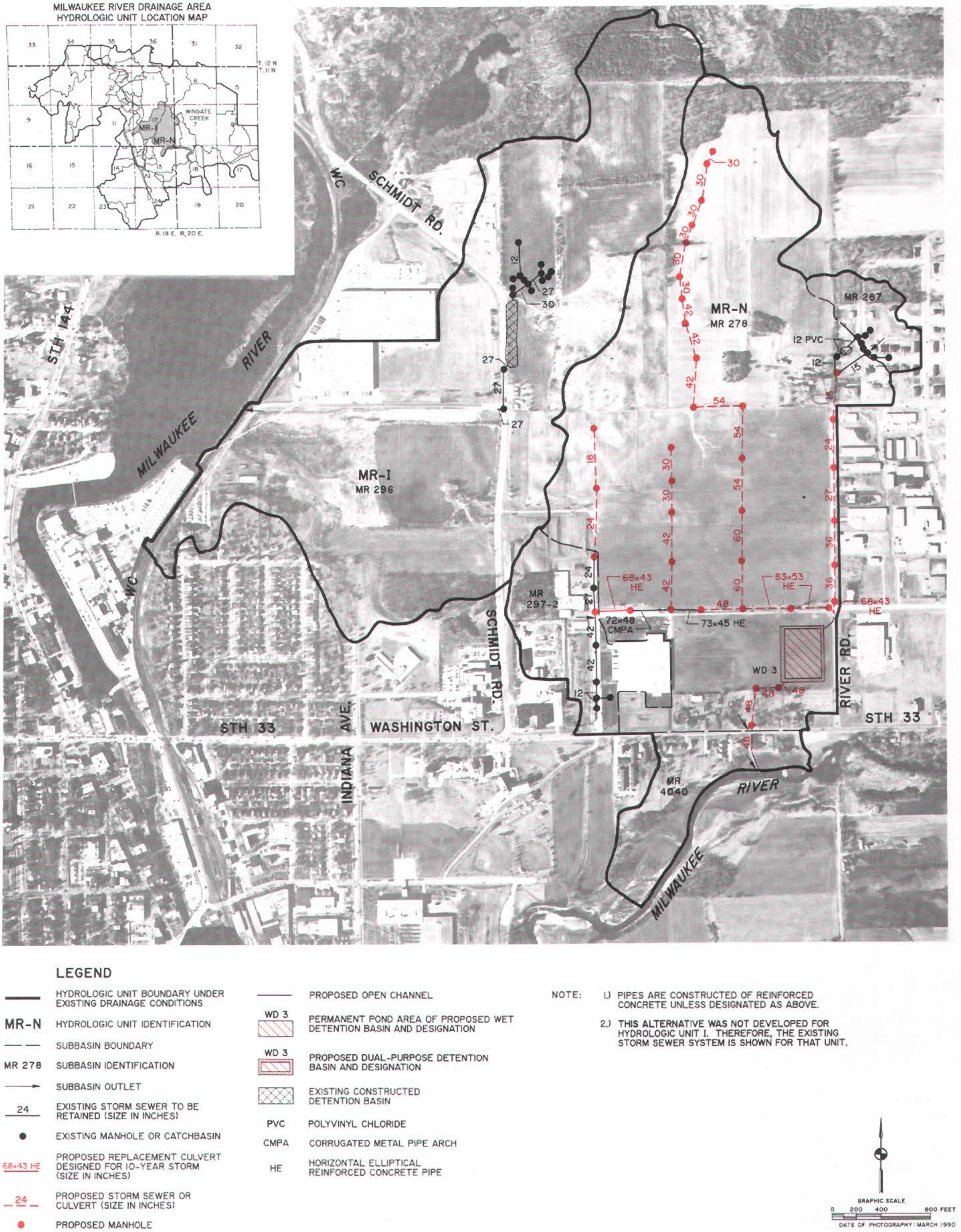
Alternative N-3 is the only alternative which is completely consistent with the recommendations of the transportation system plan prepared for the City, which plan calls for an urban street cross-section for River Road.

Recommended Stormwater Management Plan: Alternative N-3, Storm Sewer and Open Channel Conveyance with Storm Sewers in River Road and Centralized Detention for Water Quality Control, is recommended for adoption in this hydrologic unit because it is consistent with the recommendations of the transportation system plan prepared for the City and because its cost is only slightly more than the least costly alternative. The components and costs of the recommended plan are set forth in Table 9. The approximate location, alignment, and configuration of the recommended facilities, including nonpoint source pollution control measures, are shown graphically on Map 14.

Map 12

STORM SEWER AND OPEN CHANNEL CONVEYANCE WITH STORM SEWERS IN RIVER ROAD AND CENTRALIZED DETENTION FOR WATER QUALITY CONTROL ALTERNATIVE PLAN

HYDROLOGIC UNITS MR-I AND MR-N



NOTE: 1.) PIPES ARE CONSTRUCTED OF REINFORCED CONCRETE UNLESS DESIGNATED AS ABOVE.

2.) THIS ALTERNATIVE WAS NOT DEVELOPED FOR HYDROLOGIC UNIT I. THEREFORE, THE EXISTING STORM SEWER SYSTEM IS SHOWN FOR THAT UNIT.

Source: SEWRPC.

Table 36

ALTERNATIVE N-3: COMPONENTS AND COSTS OF THE STORM SEWER AND OPEN CHANNEL CONVEYANCE WITH STORM SEWERS IN RIVER ROAD STORMWATER DRAINAGE PLAN FOR WEST BEND HYDROLOGIC UNIT MR-N

Hydrologic Unit	Project and Component Description[a]	Estimated Cost	
		Capital[b]	Annual Operation and Maintenance
N	1. through 11. Same components as Storm Sewer and Open Channel Conveyance Alternative (see Table 34)	$1,692,000	$2,240
	12. Install 415 feet of new 15-inch storm sewer	22,000	170
	13. Install 385 feet of new 24-inch storm sewer	32,000	150
	14. Install 440 feet of new 27-inch storm sewer	41,000	180
	15. Install 670 feet of new 36-inch storm sewer	89,000	130
	16. Install 60 feet of new 68-inch-wide by 43-inch-high HE storm sewer	15,000	10
	17. Construct 200-foot-long riprap-lined open channel from proposed 48-inch-diameter storm sewer outfall to the Milwaukee River	20,000	100
	Subtotal	$1,911,000	$2,980
	18. Wet detention basin WD3[c]	$ 644,000	$6,500
- -	Total	$2,555,000	$9,480

NOTE: The following abbreviation has been used: HE = horizontal elliptical.

[a] *All new and replacement storm sewers are reinforced concrete pipe.*

[b] *Includes 35 percent for engineering, administration, and contingencies. Costs are for year 1991 with Engineering News-Record Construction Cost Index = 5,015.*

[c] *The capital cost is the total to construct the detention basin which is recommended for water quality control in Chapter IV of this volume. Because the basin would provide some water quantity control as well, the capital cost is presented here to enable comparison of the three alternative plans on a consistent basis.*

Source: SEWRPC.

Hydrologic Unit MR-O

Evaluation of the Stormwater Management System: Hydrologic Unit MR-O is a 0.08-square-mile area located as shown on Map 1 in Chapter I of this volume. This hydrologic unit includes much of the West Bend Industrial Park-North. Under existing land use conditions, 60 percent of the hydrologic unit is developed in predominantly industrial land uses. Under year 2010 conditions, the hydrologic unit would essentially be completely developed in urban uses, predominantly industrial, but would include some commercial uses. The existing stormwater management system consists of roadway curbs and gutters, storm sewer inlets, storm sewers, roadside swales, and open channels.

Problems with inadequate minor system hydraulic capacities were identified in parts of this hydrologic unit. As seen in Table 37, a comparison of the existing 10-year recurrence interval storm flows with the capacities of the existing storm sewers shows that the storm sewer system has inadequate capacity to meet the minor system requirement of passing the peak rate of runoff from a 10-year storm. Flooding problems due an inadequate system of swales and open channels in the area north of Lang Street have also been reported.

Alternative Stormwater Drainage Plans: The following three alternative stormwater management plans were developed for Hydrologic

Table 37

COMPARISON OF EXISTING AND PROPOSED FLOWS AND HYDRAULIC CAPACITIES OF STORM SEWERS: ALTERNATIVE O-1, STORM SEWER AND OPEN CHANNEL CONVEYANCE

Branch	Reach	Storm Sewer Location[a]	Existing Size[b] (inches)	Existing Capacity (cubic feet per second)	Planned Size[b] (inches)	Length (feet)	Planned Capacity (cubic feet per second)	Existing 10-Year Storm Flow (cubic feet per second)	Planned 10-Year Storm Flow (cubic feet per second)	Existing 100-Year Storm Flow (cubic feet per second)	Planned 100-Year Storm Flow (cubic feet per second)	Frequency Storm Used for Evaluation of Existing Storm Sewers and Replacement of Inadequate Storm Sewers (years)
1	0	In Lang Street (134)	18	8	30	201	31	21	26	36	43	10
1	2	In easement between Lang and Washington Streets (134)	30	18	42 at 0.4 percent	202	95	51	85	86	139	10
1	4	In easement between Lang and Washington Streets (134)	30	26	42 at 0.9 percent	281	95	51	93	86	154	10
1	6	In easement between Lang and Washington Streets (134)	30	37	48 at 0.6 percent	257	111	51	101	86	169	10
1	8	In easement between Lang and Washington Streets (134)	36	80	48 at 0.6 percent	216	111	51	109	86	183	10
1	10	In easement between Lang and Washington Streets (134)	30	53	48 at 0.6 percent	107	111	51	109	86	183	10
1	12	In easement between Lang and Washington Streets (134)	30	52	48 at 0.6 percent	201	111	51	109	86	183	10

[a] *City storm sewer system plan sheet number in parentheses.*

[b] *Diameter of circular reinforced concrete pipe unless noted otherwise.*

Source: SEWRPC.

Unit O: 1) a storm sewer and open channel conveyance plan, 2) a storm sewer and open channel conveyance plan with centralized storage, and 3) a storm sewer and open channel conveyance plan with centralized storage and sewers in River Road.

Alternative Plan No. O-1, Storm Sewer and Open Channel Conveyance Alternative: The storm sewer and open channel conveyance alternative plan calls for the provision of 1,700 lineal feet of 30-inch- to 48-inch-diameter reinforced concrete replacement storm sewer to abate existing stormwater runoff problems. This alternative also calls for the widening and deepening of the open channel running from north to south along the back lot lines of the industrial properties located north of Lang Street. The proposed channel is sized to convey the runoff from a 100-year recurrence interval storm. The channel would be from three to nine feet deep, would be lined with natural vegetation or turf, would have average side slopes of one vertical on four horizontal or other equivalent shape, and would have an average bottom width of about five feet. A similar trapezoidal channel would be constructed in the area between Lang and Washington Streets in order to provide adequate major system capacity by conveying runoff in excess of the storm sewer capacity. The depth of that channel would range from two to 4.5 feet. Runoff from the industrial park which drains to River Road would be conveyed to the south in a 550-foot-long, 1.5-foot-deep roadside swale followed by an 800-foot-long, 2.5-foot-deep swale. That swale would have the standard City of West Bend rural triangular cross-section, with a one vertical on four horizontal side slope adjacent to the road and a one vertical on three horizontal side slope away from the road. Map 7 shows the approximate location and alignment of the stormwater drainage facilities proposed under this alternative. Table 37 presents a comparison of peak flows and existing and proposed storm sewer hydraulic capacities. Table 38 presents the salient characteristics and estimated costs of the replacement storm sewers comprising this alternative plan. The total present value cost of this alternative plan is $482,000, consisting of an estimated capital cost of $470,000 and an estimated annual operation and maintenance cost increase of $770.

Table 38

ALTERNATIVE O-1: COMPONENTS AND COSTS OF THE STORM SEWER AND OPEN CHANNEL CONVEYANCE STORMWATER DRAINAGE PLAN FOR WEST BEND HYDROLOGIC UNIT MR-O

Hydrologic Unit	Project and Component Description[a]	Estimated Cost	
		Capital[b]	Annual Operation and Maintenance[c]
O	1. Replace 201 feet of 18-inch storm sewer in Lang Street with 30-inch storm sewer	$ 30,000	$ 0
	2. Replace 202 feet of 30-inch storm sewer in easement between Lang and Washington Streets with 42-inch storm sewer at 0.9 percent slope	45,000	-40
	3. Replace 281 feet of 30-inch storm sewer in easement between Lang and Washington Streets with 42-inch storm sewer at 0.9 percent slope	63,000	-50
	4. Replace 257 feet of 30-inch storm sewer in easement between Lang and Washington Streets with 48-inch storm sewer at 0.6 percent slope	66,000	-50
	5. Replace 216 feet of 36-inch storm sewer in easement between Lang and Washington Streets with 48-inch storm sewer at 0.6 percent slope	55,000	0
	6. Replace 107 feet of 30-inch storm sewer in easement between Lang and Washington Streets with 48-inch storm sewer at 0.6 percent slope	27,000	-20
	7. Replace 201 feet of 30-inch storm sewer in easement between Lang and Washington Streets with 48-inch storm sewer at 0.6 percent slope	51,000	-40
	8. Construct 1,400-foot-long open channel in industrial park north of Lang Street	80,000	600
	9. Construct 880-foot-long open channel through area between Lang and Washington Streets	23,000	370
	10. Construct 550-foot-long, 1.5-foot-deep roadside swale with driveway culverts along east side of River Road	12,000	0
	11. Construct 800-foot-long, 2.5-foot-deep roadside swale with driveway culverts along east side of River Road	18,000	0
- -	Total	$470,000	$770

[a] *All new and replacement storm sewers are reinforced concrete pipe.*

[b] *Includes 35 percent for engineering, administration, and contingencies.*

[c] *Costs were noted to be zero when the alternative proposed replacement of a component with a component having similar operation and maintenance costs. Negative costs were noted when the replacement component was estimated to have a lower operation and maintenance cost than that of the existing facility.*

Source: SEWRPC.

Alternative Plan No. O-2, Storm Sewer and Open Channel Conveyance with Centralized Detention Storage: This alternative calls for the same open channels north and south of Lang Street and the same swale along River Road as under Alternative No. O-1. In addition, this alternative calls for the control of the runoff from a 100-year recurrence interval storm through the provision of 3.2 acre-feet of detention storage along the proposed channel just north of Lang Street. The detention storage enables the retention of the existing storm sewer system. Map 8 shows the approximate location, alignment, and configuration of the facilities called for under this alternative. Table 39 presents the salient characteristics and estimated costs of the components of this alternative. The total present value cost of this alternative plan

Table 39

ALTERNATIVE O-2: COMPONENTS AND COSTS OF THE STORM SEWER AND OPEN CHANNEL CONVEYANCE WITH CENTRALIZED DETENTION STORMWATER DRAINAGE PLAN FOR WEST BEND HYDROLOGIC UNIT MR-O

Hydrologic Unit	Project and Component Description[a,b]	Estimated Cost	
		Capital[c]	Annual Operation and Maintenance[d]
O	1. Construct 1,200-foot-long open channel in industrial park north of Lang Street	$ 75,000	$ 500
	2. Construct 880-foot-long open channel through area between Lang and Washington Streets	23,000	370
	3. Construct 550-foot-long 1.5-foot-deep roadside swale with driveway culverts along east side of River Road	12,000	0
	4. Construct 800-foot-long 2.5-foot-deep roadside swale with driveway culverts along east side of River Road	18,000	0
	5. Detention basin WD6 with a 100-year live storage volume of 3.2 acre-feet	63,000	900
- -	Total	$191,000	$1,770

[a] *All new and replacement storm sewers are reinforced concrete pipe.*

[b] *The existing storm sewers are utilized under this alternative.*

[c] *Includes 35 percent for engineering, administration, and contingencies.*

[d] *Costs were noted to be zero when the alternative proposed replacement of a component with a component having similar operation and maintenance costs. Negative costs were noted when the replacement component was estimated to have a lower operation and maintenance cost than that of the existing facility.*

Source: SEWRPC.

Table 40

ALTERNATIVE 0-3: COMPONENTS AND COSTS OF THE STORM SEWER AND OPEN CHANNEL CONVEYANCE WITH CENTRALIZED DETENTION AND STORM SEWERS IN RIVER ROAD STORMWATER DRAINAGE PLAN FOR WEST BEND HYDROLOGIC UNIT MR-O

Hydrologic Unit	Project and Component Description[a,b]	Estimated Cost	
		Capital[c]	Annual Operation and Maintenance
O	1. Construct 1,200-foot-long open channel in industrial park north of Lang Street	$ 75,000	$ 500
	2. Construct 880-foot-long open channel through area between Lang and Washington Streets	23,000	370
	3. Detention basin WD6 with a 100-year live storage volume of 3.2 acre-feet	63,000	900
- -	Total	$161,000	$1,770

[a] *All new and replacement storm sewers are reinforced concrete pipe.*

[b] *The existing storm sewers are utilized under this alternative.*

[c] *Includes 35 percent for engineering, administration, and contingencies. Costs are for year 1991 with Engineering News-Record Construct Cost Index = 5,015.*

Source: SEWRPC.

is $219,000, consisting of an estimated capital cost of $191,000, including land acquisition for the detention basin, and an estimated annual operation and maintenance cost increase of $1,770.

Alternative Plan No. O-3, Storm Sewer and Open Channel Conveyance with Centralized Detention Storage and Storm Sewers in River Road: This alternative was considered in combination with Alternative N-3 for Hydrologic Unit MR-N. The alternative was developed because the provision of an urban street cross section with storm sewers for River Road is consistent with the recommendations of the transportation system plan which the Commission prepared in conjunction with the City of West Bend. This alternative is the same as Alternative O-2 with the exception that the roadside swales called for under Alternative O-2 are eliminated, replaced by the storm sewers provided under Alternative N-3.

Map 13 shows the approximate location and alignment of the stormwater drainage facilities proposed under this alternative. Table 40 presents the salient characteristics and estimated costs of the components of this alternative plan. The total present value cost of this alternative plan is $189,000 consisting of an estimated capital cost of $161,000 and an estimated annual operation and maintenance cost increase of $1,770.

Evaluation of Alternative Stormwater Drainage Plans: The foregoing information provides a basis for a comparative evaluation of the three alternative stormwater drainage plans. Each alternative was designed to resolve the identified existing drainage problems as well as to serve anticipated future development within the hydrologic unit. Each, when expanded to include the nonpoint source pollution control measures recommended in Chapter IV of this volume, would achieve the same degree of abatement of nonpoint source pollution. Thus, the principal criteria for the comparative evaluation were reduced to cost and implementability.

Alternative O-3 is the least costly of the three alternatives and the only alternative which is completely consistent with the recommendations of the transportation system plan prepared for the City, which calls for an urban street cross-section for River Road. Portions of Alternative O-1 would be more easily implemented than Alternatives O-2 and O-3, since O-1 would involve replacement of storm sewers which are generally within existing rights-of-way and easements and it would not require purchasing land or easements for the provision of a detention basin. Because the recommended water quality management element of this plan calls for a wet detention basin to control nonpoint source pollution from the upstream industrial park, the construction of a dual-purpose detention basin under Alternatives O-2 and 0-3 for the control of both water quality and water quality would be practical and cost effective.

Recommended Stormwater Management Plan: Alternative O-3, Storm Sewer and Open Channel Conveyance with Centralized Detention and Storm Sewers in River Road, is recommended for adoption in this hydrologic unit because it is the least costly alternative, because it is consistent with the recommendations of the transportation system plan prepared for the City, and because it can be constructed in conjunction with a recommended wet detention basin to control industrial park runoff. The components and costs of the recommended plan are set forth in Table 9. The approximate location, alignment, and configuration of the recommended facilities, including nonpoint source pollution control measures, are shown graphically on Map 14.

Hydrologic Unit MR-P

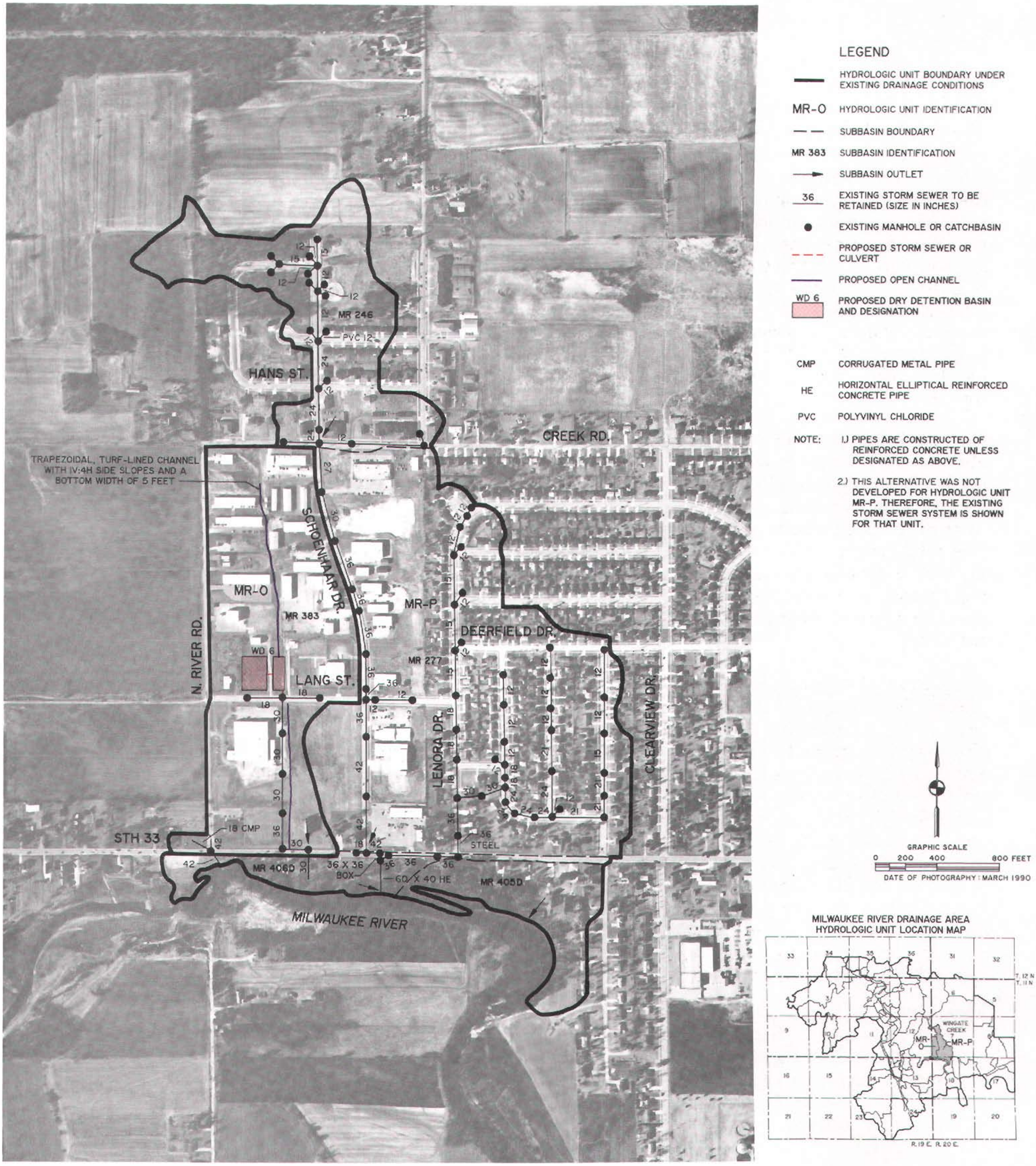
Evaluation of the Stormwater Management System: Hydrologic Unit MR-P is a 0.22-square-mile area located as shown on Map 1 in Chapter I of this volume. Under existing land use conditions, 91 percent of the hydrologic unit is developed in urban land uses. Under planned year 2010 conditions the hydrologic unit would essentially be completely developed in urban uses, predominantly medium-density residential and industrial, but would include some commercial, two-family residential, and government and institutional uses.. The existing stormwater management system consists of roadway curbs and gutters, storm sewer inlets, and storm sewers.

Problems with inadequate minor system hydraulic capacities were identified in parts of this hydrologic unit. As seen in Table 41, a comparison of the existing 10-year recurrence interval storm flows with the capacities of the existing

Map 13

STORM SEWER AND OPEN CHANNEL CONVEYANCE WITH CENTRALIZED DETENTION STORAGE AND STORM SEWERS IN RIVER ROAD ALTERNATIVE PLAN

HYDROLOGIC UNITS MR-O AND MR-P



NOTE: 1.) PIPES ARE CONSTRUCTED OF REINFORCED CONCRETE UNLESS DESIGNATED AS ABOVE.

2.) THIS ALTERNATIVE WAS NOT DEVELOPED FOR HYDROLOGIC UNIT MR-P. THEREFORE, THE EXISTING STORM SEWER SYSTEM IS SHOWN FOR THAT UNIT.

Source: SEWRPC.

Table 41

COMPARISON OF EXISTING AND PROPOSED FLOWS AND HYDRAULIC CAPACITIES OF STORM SEWERS: ALTERNATIVE P-1, STORM SEWER CONVEYANCE

Branch	Reach	Storm Sewer Location[a]	Existing Size[b] (inches)	Existing Capacity (cubic feet per second)	Planned Size[b] (inches)	Length (feet)	Planned Capacity (cubic feet per second)	Existing 10-Year Storm Flow (cubic feet per second)	Planned 10-Year Storm Flow (cubic feet per second)	Existing 100-Year Storm Flow (cubic feet per second)	Planned 100-Year Storm Flow (cubic feet per second)	Frequency Storm Used for Evaluation of Existing Storm Sewers and Replacement of Inadequate Storm Sewers (years)
1	0	In Schoenhaar Drive between Hans Street and Creek Drive (119)	24	19	30	55	35	13	35	37	70	10
1	8	In Schoenhaar Drive north of Washington Street (134)	42	91	68 by 43 HE	302	183	76	151	144	256	10
1	10	In easement south of Washington Street between Schoenhaar and Lenora Drives extended (134)	60 by 38 HE	155	60	203	264	133	208	234	346	10

NOTE: The following abbreviation has been used: HE = horizontal elliptical.

[a] *City storm sewer system plan sheet number in parentheses.*

[b] *Diameter of circular reinforced concrete pipe unless noted otherwise.*

Source: SEWRPC.

storm sewers shows that three segments of storm sewer have inadequate capacities to meet the minor system requirement of passing the peak rate of runoff from a 10-year storm. No major system capacity problems were identified.

Alternative Stormwater Drainage Plans: The following two alternative stormwater management plans were developed for Hydrologic Unit P: 1) a storm sewer conveyance plan and 2) a storm sewer conveyance with centralized detention plan.

Alternative Plan No. P-1, Storm Sewer Conveyance: The storm sewer conveyance alternative plan provides for new and replacement storm sewers to abate existing stormwater runoff problems and to effectively serve planned new urban development. This alternative calls for 560 lineal feet of replacement storm sewer, including 30-inch- and 60-inch-diameter reinforced concrete pipe and 68-inch-wide by 43-inch-high horizontal elliptical reinforced concrete pipe. Map 9 shows the approximate location and alignment of the new and replacement storm sewers proposed under this alternative. Table 41 presents a comparison of peak flows and existing and proposed storm sewer hydraulic capacities. Table 42 presents the salient characteristics and estimated costs of the replacement storm sewers comprising this alternative plan. The total present value and capital costs of this alternative plan are $203,000. No net change in the annual operation and maintenance cost would be expected.

Alternative Plan No. P-2, Storm Sewer Conveyance with Centralized Detention: This alternative calls for the provision of 2.4 acre-feet of detention storage. The detention basin would have an 80-foot-long, 48-inch-diameter reinforced concrete inlet pipe to convey runoff collected in the storm sewer in Schoenhaar Drive and a 225-foot-long 68-inch-wide by 43-inch-high horizontal elliptical reinforced concrete outlet to convey outflow from the basin to the storm sewer in the intersection of Schoenhaar Drive and Washington Street. The detention storage enables the retention of 450 lineal feet of existing storm sewer which would be replaced under Alternative P-1. There would also be 470 lineal feet of new 24-inch-diameter storm sewer and 55 lineal feet of 30-inch-diameter replacement sewer installed under this alternative. Map 10 shows the approximate location, alignment, and

Table 42

ALTERNATIVE P-1: COMPONENTS AND COSTS OF THE STORM SEWER CONVEYANCE STORMWATER DRAINAGE PLAN FOR WEST BEND HYDROLOGIC UNIT MR-P

Hydrologic Unit	Project and Component Description[a]	Estimated Cost	
		Capital[b]	Annual Operation and Maintenance[c]
P	1. Replace 55 feet of 24-inch storm sewer in Schoenhaar Drive between Hans Street and Creek Drive with 30-inch storm sewer	$ 8,000	$0
	2. Replace 302 feet of 42-inch storm sewer in Schoenhaar Drive north of Washington Street with 68-inch by 43-inch HE storm sewer	110,000	0
	3. Replace 203 feet of 48-inch storm sewer in easement south of Washington Street between Schoenhaar and Lenora Drives with 60-inch storm sewer	85,000	0
- -	Total	$203,000	$0

NOTE: The following abbreviation has been used: HE = horizontal elliptical.

[a] *All new and replacement storm sewers are reinforced concrete pipe.*

[b] *Includes 35 percent for engineering, administration, and contingencies. Costs are for year 1991 with Engineering News-Record Construction Cost Index = 5,015.*

[c] *Costs were noted to be zero when the alternative proposed replacement of a component with a component having similar operation and maintenance costs. Negative costs were noted when the replacement component was estimated to have a lower operation and maintenance cost than that of the existing facility.*

Source: SEWRPC.

configuration of the facilities called for under this alternative. Table 43 presents a comparison of peak flows and existing and proposed storm sewer hydraulic capacities. Table 44 presents the salient characteristics and estimated costs of the components of this alternative. The total present value cost of this alternative plan is $164,000, consisting of an estimated capital cost of $155,000, and an estimated annual operation and maintenance cost increase of $600.

Evaluation of Alternative Stormwater Drainage Plans: The foregoing information provides a basis for a comparative evaluation of the two alternative stormwater drainage plans. Each alternative was designed to resolve the identified existing drainage problems as well as to serve anticipated future development within the hydrologic unit. Each, when expanded to include the nonpoint source pollution control measures recommended in Chapter IV of this volume, would achieve the same degree of abatement of nonpoint source pollution. Thus, the principal criteria for the comparative evaluation were reduced to cost and implementability.

The present value cost of Alternative P-2 is about 80 percent of that of Alternative P-1. Implementation of Alternative P-1 may require evaluation by the Wisconsin Department of Natural Resources according to the standards of Chapter NR 103 of the Wisconsin Administrative Code because the replacement of the existing 48-inch-diameter, 203-foot-long storm sewer at the hydrologic unit outlet would involve some construction in a wetland. Because the recommended water quality management element of this plan calls for a wet detention basin to control nonpoint source pollution from the upstream industrial park, the construction of a dual-purpose detention basin under Alternative P-2 for the control of both water quantity and quality would be practical and cost effective.

During a November 23, 1993, interagency meeting of City and Regional Planning Commission staff, the City staff rejected the storm sewer conveyance with centralized detention plan because construction of dual-purpose wet detention basin WD5 would involve the loss of high value, prime development land.

Table 43

COMPARISON OF EXISTING AND PROPOSED FLOWS AND HYDRAULIC CAPACITIES OF STORM SEWERS: ALTERNATIVE P-2, STORM SEWER CONVEYANCE WITH CENTRALIZED DETENTION

Branch	Reach	Storm Sewer Location[a]	Existing Size[b] (inches)	Existing Capacity (cubic feet per second)	Planned Size[b] (inches)	Length (feet)	Planned Capacity (cubic feet per second)	Existing 10-Year Storm Flow (cubic feet per second)	Planned 10-Year Storm Flow (cubic feet per second)	Existing 100-Year Storm Flow (cubic feet per second)	Planned 100-Year Storm Flow (cubic feet per second)	Frequency Storm Used for Evaluation of Existing Storm Sewers and Replacement of Inadequate Storm Sewers (years)
1	0	In Schoenhaar Drive between Hans Street and Creek Drive (119)	24	19	30	55	35	13	35	37	70	10
1	8	In Schoenhaar Drive north of Washington Street (134)	42	91	Retain existing	302	913	76	88	144	256	10
Basin WD5	Inlet	- -	- -	- -	48 at 1.24 percent	80	160	- -	152	- -	152[c]	10
Basin WD5	Outlet	- -	- -	- -	68 by 43 HE at 0.22 percent	225	95	- -	88	- -	95	10
1	10	In easement south of Washington Street between Schoenhaar and Lenora Drives extended (134)	60 by 38 HE	155	Retain existing	203	146	133	130	234	270	10

NOTE: The following abbreviation has been used: HE = horizontal elliptical.

[a] *City storm sewer system plan sheet number in parentheses.*

[b] *Diameter of circular reinforced concrete pipe unless noted otherwise.*

[c] *An additional 104 cubic feet per second would be conveyed in the Schoenhaar Drive storm sewer adjacent to the proposed detention basin WD5 and would bypass the proposed basin.*

Source: SEWRPC.

Table 44

ALTERNATIVE P-2: COMPONENTS AND COSTS OF THE STORM SEWER CONVEYANCE WITH CENTRALIZED DETENTION STORMWATER DRAINAGE PLAN FOR WEST BEND HYDROLOGIC UNIT MR-P

Hydrologic Unit	Project and Component Description[a]	Estimated Cost	
		Capital[b]	Annual Operation and Maintenance[c]
P	1. Replace 55 feet of 24-inch storm sewer in Schoenhaar Drive between Hans Street and Creek Drive with 30-inch storm sewer	$ 8,000	$ 0
	2. WD5 inlet, 80 feet of 48-inch storm sewer	20,000	0
	3. WD5 outlet, 225 feet of 68-inch-wide by 43-inch-high HE storm sewer	82,000	0
	4. 2.4 acre-foot detention basin located northwest of the intersection of Schoenhaar Drive and Washington Street, T11N, R20E, southwest quarter, Section 7 (basin WD5)	45,000	600
- -	Total	$115,000	$600

NOTE: The following abbreviation has been used: HE = horizontal elliptical.

[a] *All new and replacement storm sewers are reinforced concrete pipe.*

[b] *Includes 35 percent for engineering, administration, and contingencies. Costs are for year 1991 with Engineering News-Record Construction Cost Index = 5,015.*

[c] *Costs were noted to be zero when the alternative proposed replacement of a component with a component having similar operation and maintenance costs. Negative costs were noted when the replacement component was estimated to have a lower operation and maintenance cost than that of the existing facility.*

Source: SEWRPC.

Table 45

COMPARISON OF EXISTING AND PROPOSED FLOWS AND HYDRAULIC CAPACITIES OF STORM SEWERS: ALTERNATIVE Q-1, STORM SEWER CONVEYANCE

Branch	Reach	Storm Sewer Location[a]	Existing Size[b] (inches)	Existing Capacity (cubic feet per second)	Planned Size[b] (inches)	Length (feet)	Planned Capacity (cubic feet per second)	Existing 10-Year Storm Flow (cubic feet per second)	Planned 10-Year Storm Flow (cubic feet per second)	Existing 100-Year Storm Flow (cubic feet per second)	Planned 100-Year Storm Flow (cubic feet per second)	Frequency Storm Used for Evaluation of Existing Storm Sewers and Replacement of Inadequate Storm Sewers (years)
1	0	In Redwood Street between Juniper Court and Sheridan Drive (171)	21	5	36	322	40	20	20	41[c]	41[c]	100
1	2	In Redwood Street between Sheridan Drive and Imperial Court (171)	21	5	36	325	40	20	20	41[c]	41[c]	100
1	4	In Redwood Street between Imperial Court and River Road South (171)	30	26	53 by 34 HE	348	66	28	28	55[c]	55[c]	100
1	6	In River Road South between Redwood Street and Kilbourn Street (171)	30	27	53 by 34 HE at 0.70 percent[d]	231	87	38	38	86[e]	86[e]	100
1	8	In River Road South between Redwood Street and Kilbourn Street (171)	30	29	53 by 34 HE at 0.70 percent[f]	231	87	38	38	86	86	100
1	10	Outfall in River Road South between Redwood Street and Kilbourn Street (171)	36	32	53 by 34 HE at 0.82 percent[g]	171	94	38	38	86	86	100

[a] City storm sewer system plan sheet number in parentheses.

[b] Diameter of circular reinforced concrete pipe unless noted otherwise.

[c] Includes approximately 10 cubic feet per second overflow from Decorah Road in the Quass Creek subwatershed.

[d] Downstream invert at elevation 903.2 feet National Geodetic Vertical Datum.

Source: SEWRPC.

[e] Includes approximately 24 cubic feet per second overflow from Decorah Road in the Quass Creek subwatershed.

[f] Downstream invert at elevation 901.6 feet National Geodetic Vertical Datum.

[g] Downstream invert at elevation 900.2 feet National Geodetic Vertical Datum.

Recommended Stormwater Management Plan: As requested by City staff at the interagency staff meeting on November 23, 1993, Alternative P-1, Storm Sewer Conveyance, is recommended for adoption in this hydrologic unit. The components and costs of the recommended plan are set forth in Table 9. The approximate location, alignment, and configuration of the recommended facilities are shown graphically on Map 14.

Hydrologic Unit MR-Q

Evaluation of the Stormwater Management System: Hydrologic Unit MR-Q is a 0.24-square-mile area located as shown on Map 1 in Chapter I of this volume. Under existing land use conditions, 33 percent of the hydrologic unit is developed in urban land uses. Under planned year 2010 conditions, the hydrologic unit would about 98 percent developed in urban uses, predominantly medium-density residential, but also including some two-family and high-density residential uses. The remaining 2 percent would be devoted to woodlands and wetlands. The existing stormwater management system consists of roadway curbs and gutters, storm sewer inlets, storm sewers, and an open channel drainageway. A 0.6-mile-long agricultural drainageway flows from the storm sewer outfall just east of River Road to the Milwaukee River. The drainageway is not classified as an intermittent or perennial stream on existing large-scale topographic maps prepared by the Regional Planning Commission for the City of West Bend in 1988 nor on the 7.5-minute-quadrangle map of the area prepared by the U. S. Geological Survey.

The hydraulic capacity of the major drainage system is adequate. Problems with inadequate minor system hydraulic capacities were identified in parts of this hydrologic unit. As seen in Table 45, a comparison of the existing 10-year recurrence interval storm flows with the capacities of the existing storm sewers shows that several sewers have inadequate capacities to meet the minor system requirement of passing the peak rate of runoff from a 10-year storm. There are also major system problems in Redwood Street which are in part due to overflow from the Quaas Creek subwatershed as described in Volume Four of this report.

Alternative Stormwater Drainage Plans: The following two alternative stormwater management plans were considered for Hydrologic Unit Q: 1) a storm sewer and open channel conveyance plan and 2) a storm sewer and open channel conveyance with centralized detention plan.

Alternative Plan No. Q-1, Storm Sewer and Open Channel Conveyance: The storm sewer and open channel conveyance alternative plan calls for the provision of 1,628 lineal feet of 36-inch-diameter and 53-inch-wide by 34-inch-high horizontal elliptical reinforced concrete replacement storm sewer to abate existing stormwater runoff problems. This alternative also calls for the widening and deepening of the agricultural drainageway to serve planned new urban development effectively. The channel modification would terminate about 0.1 mile upstream from the Milwaukee River, at which point the drainageway passes through a planned park site. The alignment of the proposed channel was based on a June 1992 preliminary subdivision and street layout provided by City of West Bend staff. The proposed channel is sized to convey the runoff from a 100-year recurrence interval storm. The channel would be lined with natural vegetation or turf, would have average side slopes of one vertical on four horizontal or other equivalent shape, and would have an average flood control channel bottom width of about 10 feet. A small, meandering low-flow channel would be provided. In the final design stage, the cross-section shape and alignment of the channel could be refined to provide an attractively landscaped feature within the planned residential setting. The planned 100-foot-wide greenway along the open channel would accommodate inundation in the flatter overbanks outside the main channel under 100-year flood conditions. On the basis of the preliminary street layout, two 48-inch-diameter reinforced concrete culverts were provided at the proposed Kilbourn Street crossing.

As shown on the June 1992 subdivision and street layout, the cul-de-sac which is proposed to be located southeast of the intersection of River Road and Kilbourn Street would cross the drainageway. It is recommended that the preliminary street layout be revised to modify the alignment of the cul-de-sac and to extend the proposed drainageway to the west property line of the land to be developed east of River Road. If the cul-de-sac were shortened, as shown on an earlier street layout provided by City staff, the overflow path for major drainage system runoff from the area to the west of River Road would not be blocked by the cul-de-sac or buildings constructed around the cul-de-sac.

Map 14 shows the approximate location and alignment of the stormwater drainage facilities proposed under this alternative. Table 45 presents a comparison of peak flows and existing and proposed storm sewer hydraulic capacities. Table 9 presents the salient characteristics and estimated costs of the components of this alternative plan. The total present value cost of this alternative plan is $478,000, consisting of an estimated capital cost of $456,000 and an estimated annual operation and maintenance cost increase of $1,400.

Alternative Plan No. Q-2, Storm Sewer and Open Channel Conveyance with Centralized Detention: The only available site for the provision of detention storage within this hydrologic unit is the in the area to be developed east of River Road. Because the major drainage system for that area consists of a relatively inexpensive, vegetation-lined open channel located within a 100-foot-wide greenway, there would be no need to provide detention for the purpose of reducing the cost of the downstream conveyance system. Also, because the channel is adequate to convey the anticipated 100-year flood flow under planned land use, channel, and drainage conditions; because the channel discharges directly to the Milwaukee River; and because flows from the hydrologic unit would have no significant impact on peak flows in the Milwaukee River; there is no need to provide detention storage to alleviate downstream flooding. Finally, in the downstream, unmodified reach of the channel, the estimated flow velocities and depths during floods with recurrence intervals ranging from two- through 100-years and no detention storage provided would not be significantly greater than under existing conditions and a significant increase in streambank erosion and streambed scour would not be expected. Thus, there is no need to provide detention to control channel erosion. On the basis of the above findings, an alternative incorporating detention storage for the control of flood peaks was eliminated from further consideration.

Evaluation of Alternative Stormwater Drainage Plans and Plan Recommendations: As outlined above, Alternative Q-1, Storm Sewer and Open Channel Conveyance, is the preferable alternative and it was selected for this hydrologic unit. The components and costs of the recommended plan are set forth in Table 9. The approximate location, alignment, and configuration of the recommended facilities are shown graphically on Map 14.

Hydrologic Unit MR-R

Evaluation of the Stormwater Management System: Hydrologic Unit MR-R is a 0.27-square-mile area located as shown on Map 1 in Chapter I of this volume. Under existing land use conditions, about 29 percent of the hydrologic unit is developed in urban land uses, which consist primarily of airport-related transportation uses. Under planned land use conditions, about 74 percent of the hydrologic unit would be developed in urban uses, including airport, commercial, and medium-density multi-family uses. The remaining 26 percent would be devoted primarily to woodlands and wetlands.

With the exception of a narrow band of commercial and residential land along the north side of E. Washington Street (STH 33) and a small area of residential land in the extreme northern part of the hydrologic unit, all the land in the unit north of STH 33 is presently in rural uses. Runoff from this area drains overland or through minor feeder streams to an intermittent unnamed tributary to the Milwaukee River. The existing stormwater management system for the West Bend Municipal Airport, which is located south of STH 33, consists of roadside swales and cross culverts which discharge to the intermittent unnamed tributary to the Milwaukee River.

Owing to the relatively low development density of the hydrologic unit under existing conditions and the flood-attenuating effects of the natural drainage system, there are no known existing, significant stormwater drainage problems in the unit.

Under planned land use conditions, the airport would be expanded. Expansion alternatives are set forth in the West Bend Municipal Airport Runway Feasibility Study, prepared for the Wisconsin Department of Transportation (WisDOT) and the City of West Bend in May 1993 by Rust Environment & Infrastructure, Inc. According to the City Engineer, the preferred airport expansion alternative at the time of preparation of this stormwater management plan was Alternative 3A. That alternative called for the runway to be realigned and extended to the northeast across the existing STH 33. STH 33 would be realigned to the north of its present alignment and would pass under the runway.

Alternative Stormwater Management Plans: The following two alternative stormwater management plans were considered for Hydrologic Unit R: 1) a storm sewer and open channel conveyance plan which would maintain as much as possible of the existing detention storage in the open channel system and 2) a storm sewer and open channel conveyance plan with existing detention storage and additional centralized detention storage.

Alternative Plan No. R-1, Storm Sewer and Open Channel Conveyance: Under planned land use conditions, this alternative plan would convey runoff to the existing unnamed tributary through the provision of 4,830 lineal feet of new reinforced concrete storm sewer, ranging in size from 15-inch-diameter circular reinforced concrete pipe to 45-inch-wide by 29-inch-high horizontal elliptical reinforced concrete pipe. This alternative also calls for the provision of the following culverts: 1) two parallel, 470-foot-long, 30-inch-diameter reinforced concrete pipe culverts under the realigned airport runway and taxiway, 2) one 60-foot-long, 30-inch-diameter reinforced concrete pipe culvert under a new north-south collector street which was assumed to cross the unnamed tributary under planned conditions, 3) one 110-foot-long, 30-inch-diameter reinforced concrete pipe culvert under the realigned E. Washington Street (STH 33), where the highway would cross the unnamed tributary, and 4) one 60-foot-long, 18-inch-diameter reinforced concrete pipe culvert under a new east-west collector street which was assumed to cross the unnamed tributary under planned conditions. Commission design standards call for the hydraulic structure under a collector street to convey the peak flow from a 10-year recurrence interval flood without overtopping the roadway; for the hydraulic structure under an arterial highway, such as STH 33, to convey the peak flow from a 50-year recurrence interval flood without overtopping the roadway; and for the hydraulic structure under an airport runway to convey the peak flow from a 100-year recurrence interval flood without overtopping the runway. The proposed structures all meet or exceed the

Table 46

ALTERNATIVE R-1: COMPONENTS AND COSTS OF THE STORM SEWER AND OPEN CHANNEL CONVEYANCE STORMWATER DRAINAGE PLAN FOR WEST BEND HYDROLOGIC UNIT MR-R

Hydrologic Unit	Project and Component Description[a]	Estimated Cost	
		Capital[b]	Annual Operation and Maintenance
R	1. Install 550 feet of 15-inch storm sewer	$ 29,000	$ 220
	2. Install 370 feet of 18-inch storm sewer	23,000	150
	3. Install 800 feet of 21-inch storm sewer	56,000	320
	4. Install 690 feet of 24-inch storm sewer	208,000	280
	5. Install 1,160 feet of 27-inch storm sewer	108,000	470
	6. Install 460 feet of 36-inch storm sewer	61,000	90
	7. Install 800 feet of 45-inch by 29-inch concrete HE storm sewer	119,000	150
	8. Install two 470-foot-long, 30-inch-diameter RCP culverts under the proposed realigned West Bend Airport runway and taxiway	70,000	380
	9. Install one 60-foot-long, 30-inch-diameter RCP culvert under assumed future collector street	4,000	20
	10. Install one 110-foot-long, 30-inch-diameter RCP culvert under proposed realigned STH 33	9,000	40
	11. Install one 60-foot-long, 18-inch-diameter RCP culvert under assumed future collector street	3,000	20
- -	Total	$690,000	$2,140

NOTE: The following abbreviations have been used: HE = horizontal elliptical and RCP = reinforced concrete pipe.

[a] *All new and replacement storm sewers are reinforced concrete pipe.*

[b] *Includes 35 percent for engineering, administration, and contingencies. Costs are for year 1991 with Engineering News-Record Construction Cost Index = 5,015.*

Source: SEWRPC.

Commission standards, on the basis of assumed new road grades.

The proposed runway and STH 33 crossings of the unnamed tributary and the assumed north-south collector street crossing would all pass through wetlands located along the stream. Those crossings would, thus, result in some loss of wetlands. The wetland loss is dependent on the which airport expansion alternative is ultimately selected. The locations of both the road and runway crossings are governed by transportation, rather than stormwater management, considerations. It would be necessary to obtain water quality certification from the Wisconsin Department of Natural Resources for any road or runway crossings through wetlands.

This alternative utilizes the existing floodplain storage in the wetlands and other open lands along the unnamed tributary. The proposed road and highway crossings are designed to temporarily impound runoff, enhancing the utilization of that storage.

Map 14 shows the approximate location and alignment of the stormwater management facilities proposed under this alternative and also the proposed 100-year recurrence interval floodplain to be maintained along the unnamed tributary. The floodplain area shown would have to be maintained under planned development conditions in order to provide sufficient storage and conveyance of floodwaters. The City zoning ordinance should recognize the need to preserve that floodplain storage or to compensate for any storage loss due to filling in the floodplain. Table 46 presents the salient characteristics and estimated costs of the components of this alternative plan. The total present value cost of this alternative plan is $724,000, consisting of an estimated capital cost of $690,000 and an estimated annual operation and maintenance cost increase of $2,140.

Alternative Plan No. R-2, Storm Sewer and Open Channel Conveyance with Centralized Detention Storage: This alternative plan is identical to Alternative R-1 except that it calls for the provision of a centralized detention storage basin to collect runoff from a 0.5-square-mile area in the eastern part of subbasin MR270 and north of the unnamed tributary. It was found that the provision of that additional detention storage would not appreciably reduce peak flood flows and would, therefore, not reduce costs by enabling the use of fewer or smaller culverts under the proposed downstream airport runway and taxiway. Thus, this alternative was not considered further.

Recommended Stormwater Management Plan: As outlined above in the section which describes Alternative R-1, Storm Sewer and Open Channel Conveyance, the recommended plan will serve planned development through the provision of new storm sewers and culverts and the utilization of significant open channel detention storage along the unnamed tributary to the Milwaukee River. The components and costs of the recommended plan are set forth in Table 9. The approximate location, alignment, and configuration of the recommended facilities, including the nonpoint source pollution control recommendations, are shown graphically on Map 14.

Hydrologic Unit MR-S

Evaluation of the Stormwater Management System: Hydrologic Unit MR-S is a 0.02-square-mile area located as shown on Map 1 in Chapter I of this volume. Under existing land use conditions, the entire hydrologic unit is developed in medium-density residential land uses. The existing stormwater management system consists of roadway curbs and gutters, storm sewer inlets, and storm sewers. There are no identified intermittent or perennial streams within the hydrologic unit and the storm sewers discharge directly to the Milwaukee River.

Problems with inadequate minor system hydraulic capacities were identified in parts of this hydrologic unit. As seen in Table 47, a comparison of the existing 10-year recurrence interval storm flows with the capacities of the existing storm sewers shows that several sewers have inadequate capacities to meet the minor system requirement of passing the peak rate of runoff from a 10-year storm. In addition, a major system capacity problem related to overflow from the adjacent Hydrologic Unit MR-M was identified. It was found that, during storms producing runoff at rates exceeding the capacity of the existing storm sewer in Unit MR-M in Indiana Avenue between Locust and Oak Streets, runoff would pond in Indiana Avenue, creating the potential for overflow and flooding of houses on the east side of Indiana Avenue. The shortest route available to convey the ponded runoff to the Milwaukee River is to the north along Indiana Avenue in Unit MR-S.

Alternative Stormwater Drainage Plans: Because of the lack of available open space in which to construct detention storage facilities, the only practicable solution to the stormwater drainage problems of this hydrologic unit is to upgrade the storm sewer conveyance system.

Recommended Stormwater Management Plan: The recommended storm sewer conveyance plan calls for the provision of replacement storm sewers to abate existing stormwater runoff problems. This alternative includes 1,730 lineal feet of replacement storm sewer, ranging in size from 21-inch- to 42-inch-diameter reinforced concrete pipe, and 500 lineal feet of new 36-inch-diameter reinforced concrete pipe. Table 47 presents a comparison of peak flows and existing and proposed storm sewer hydraulic capacities. The components and costs of the recommended plan are set forth in Table 9 and the approximate location, alignment, and configuration of the recommended facilities is shown graphically on Map 14. The total present value cost of this alternative plan is $356,000, consisting of an estimated capital cost of $360,000 and an estimated annual operation and maintenance cost decrease of $240.

Hydrologic Unit MR-T

Evaluation of the Stormwater Management System: Hydrologic Unit MR-T is a 0.52-square-mile area located as shown on Map 1 in Chapter I of this volume. Under existing land use conditions, about 20 percent of the hydrologic unit is developed in urban land uses, predominantly in residential uses. Under planned land use conditions, about 50 percent of the hydrologic unit would be developed in urban uses, mostly medium- and low-density residential. The remaining 50 percent would be devoted to water, woodlands, wetlands, park and recreational, agricultural, and other open space uses. The

Table 47

COMPARISON OF EXISTING AND PROPOSED FLOWS AND HYDRAULIC CAPACITIES OF STORM SEWERS: ALTERNATIVE S-1, STORM SEWER CONVEYANCE

Branch	Reach	Storm Sewer Location[a]	Existing Size[b] (inches)	Existing Capacity (cubic feet per second)	Planned Size[b] (inches)	Length (feet)	Planned Capacity (cubic feet per second)	Existing 10-Year Storm Flow (cubic feet per second)	Planned 10-Year Storm Flow (cubic feet per second)	Existing 100-Year Storm Flow (cubic feet per second)	Planned 100-Year Storm Flow (cubic feet per second)	Frequency Storm Used for Evaluation of Existing Storm Sewers and Replacement of Inadequate Storm Sewers (years)
60	0	In Indiana Avenue between Locust Street and Oak Street (178)	New storm sewer	New storm sewer	36 at 1.0 percent	500	64	33[c]	33[c]	64[c]	64[c]	100
60	2	In Indiana Avenue between Oak Street and Kilbourn Street (178)	12 clay	6	36 at 1.0 percent	364	67	33	33	64	64	100
62	0	In Pennsylvania Avenue between Oak Street and Kilbourn Street and in Kilbourn Street between Pennsylvania Avenue and Indiana Avenue (178)	12 clay	2	30 by 19 HE at 0.43 percent	591	15	3[d]	10	3[d]	15[d]	10
64	0	In Kilbourn Street between Michigan Avenue and Indiana Avenue (178)	12 clay	3	21 at 1.1 percent	273	17	11	11	20	20	10
		In Kilbourn Street between Michigan Avenue and Indiana Avenue (178)	12 clay	5	21 at 1.1 percent	139	17	11	11	20	20	10
60	4	In Indiana Avenue between Kilbourn Street and the Milwaukee River (178)	18 clay	8	42 at 1.0 percent	267	101	50	57	93	105	100
		In Indiana Avenue between Kilbourn Street and the Milwaukee River (178)	18 clay	3	42 at 1.0 percent[e]	94	101	50	57	93	105	100

NOTE: The following abbreviation has been used: HE = horizontal elliptical.

[a] *City storm sewer system plan sheet number in parentheses.*

[b] *Diameter of circular reinforced concrete pipe unless noted otherwise.*

[c] *Overflow from Hydrologic Unit MR-M, Subbasin MR206.*

[d] *An additional 89 cubic feet per second peak flow travels through the backyards of the buildings between Riverview Drive and Eastern Avenue and south of Locust Street.*

[e] *Outfall on downstream side of Indiana Avenue bridge with invert elevation 878.8 feet National Geodetic Vertical Datum.*

Source: SEWRPC.

existing stormwater management system consists of roadside swales which ultimately discharge to Lenwood and Wallace Lakes. Those lakes are hydraulically connected by a culvert/swale system.

Owing to the relatively low development density of the hydrologic unit under existing conditions and the flood-attenuating effects of the natural drainage system, there are no known existing, significant stormwater drainage problems in the unit.

Alternative Stormwater Management Plans: The following two alternative stormwater management plans were considered for Hydrologic Unit T: 1) a storm sewer and open channel conveyance plan with detention storage for water quality control and 2) a storm sewer and open channel conveyance plan with detention

Table 48

ALTERNATIVE T-1: COMPONENTS AND COSTS OF THE STORM SEWER AND OPEN CHANNEL CONVEYANCE STORMWATER DRAINAGE PLAN WITH DETENTION STORAGE FOR WATER QUALITY CONTROL FOR WEST BEND HYDROLOGIC UNIT MR-T

Hydrologic Unit	Project and Component Description[a]	Estimated Cost	
		Capital[b]	Annual Operation and Maintenance[c]
T	1. Install 520 feet of 12-inch storm sewer	$ 23,000	$ 210
	2. Install 1,395 feet of 15-inch storm sewer	231,000	560
	3. Install 785 feet of 18-inch storm sewer	48,000	150
	4. Install 405 feet of 21-inch storm sewer	29,000	160
	5. Install 1,795 feet of 24-inch storm sewer	148,000	660
	6. Install 1,295 feet of 27-inch storm sewer	120,000	520
	7. Install 590 feet of 30-inch storm sewer	62,000	230
	8. Install 80 feet of 36-inch storm sewer	11,000	20
	9. Install 360 feet of 38-inch by 24-inch concrete HE storm sewer	45,000	70
	10. 1,070-foot-long, trapezoidal, turf-lined channel with one vertical on four horizontal side slopes and a 5-foot bottom width	32,000	430
	11. Four 34-foot-long, 24-inch-diameter RCP culverts under North River Road	8,000	0
- -	Total	$757,000	$3,010

NOTE: The following abbreviations have been used: HE = horizontal elliptical and RCP = reinforced concrete pipe.

[a] *All new and replacement storm sewers are reinforced concrete pipe.*

[b] *Includes 35 percent for engineering, administration, and contingencies. Costs are for year 1991 with Engineering News-Record Construction Cost Index = 5,015.*

[c] *Costs were noted to be zero when the alternative proposed replacement of a component with a component having similar operation and maintenance cost. Negative costs were noted when the replacement component was estimated to have a lower operation and maintenance cost than that of the existing facility.*

Source: SEWRPC.

storage for both water quality and quantity control. Both alternative plans fully utilize existing lake and wetland storage.

Alternative Plan No. T-1, Storm Sewer and Open Channel Conveyance with Detention Storage for Water Quality Control: Under planned land use conditions, this alternative plan would convey runoff through the provision of 7,220 lineal feet of new reinforced concrete storm sewer, ranging in diameter from 18 inches to 36 inches. This alternative also calls for the modification of the drainageway between Wallace Lake Road and North River Road to protect existing houses from flooding due to the runoff from a 100-year recurrence interval storm occurring under planned conditions when the upstream area is anticipated to be developed in medium-density residential uses. The proposed 1,070-foot-long, turf-lined, modified channel would have average side slopes of one vertical on four horizontal, or other equivalent shape, and would have an average flood control channel bottom width of about five feet. A small, meandering low-flow channel could be provided to improve the aesthetic character of the channel. The existing 18-inch-diameter corrugated metal pipe culvert under North River Road would be replaced with four 24-inch-diameter reinforced concrete culverts which would convey the 100-year flood flow without overtopping the roadway. Commission design standards call for the hydraulic structure under a collector street such as North River Road to convey the peak flow from a 10-year recurrence interval flood without overtopping the roadway. However, in order to prevent flooding of upstream houses this alternative plan calls for the provision of culvert capacity to convey the peak 100-year flood flow.

The existing outlet structures for Wallace and Lenwood Lakes and for the small wetland south of Wallace Lake Road and west of North River Road in subbasin MR260 would remain the same. As set forth in Chapter IV of this volume, wet detention basin WD22 is recommended to be constructed in subbasin MR288 to provide control of nonpoint source pollution.

The stormwater management measures which discharge to Hydrologic Unit MR-T and which are recommended to be located in that portion of subbasin MR260 which receives runoff from the area west of STH 144 are set forth in the section of this chapter which describes the recommended plan for Hydrologic Unit MR-H.

Map 7 shows the approximate location and alignment of the stormwater management facilities proposed under this alternative. Table 48 presents the salient characteristics and estimated costs of the components of this alternative plan. The total present value cost of this alternative plan is $804,000, consisting of an estimated capital cost of $757,000 and an estimated annual operation and maintenance cost increase of $3,010.

Alternative Plan No. T-2, Storm Sewer and Open Channel Conveyance with Detention for Water Quality and Quantity Control: This alternative plan is identical to Alternative T-1 except that detention basin WD27 is called for to provide control of both water quantity and quality, enabling the bottom width of the modified downstream channel to be reduced to four feet and the number of 24-inch-diameter reinforced concrete culverts under North River Road to be reduced to two. As described in Chapter IV of this volume, basin WD27 would have a permanent pond area of approximately 0.25 acre. In addition to the permanent pond, this alternative calls for 0.83 acre-feet of surcharge storage to control runoff from storms with recurrence intervals up to, and including, 100 years. Map 8 shows the approximate location and alignment of the stormwater drainage facilities proposed under this alternative. Table 49 presents the salient characteristics and estimated costs of the components of this alternative plan. The total present value cost of this alternative plan is $822,000, consisting of an estimated capital cost of $771,000 and an estimated annual operation and maintenance cost increase of $3,260.

Evaluation of Alternative Stormwater Drainage Plans: The foregoing information provides a basis for a comparative evaluation of the two alternative stormwater drainage plans. Each alternative was designed to serve anticipated future development within the hydrologic unit. Thus, the principal criteria for the comparative evaluation are cost, implementability, and control of nonpoint source pollution.

Alternative T-1 has marginally lower capital and present value costs than Alternative T-2. Although annual operation and maintenance costs of the two alternatives are similar, the additional detention basin called for under Alternative T-2 results in a somewhat higher annual operation and maintenance cost. Alternative T-2 may be somewhat more difficult to implement since it would involve acquiring potentially developable land for construction of detention basin WD27. Both alternative plans provide the same degree of nonpoint source pollution reduction for areas directly tributary to Lenwood Lake. Alternative T-2 affords a greater level of control of loadings to Wallace Lake through the provision of basin WD27.

Recommended Stormwater Management Plan: On the basis of a comparative evaluation of the two alternative plans, Alternative T-2, Storm Sewer and Open Channel Conveyance with Detention for Water Quality and Quantity Control, is recommended for adoption in this hydrologic unit. That plan provides the same level of water quantity control as does Alternative T-1, is similar in cost to Alternative T-1, and provides a greater degree of nonpoint source pollution control for Wallace Lake than does Alternative T-1. The recommended stormwater management plan, including nonpoint source pollution control measures, is summarized in graphic form on Map 14. The components and costs of this recommended plan are set forth in Table 9.

Table 49

ALTERNATIVE T-2: COMPONENTS AND COSTS OF THE STORM SEWER AND OPEN CHANNEL CONVEYANCE STORMWATER DRAINAGE PLAN WITH DETENTION FOR WATER QUALITY AND QUANTITY CONTROL FOR WEST BEND HYDROLOGIC UNIT MR-T

Hydrologic Unit	Project and Component Description[a]	Estimated Cost	
		Capital[b]	Annual Operation and Maintenance[c]
T	1. Install 520 feet of 12-inch storm sewer	$ 23,000	$ 210
	2. Install 1,395 feet of 15-inch storm sewer	231,000	560
	3. Install 785 feet of 18-inch storm sewer	48,000	150
	4. Install 405 feet of 21-inch storm sewer	29,000	160
	5. Install 1,795 feet of 24-inch storm sewer	148,000	660
	6. Install 1,295 feet of 27-inch storm sewer	120,000	520
	7. Install 590 feet of 30-inch storm sewer	62,000	230
	8. Install 80 feet of 36-inch storm sewer	11,000	20
	9. 360 feet of 38-inch by 24-inch concrete HE storm sewer	45,000	70
	10. 1,070-foot-long, trapezoidal, turf-lined channel with one vertical on four horizontal side slopes and a 4-foot bottom width	31,000	430
	11. Two 34-foot-long, 24-inch-diameter culverts under North River Road	4,000	0
	12. Incremental quantity control portion of basin WD27, 0.83-acre-foot detention basin to serve planned development	19,000	250
- -	Total	$771,000	$3,260

NOTE: The following abbreviation has been used: HE = horizontal elliptical.

[a] *All new and replacement storm sewers are reinforced concrete pipe.*

[b] *Includes 35 percent for engineering, administration, and contingencies. Costs are for year 1991 with Engineering News-Record Construction Cost Index = 5,015.*

[c] *Costs were noted to be zero when the alternative proposed replacement of a component with a component having similar operation and maintenance cost. Negative costs were noted when the replacement component was estimated to have a lower operation and maintenance cost than that of the existing facility.*

Source: SEWRPC.

Hydrologic Unit MR-U

Evaluation of the Stormwater Management System: Hydrologic Unit MR-U is a 0.01-square-mile area located along the Milwaukee River, as shown on Map 1 in Chapter I of this volume. Under existing land use conditions, about 47 percent of the hydrologic unit is developed in urban land uses. Under planned year 2010 land use conditions, the hydrologic unit would be about 74 percent developed for urban use, predominantly low-density residential. The remaining 26 percent would be devoted to open lands. The existing drainage patterns consist of overland flow directly to the Milwaukee River. There are no identified intermittent or perennial streams within the hydrologic unit.

Owing to the relatively low development density of the hydrologic unit under existing conditions and the fairly steep topography of the residential area, there are no known existing, significant stormwater drainage problems in the unit.

Plan Recommendations: Because most of the hydrologic unit would be developed in low-density residential land uses under planned conditions, because the increase in runoff due to additional urban development could be adequately conveyed in the existing overland drainageways, and because runoff from the hydrologic unit would have no significant impact on peak flows in the Milwaukee River, no new stormwater management measures are considered to be needed.

Hydrologic Unit MR-V

Evaluation of the Stormwater Management System: Hydrologic Unit MR-V is a 0.02-square-mile area located along the Milwaukee River, as shown on Map 1 in Chapter I of this volume. Under existing land use conditions, 22 percent of the hydrologic unit is in low-density residential use. The remaining 78 percent is in primarily agricultural uses. The hydrologic unit is located almost completely within the 100-year recurrence interval floodplain of the Milwaukee River and within a primary environmental corridor. Planned year 2010 land use conditions would be similar to existing conditions.

The existing drainage patterns in the hydrologic unit consist of overland flow directly to the Milwaukee River and there are no known existing, significant stormwater drainage problems in the unit.

Plan Recommendations: Because no new urban development is planned for the hydrologic unit and no increase in stormwater runoff is expected, no new stormwater management measures are recommended for this hydrologic unit.

Hydrologic Unit MR-W

Evaluation of the Stormwater Management System: Hydrologic Unit MR-W is a 0.02-square-mile area located along the Milwaukee River, as shown on Map 1 in Chapter I of this volume. Under existing land use conditions, 52 percent of the hydrologic unit is developed in low-density residential uses, with the remaining land in primarily agricultural uses. Under planned year 2010 conditions, about 92 percent of the hydrologic unit would be developed in urban uses, which would be predominantly medium-density residential. The remaining rural areas would be open lands. The existing drainage patterns in the hydrologic unit consist mostly of overland flow directly to the Milwaukee River and of roadside swales along Woodford Drive also discharging directly to the Milwaukee River. There are no identified intermittent or perennial streams within the hydrologic unit.

Owing to the relatively low development density of the hydrologic unit under existing conditions and to the existence of a drainage system adequate for such development, there are no known existing, significant stormwater drainage problems in the unit.

Recommended Stormwater Management Plan: The hydrologic unit concerned is predominantly undeveloped and has drainage patterns consisting primarily of overland flow directly to the Milwaukee River. The configuration of the stormwater management system for such an area would, to a large extent, be dictated by a future street layout. Because of the density of the planned land uses in this hydrologic unit and because runoff from the unit drains directly to the Milwaukee River, the stormwater drainage system would consist of a combination of storm sewers and overland flow. Specific stormwater drainage facilities would be established by developers and City staff during the design and review processes for proposed development. Detention storage would not be required in this hydrologic unit because such facilities could not be practically implemented to reduce overall costs through provision of smaller conveyance facilities and because increases in rates of runoff would have no significant impact on peak flows in the Milwaukee River. Drainage improvements in this unit would have only a small impact on the City capital improvements budget since most facilities would be paid for by private developers.

Hydrologic Unit MR-X

Evaluation of the Stormwater Management System: Hydrologic Unit MR-X is a 0.04-square-mile area located along the Milwaukee River, as shown on Map 1 in Chapter I of this volume. Under existing land use conditions, about 48 percent of the hydrologic unit is developed in urban land uses. Under planned year 2010 land use conditions, about 80 percent of the hydrologic unit would be developed for urban uses, predominantly medium-density residential, government, and institutional. The remaining 20 percent would be devoted to wetlands and open lands. The existing drainage patterns consist of overland flow directly to the Milwaukee River. There are no identified intermittent or perennial streams within the hydrologic unit.

Much of the northeastern portion of the hydrologic unit, including several houses, is located within the 100-year recurrence interval floodplain of the Milwaukee River. Although the provision of some form of flood protection may be desirable for the houses in the floodplain, the recommendation of specific flood control measures for buildings in the Milwaukee River floodplain is beyond the scope of this report.

The southern portion of the hydrologic unit, located south of the Wisconsin Central Transportation Corporation and consisting of subbasin MR312, is in agricultural uses under existing conditions. There are no known existing, significant stormwater drainage problems in subbasin MR312.

Recommended Stormwater Management Plan: The additional urban development which is expected in this hydrologic unit under planned land use conditions would most likely occur in the northwestern corner of subbasin MR308, and would be located outside the 100-year recurrence interval floodplain of the Milwaukee River. This portion of the hydrologic unit is predominantly undeveloped and has drainage patterns consisting primarily of overland flow directly to the Milwaukee River. Under planned conditions, the southern portion of the hydrologic unit would be part of the Moraine Park Technical Institute. The configuration of the stormwater management system for both of these areas would, to a large extent, be dictated by future street layouts and site grading considerations. Because of the density of the planned land uses and because runoff from these areas drains directly to the Milwaukee River, the stormwater drainage system would consist of a combination of storm sewers and overland flow.

Specific stormwater drainage facilities, in both the northern and southern portions of this hydrologic unit, would be established by developers and City staff during the design and review processes for proposed development. Detention storage would not be required in this hydrologic unit because such facilities could not be practically implemented to reduce overall costs through provision of smaller conveyance facilities and because increases in rates of runoff would have no significant impact on peak flows in the Milwaukee River. Drainage improvements in this unit would have only a small impact on the City capital improvements budget since most facilities would be paid for by private developers.

Hydrologic Unit MR-Y

Evaluation of the Stormwater Management System: Hydrologic Unit MR-Y is a 0.01-square-mile area located along the Milwaukee River, as shown on Map 1 in Chapter I of this volume. Under existing land use conditions, about 23 percent of the hydrologic unit is developed in urban land uses. Under planned year 2010 land use conditions, about 63 percent of the hydrologic unit would be developed in urban use, predominantly medium-density residential. The remaining 37 percent would be devoted to wetlands and open lands. The existing drainage patterns consist of overland flow directly to the Milwaukee River. There are no identified intermittent or perennial streams within the hydrologic unit.

About 20 percent of the hydrologic unit area is located within the 100-year recurrence interval floodplain of the Milwaukee River. There is no existing urban development in this portion of the hydrologic unit. Because of the relatively low development density of the hydrologic unit under existing conditions and to the existence of a drainage system adequate for such development, there are no known existing, significant stormwater drainage problems in the unit.

Recommended Stormwater Management Plan: The portion of the hydrologic unit where urban development is expected under planned land use conditions is predominantly undeveloped under existing conditions and it has drainage patterns consisting primarily of overland flow directly to the Milwaukee River. The configuration of the stormwater management system for such an area would, to a large extent, be dictated by a future street layout. Because of the density of the planned land uses in this hydrologic unit and because runoff from the unit drains directly to the Milwaukee River, the stormwater drainage system would consist of a combination of storm sewers and overland flow. Specific stormwater drainage facilities would be established by developers and City staff during the design and review processes for proposed development. Detention storage would not be required because increases in rates of runoff would have no significant impact on peak flows in the Milwaukee River; however, the provision of such storage could be considered at the time of development if it were possible to achieve a cost savings in the conveyance system through the reduction of peak flows within the hydrologic unit. Drainage

Table 50

COMPARISON OF EXISTING AND PROPOSED FLOWS AND HYDRAULIC CAPACITIES OF STORM SEWERS: ALTERNATIVE Z-1, STORM SEWER CONVEYANCE WITH DECENTRALIZED DETENTION

Branch	Reach	Storm Sewer Location[a]	Existing Size[b] (inches)	Existing Capacity (cubic feet per second)	Planned Size[b] (inches)	Length (feet)	Planned Capacity (cubic feet per second)	Existing 10-Year Storm Flow (cubic feet per second)	Planned 10-Year Storm Flow (cubic feet per second)	Existing 100-Year Storm Flow (cubic feet per second)	Planned 100-Year Storm Flow (cubic feet per second)	Frequency Storm Used for Evaluation of Existing Storm Sewers and Replacement of Inadequate Storm Sewers (years)
4	0	Private drive east of Camden Lane (102)	12 PVC	3	15	85	6	4	4	7	7	10
		Private drive east of Camden Lane (102)	12 PVC	3	15	179	5	4	4	7	7	10
5	0	Woodlawn Avenue south of Greentree Road (101)	12	3	15	143	6	4	4	7	7	10
1	10	Outfall from intersection of Greentree Road and River Road to Milwaukee River (101)	24 CMP	26	27	43	69	60	60	95	95	10

NOTE: The following abbreviations have been used: CMP = corrugated metal pipe and PVC = polyvinyl chloride [pipe].

[a] *City storm sewer system plan sheet number in parentheses.*

[b] *Diameter of circular reinforced concrete pipe unless noted otherwise.*

Source: SEWRPC.

improvements in this unit would have only a small impact on the City capital improvements budget since most facilities would be paid for by private developers.

Hydrologic Unit MR-Z

Evaluation of the Stormwater Management System: Hydrologic Unit MR-Z is a 0.05-square-mile area located along the Milwaukee River, as shown on Map 1 in Chapter I of this volume. As of 1985, about 81 percent of the hydrologic unit was developed in urban land uses, predominantly medium-density residential, commercial, government and institutional. Since 1985, the hydrologic unit has been further developed for multi-family residential use. Its current state of development, with about 97 percent of the hydrologic unit in urban uses, is essentially that of plan year 2010 conditions. The remaining 3 percent is devoted to open lands. The existing stormwater management system consists of roadway curbs and gutters, storm sewer inlets, storm sewers, roadside swales, and two decentralized detention basins. There are no identified intermittent or perennial streams within the hydrologic unit and the storm sewers discharge directly to the Milwaukee River.

Problems with inadequate minor system hydraulic capacities were identified in this hydrologic unit. As seen in Table 50, a comparison of the existing 10-year recurrence interval storm flows with the capacities of the existing storm sewers shows that four segments of storm sewer have inadequate capacities to meet the minor system requirement of passing the peak rate of runoff from a 10-year storm. No major system capacity problems were identified.

Alternative Stormwater Drainage Plans: Because of the lack of available open space in which to construct additional detention storage facilities, the only practicable solution to the stormwater drainage problems of this hydrologic unit is to upgrade the storm sewer conveyance system.

Plan Recommendations: The recommended storm sewer conveyance with decentralized detention plan calls for maintaining the existing decentralized detention facilities and for providing replacement storm sewers to abate existing stormwater runoff problems. This recommended plan includes 450 lineal feet of replacement storm sewer, ranging in size from 15-inch- to 27-inch-diameter reinforced concrete pipe.

Because of a mid-block sag in Woodlawn Avenue between Fairview Drive and Greentree Road, the recommended plan calls for preserving the existing overland flow drainageway from Woodlawn Avenue eastward to the subbasin outlet to enable runoff in excess of the proposed storm sewer capacity to be conveyed to the subbasin outlet without flooding any buildings.

Table 50 presents a comparison of peak flows and existing and proposed storm sewer hydraulic capacities. The components and costs of the recommended plan are set forth in Table 9. The approximate location, alignment, and configuration of the recommended facilities, including measures for the control of nonpoint source pollution, are shown graphically on Map 14. The total capital cost of this plan is about $33,000 and there would be no increase in the annual operation and maintenance cost over existing conditions.

Hydrologic Unit MR-AA

Evaluation of the Stormwater Management System: Hydrologic Unit MR-AA is a 0.05-square-mile area located along the Milwaukee River, as shown on Map 1 in Chapter I of this volume. Under existing land use conditions, the hydrologic unit is essentially completely developed for urban uses, predominantly medium-density residential, high-density residential, commercial, and government and institutional. The existing stormwater management system in the western portion of the hydrologic unit to the south and west of Fairview Drive, consists of roadway curbs and gutters, storm sewer inlets and storm sewers. The remaining area of the hydrologic unit, to the east of Fairview Drive, is drained through a combination of overland flow directly to the Milwaukee River and storm sewers which discharge directly to the River. There are no identified intermittent or perennial streams within the hydrologic unit. There are no known existing, significant stormwater drainage problems in the unit.

Plan Recommendations: Under planned year 2010 conditions, the existing storm sewers in the western portion of the hydrologic unit were found to have adequate capacities to meet the minor system requirement of passing the peak rate of runoff from a 10-year storm. The eastern portion of the hydrologic unit has adequate drainage through overland flow directly to the Milwaukee River. Maintenance of the existing overland flow paths which function to convey runoff when the storm sewer capacities are exceeded will insure adequate functioning of the major drainage system. Therefore, no new stormwater management measures are recommended for this hydrologic unit.

Hydrologic Unit MR-AB

Evaluation of the Stormwater Management System: Hydrologic Unit MR-AB is a 0.04-square-mile area located along the Milwaukee River, as shown on Map 1 in Chapter I of this volume. Under existing land use conditions, the entire hydrologic unit is developed in urban land uses, which consist primarily of medium-density residential and two-family residential uses. Under planned year 2010 land use conditions it is anticipated that some residential land will be redeveloped as commercial, potentially increasing the impervious area in the unit. The existing stormwater management system consists of roadway curbs and gutters, storm sewer inlets, and storm sewers. There are no identified intermittent or perennial streams within the hydrologic unit and the storm sewers discharge directly to the Milwaukee River.

The major drainage system has adequate capacity. Problems with inadequate minor system hydraulic capacities were identified in parts of this hydrologic unit. As seen in Table 51, a comparison of the existing and planned 10-year recurrence interval storm flows with the capacities of the existing storm sewers shows that several sewers have inadequate capacities to meet the minor system requirement of passing the peak rate of runoff from a 10-year storm. Also, several existing storm sewers have inadequate capacity to convey the peak runoff from a 10-year recurrence interval storm; however, the overall minor system capacity of the sewers and a portion of the street is adequate because that capacity meets the requirements of Standard No. 3 of Objective No. 1, as set forth in Chapter IV of Volume One of this report. That standard calls for the provision of two clear 10-foot-wide lanes for moving traffic on existing arterial streets and one clear 10-foot-wide lane for moving traffic on existing collector and land access streets during storm events up to and including the 10-year recurrence interval event. The application of the standard for arterial streets to this hydrologic unit avoids the replacement of the following pipes in Barton Avenue (STH 144): 1) 401 feet of 12-inch-diameter storm

Table 51

COMPARISON OF PROPOSED FLOWS AND HYDRAULIC CAPACITIES OF STORM SEWERS: ALTERNATIVE AB-1, STORM SEWER CONVEYANCE

Branch	Reach	Storm Sewer Location[a]	Existing Size[b] (inches)	Existing Capacity (cubic feet per second)	Planned Size[b] (inches)	Length (feet)	Planned Capacity (cubic feet per second)	Planned 10-Year Storm Flow (cubic feet per second)	Frequency Storm Used for Evaluation of Existing Storm Sewers and Replacement of Inadequate Storm Sewers (years)
1	0	Barton Avenue (STH 144) between Jefferson Street and Roosevelt Drive (116)	12	5[c]	Retain existing pipe[d]	35	- -	11	10
1	2	Intersection of Barton Avenue (STH 144) and Roosevelt Drive (116)	12	5[c]	Retain existing pipe[d]	48	- -	17	10
1	2	Barton Avenue (STH 144) northeast of Roosevelt Drive (116)	15	10[c]	Retain existing pipe[d]	312	- -	17	10
1	4	Barton Avenue (STH 144) between River Drive and the Milwaukee River (100)	18	25	Retain existing pipe[d]	217	- -	28	10
- -	- -	Monroe Street southwest of Roosevelt Drive (116)	10 cast iron	5	Retain existing pipe[e]	133	- -	10	10
- -	- -	Monroe Street southwest of Roosevelt Drive (116)	12	6	18 at 2.8 percent	159	18	17	10
- -	- -	Intersection of Roosevelt Drive and Monroe Street (116)	15	4	21 at 2.5 percent	32	25	18	10
- -	- -	Intersection of Roosevelt Drive and Monroe Street (116)	15	13	21 at 2.5 percent	45	25	18	10
- -	- -	Monroe Street between Roosevelt and River Drives (101)	15	14	24 at 3.9 percent	348	45	33	10
- -	- -	Intersection of River Drive and Monroe Street (101)	24 by 24 concrete box	24[c]	24 at 3.9 percent	30[c]	45	37	10
- -	- -	Easement northeast of River Drive (101)	24 CMP	44	Retain existing pipe	37	- -	37	10
- -	- -	MR363 outfall to Milwaukee River (101)	24 CMP	39	Retain existing pipe	70	- -	37	10

NOTE: The following abbreviation has been used: CMP = corrugated metal pipe.

[a] *City storm sewer system plan sheet number in parentheses.*

[b] *Diameter of circular reinforced concrete pipe unless noted otherwise.*

[c] *Estimated using street slope. Field surveyed slope is not available.*

[d] *Allowable street capacity is 13 cubic feet per second per Objective No. 1, Standard 3, of Volume One of this report. Twenty-foot-wide northbound lanes would remain open. All or part of southbound lanes would be flooded.*

[e] *Allowable street capacity is seven cubic feet per second per Objective No. 1, Standard 3, of Volume One of this report.*

Source: SEWRPC.

sewer, 2) 312 feet of 15-inch-diameter storm sewer, and 3) 217 feet of 18-inch-diameter storm sewer, as well as 133 feet of 10-inch-diameter cast iron storm sewer in Monroe Street southwest of Roosevelt Drive.

Alternative Stormwater Drainage Plans: Because of the lack of acceptable, cost-effective open space sites for detention storage facilities, the only practicable solution to the stormwater drainage problems of this hydrologic unit is to upgrade the storm sewer conveyance system.

Recommended Stormwater Management Plan: The recommended storm sewer conveyance plan calls for the provision of replacement storm sewers to abate existing stormwater runoff problems. This plan includes 610 lineal feet of replacement storm sewers, ranging in size from 18-inch- to 24-inch-diameter reinforced concrete pipe. Table 51 presents a comparison of peak flows and existing and proposed storm sewer hydraulic capacities. The components and costs of the recommended plan are set forth in Table 9. The approximate location, alignment, and configuration of the recommended facilities, including measures for the control of nonpoint source pollution, are shown graphically on Map 14. The total present value cost of this plan is $62,000, on the basis of an estimated capital cost of $62,000 and no increase in annual operation and maintenance costs.

Hydrologic Unit MR-AC

Evaluation of the Stormwater Management System: Hydrologic Unit MR-AC is a 0.02-square-mile area located along the Milwaukee River, as shown on Map 1 in Chapter I of this volume. Under existing land use conditions, 75 percent of the hydrologic unit is developed in urban land uses. Under planned year 2010 land use conditions, about 92 percent of the hydrologic unit would be developed in urban uses, predominantly medium-density residential, high-density residential, and commercial. The remaining 8 percent would be devoted to wetlands and open lands located in the primary environmental corridor and floodplain along the Milwaukee River. The existing drainage patterns in the hydrologic unit consist of flow in short lengths of street gutter and overland flow directly to the Milwaukee River. There are no identified intermittent or perennial streams within the hydrologic unit. There are no known existing, significant stormwater drainage problems in the unit.

Plan Recommendations: Because the increase in runoff due to additional urban development in the hydrologic unit could be adequately conveyed in the existing gutters, streets, and overland drainageways and because increases in rates of runoff from the hydrologic unit would have no significant impact on peak flows in the Milwaukee River, no new stormwater management measures are considered to be needed.

Hydrologic Unit MR-AD

Evaluation of the Stormwater Management System: Hydrologic Unit MR-AD is a 0.01-square-mile area located along the Milwaukee River, as shown on Map 1 in Chapter I of this volume. Under existing land use conditions, 44 percent of the hydrologic unit is developed in urban land uses. Under planned year 2010 land use conditions, about 68 percent of the hydrologic unit would be developed for urban uses, predominantly multi-family residential and commercial. The remaining 32 percent would be devoted to wetlands and woodlands located in the primary environmental corridor and floodplain along the Milwaukee River. The existing drainage patterns in the hydrologic unit consist of overland flow directly to the Milwaukee River. There are no identified intermittent or perennial streams within the hydrologic unit.

The existing drainage system is adequate for the existing level of development in the hydrologic unit and there are no known existing, significant stormwater drainage problems in the unit.

Plan Recommendations: Because the increase in runoff due to additional urban development in the hydrologic unit could be adequately conveyed in the existing overland drainageways; and because increases in rates of runoff would have no significant impact on peak flows in the Milwaukee River, no new stormwater management measures are recommended.

Hydrologic Unit MR-AE

Evaluation of the Stormwater Management System: Hydrologic Unit MR-AE is a 0.07-square-mile area located along the Milwaukee River, as shown on Map 1 in Chapter I of this volume. Under existing land use conditions, about 76 percent of the hydrologic unit is developed in urban land uses. Under planned year 2010 conditions, approximately 82 percent of the unit would be developed in urban uses, including residential, commercial, and industrial uses. The remaining 18 percent would be devoted to wetlands, woodlands, and open lands in the primary environmental corridor and floodplain along the Milwaukee River. The existing stormwater management system consists of roadway curbs and gutters, storm sewer inlets, storm sewers, and direct overland flow to the Milwaukee River. There are no identified intermittent or perennial streams within the hydrologic unit and the storm sewers discharge directly to the Milwaukee River.

Problems with inadequate minor system hydraulic capacities were identified in parts of this hydrologic unit. As seen in Table 52, a comparison of the existing and planned 10-year recurrence interval storm flows with the capacities of the existing storm sewers shows that several sewers have inadequate capacities to meet the minor system requirement of passing the peak rate of runoff from a 10-year storm. Several additional existing storm sewers have inadequate capacity to convey the peak runoff from a 10-year recurrence interval storm, however, the overall minor system capacity of the sewers and

Table 52

COMPARISON OF EXISTING AND PROPOSED FLOWS AND HYDRAULIC CAPACITIES OF STORM SEWERS: ALTERNATIVE AE-1, STORM SEWER CONVEYANCE

Branch	Reach	Storm Sewer Location[a]	Existing Size[b] (inches)	Existing Capacity (cubic feet per second)	Planned Size[b] (inches)	Length (feet)	Planned Capacity (cubic feet per second)	Existing and Planned 10-Year Storm Flow (cubic feet per second)	Existing and Planned 100-Year Storm Flow (cubic feet per second)	Frequency Storm Used for Evaluation of Existing Storm Sewers and Replacement of Inadequate Storm Sewers (years)
1	0	Main Street between Harrison and Monroe Streets (116)	12	6	Retain existing pipe[c]	328	- -	7	12	10
1	0	Main Street between Harrison and Monroe Streets (116)	12	6	Retain existing pipe[c]	22	- -	7	12	10
1	2	Main Street between Monroe Street and Barton Avenue (116)	15	10	Retain existing pipe[d]	347	- -	16	24	10
1	2	Main Street between Monroe Street and Barton Avenue (116)	15	6	Retain existing pipe[d]	25	- -	16	24	10
1	4	Main Street southeast of Barton Avenue (116)	15	10	21 at 2.9 percent	162	27	25	38	10
1	4	Main Street southeast of Barton Avenue (116)	15	12	21 at 2.9 percent	257	27	25	38	10
1	6	Main Street between Spring Street and Fond du Lac Street (116)	18	9	24 at 1.85 percent	384	31	30	45	10
1	6	Main Street between Spring Street and Fond du Lac Street (116)	18	12	24 at 1.85 percent	55	31	30	45	10
1	8	Main Street south of Fond du Lac Street (116)	18	22	24 at 2.9 percent	310	39	39	60	10
1	10	Main Street between High Street and Park Avenue (116)	24	51	Retain existing pipe	311	- -	49	75	10
1	10	Main Street between High Street and Park Avenue (116)	24	51	Retain existing pipe	306	- -	49	75	10
1	12	Easement between Main Street and the Milwaukee River	24	6	53 by 34 HE at 0.34 percent	339	60	64	98	10

NOTE: The following abbreviation has been used: HE = horizontal elliptical.

[a] *City storm sewer system plan sheet number in parentheses.*

[b] *Diameter of circular reinforced concrete pipe unless noted otherwise.*

[c] *Allowable street capacity is 12 cubic feet per second per Objective No. 1, Standard 3, of Volume One of this report.*

[d] *Allowable street capacity is 11 cubic feet per second per Objective No. 1, Standard 3, of Volume One of this report.*

Source: SEWRPC.

a portion of the street is adequate because that capacity meets the requirements of Standard No. 3 of Objective No. 1 as set forth in Chapter IV of Volume One of this report. That standard calls for the provision of two clear 10-foot-wide lanes for moving traffic on existing arterial streets, such as Main Street, during storm events up to and including the 10-year recurrence interval event. The application of that standard to this hydrologic unit avoids the replacement of 350 feet of 12-inch-diameter storm sewer in Main Street between Harrison and Monroe Streets and 372 feet of 15-inch-diameter storm sewer in Main Street between Monroe Street and Barton Avenue. Replacement storm sewers located downstream from the storm sewer reaches listed above must be designed to provide adequate inlet capacity to handle local inflow plus the flow in the street from the upstream reaches where street flow is allowed.

There is a mid-block sag in Fond du Lac Street between Harrison Street and Barton Avenue. Runoff at rates in excess of the hydraulic capacity of the storm sewers could pond in this sag. The outlet for runoff ponded in the sag is overland flow to the west into a depression storage area in internally drained subbasin MR366I. The volume of overflow is small enough that it can be adequately accommodated in the depression.

Runoff from subbasin MR365 at rates in excess of the hydraulic capacity of the storm sewers would pond at the intersection of Park Avenue and Main Street and then overflow to the east through open lands along the Milwaukee River. It is essential to the adequate functioning of the major stormwater drainage system that the overland flow path to the Milwaukee River be maintained.

Alternative Stormwater Drainage Plans: The following two alternative stormwater management plans were developed for Hydrologic Unit AE: 1) a storm sewer conveyance plan and 2) a storm sewer conveyance with centralized detention plan.

Alternative Plan No. AE-1, Storm Sewer Conveyance: The storm sewer conveyance alternative plan calls for the provision of replacement storm sewers to abate existing stormwater runoff problems. This alternative includes 1,510 lineal feet of replacement storm sewer, ranging in size from 15-inch-diameter circular to 53-inch-wide by 34-inch-high horizontal elliptical reinforced concrete pipe. Under this alternative, the overland flow path to the Milwaukee River located east of the intersection of Main Street and Park Avenue would be maintained. Map 9 shows the approximate location and alignment of the replacement storm sewers proposed under this alternative. Table 52 presents a comparison of peak flows and existing and proposed storm sewer hydraulic capacities. Table 53 presents the salient characteristics and estimated costs of the replacement storm sewers comprising this alternative plan. The total present value cost of this alternative plan is $216,000, consisting of an estimated capital cost of $214,000 and an estimated annual operation and maintenance cost increase of $100.

Alternative Plan No. AE-2, Storm Sewer Conveyance with Centralized Detention: Map 10 shows the approximate location, alignment, and configuration of the facilities called for under this alternative. Because of the reduction in peak 10-year recurrence interval flood flows achieved through the provision of detention storage, this alternative enables the retention of 760 lineal feet of existing storm sewer which would be replaced under Alternative AE-1. This alternative calls for 1,090 lineal feet of 24- and 36-inch-diameter reinforced concrete pipe replacement storm sewers. The overland flow path to the Milwaukee River located east of the intersection of Main Street and Park Avenue would be maintained.

Proposed retention basin AE-1 would be located in the depression area west of Fond du Lac Street in subbasin MR366I. That retention basin would have no outlet other than through infiltration and evaporation. The existing depression storage is adequate to accommodate the anticipated runoff volumes; therefore, the only constructed feature associated with the basin is a 320-foot-long, 15-inch-diameter inlet pipe to convey flow from the existing storm sewer in Fond du Lac Street to the basin.

Proposed detention basin AE-2 would be located in the existing open area southeast of Vern Street and west of Main Street. That basin would have a 24-inch-diameter, 90-foot-long inlet pipe to convey runoff from the existing storm sewer in Main Street and a 21-inch-diameter, 90-foot-long outlet to convey runoff back to that existing storm sewer. A bulkhead would be provided to seal the existing storm sewer just downstream of its junction with the proposed inlet pipe. Both retention basin AE-1 and detention basin AE-2 would be designed to accommodate the peak rate and volume of runoff from a 10-year recurrence interval storm. Table 54 presents a comparison of peak flows and existing and proposed storm sewer hydraulic capacities. Table 55 presents the salient characteristics and estimated costs of the components of this alternative. The total present value cost of this alternative plan is $282,000, consisting of an estimated capital cost of $264,000, including land acquisition or easements for the retention and detention basins, and an estimated annual operation and maintenance cost increase of $1,160.

Evaluation of Alternative Stormwater Drainage Plans: The foregoing information provides a basis for a comparative evaluation of the two alternative stormwater drainage plans. Each alternative was designed to resolve potential

Table 53

ALTERNATIVE AE-1: COMPONENTS AND COSTS OF THE STORM SEWER CONVEYANCE STORMWATER DRAINAGE PLAN FOR WEST BEND HYDROLOGIC UNIT MR-AE

Hydrologic Unit	Project and Component Description[a]	Estimated Cost	
		Capital[b]	Annual Operation and Maintenance[c]
AE	1. Replace 419 feet of 15-inch storm sewer in Main Street southeast of Barton Avenue with 21-inch storm sewer at a slope of 2.9 percent	$ 41,000	$ 0
	2. Replace 439 feet of 18-inch storm sewer in Main Street between Spring Street and Fond du Lac Street with 24-inch storm sewer at a slope of 1.85 percent	49,000	0
	3. Replace 310 feet of 18-inch storm sewer in Main Street south of Fond du Lac Street with 24-inch storm sewer at a slope of 2.9 percent	35,000	0
	4. Replace 339 feet of 24-inch storm sewer in an easement between Main Street and the Milwaukee River with 53-inch-wide by 34-inch-high HE pipe at a slope of 0.34 percent	88,000	0
	5. Construct a 100-foot-long outlet channel from the downstream end of the proposed 53-inch-wide by 34-inch-high HE outfall to the Milwaukee River	1,000	100
- -	Total	$214,000	$100

NOTE: The following abbreviation has been used: HE = horizontal elliptical.

[a] *All new and replacement storm sewers are reinforced concrete pipe.*

[b] *Includes 35 percent for engineering, administration, and contingencies. Costs are for year 1991 with Engineering News-Record CCI = 5,015.*

[c] *Costs were noted to be zero when the alternative proposed replacement of a component with a component having similar operation and maintenance cost. Negative costs were noted when the replacement component was estimated to have a lower operation and maintenance cost than that of the existing facility.*

Source: SEWRPC.

existing and future drainage problems within the hydrologic unit. Each, when expanded to include the nonpoint source pollution control measures recommended in Chapter IV of this volume, would achieve the same degree of abatement of nonpoint source pollution. Thus, the principal criteria for the comparative evaluation were reduced to cost and implementability.

Alternative AE-1 has a lower present value cost than Alternative AE-2 and Alternative AE-1 would be more easily implemented since it would involve replacement of storm sewers which are generally within existing rights-of-way and easements; it would not require purchasing land or easements for the provision of the retention and detention basins and appurtenances.

Recommended Stormwater Management Plan: Because of the lower present value cost and more favorable implementability of Alternative AE-1, Storm Sewer Conveyance, that alternative is recommended for adoption in this hydrologic unit. The components and costs of the recommended plan are set forth in Table 9. The approximate location, alignment, and configuration of the recommended facilities, including measures for the control of nonpoint source pollution, are shown graphically on Map 14.

Hydrologic Unit MR-AF

Evaluation of the Stormwater Management System: Hydrologic Unit MR-AF is a 0.14-square-mile area located along the Milwaukee River, as shown on Map 1 in Chapter I of this

Table 54

COMPARISON OF EXISTING AND PROPOSED FLOWS AND HYDRAULIC CAPACITIES OF STORM SEWERS: ALTERNATIVE AE-2, STORM SEWER CONVEYANCE WITH CENTRALIZED DETENTION

Branch	Reach	Storm Sewer Location[a]	Existing Size[b] (inches)	Existing Capacity (cubic feet per second)	Planned Size[b] (inches)	Length (feet)	Planned Capacity (cubic feet per second)	Existing and Planned 10-Year Storm Flow (cubic feet per second)	Frequency Storm Used for Evaluation of Existing Storm Sewers and Replacement of Inadequate Storm Sewers (years)
1	4	Main Street southeast of Barton Avenue (116)	15	10	Retain existing pipe	162	--	20	10
1	4	Main Street southeast of Barton Avenue (116)	15	12	Retain existing pipe	257	--	20	10
1	6	Main Street between Spring Street and Fond du Lac Street (116)	18	9	24 at 1.85 percent	384	31	25	10
1	6	Main Street between Spring Street and Fond du Lac Street (116)	18	12	24 at 1.85 percent	55	31	25	10
1	8	Main Street south of Fond du Lac Street (116)	18	22	24 at 2.9 percent	310	39	35	10
1	10	Main Street between High Street and Park Avenue (116)	24	51	Retain existing pipe	311	--	45	10
1	10	Main Street between High Street and Park Avenue (116)	24	51	Retain existing pipe	306	--	17	10
1	12	Easement between Main Street and the Milwaukee River (116)	24	6	36 at 0.25 percent	339	33	33	10

[a] *City storm sewer system plan sheet number in parentheses.*

[b] *Diameter of circular reinforced concrete pipe unless noted otherwise.*

Source: SEWRPC.

volume. Under existing land use conditions, 92 percent of the hydrologic unit is developed in commercial, industrial, and residential urban land uses. The remaining 8 percent of the hydrologic unit is woodland located in a primary environmental corridor. Planned year 2010 conditions would remain the same. The existing stormwater management system consists of roadway curbs and gutters, storm sewer inlets, and storm sewers. There are no identified intermittent or perennial streams within the hydrologic unit and the storm sewers discharge directly to the Milwaukee River.

The major drainage system has adequate capacity. Problems with inadequate minor system hydraulic capacities were identified in parts of this hydrologic unit. As seen in Table 56, a comparison of the existing and planned 10-year recurrence interval storm flows with the capacities of the existing storm sewers shows that several sewers have inadequate capacities to meet the minor system requirement of passing the peak rate of runoff from a 10-year storm.

Alternative Stormwater Drainage Plans: Because of the lack of available open space in which to construct detention storage facilities, the only practicable solution to the stormwater drainage problems of this hydrologic unit is to upgrade the storm sewer conveyance system.

Recommended Stormwater Management Plan: The recommended storm sewer conveyance plan calls for the provision of replacement storm sewers to abate existing and future stormwater runoff problems. This plan includes 2,530 lineal feet of replacement storm sewer, ranging in size from 12-inch- to 36-inch-diameter reinforced concrete pipe. Table 56 presents a comparison of peak flows and existing and proposed storm sewer hydraulic capacities. The components and

Table 55

ALTERNATIVE AE-2: COMPONENTS AND COSTS OF THE STORM SEWER CONVEYANCE WITH CENTRALIZED DETENTION STORMWATER DRAINAGE PLAN FOR WEST BEND HYDROLOGIC UNIT MR-AE

Hydrologic Unit	Project and Component Description[a]	Estimated Cost	
		Capital[b]	Annual Operation and Maintenance[c]
AE	1. Replace 439 feet of 18-inch storm sewer in Main Street between Spring Street and Fond du Lac Street with 24-inch storm sewer at a slope of 1.85 percent	$ 49,000	$ 0
	2. Replace 310 feet of 18-inch storm sewer in Main Street south of Fond du Lac Street with 24-inch storm sewer at a slope of 2.9 percent	35,000	0
	3. 320 feet of 15-inch storm sewer for detention basin AE-1 inlet	21,000	120
	4. Land acquisition for basin AE-1	5,000	0
	5. Construct detention basin AE-2 with 10-year storm live storage volume of 0.38 acre-foot	70,000	1,100
	6. 90 feet of 24-inch storm sewer for basin AE-2 inlet	10,000	0
	7. 90 feet of 21-inch storm sewer for basin AE-2 outlet	9,000	0
	8. Replace the 339-foot-long 24-inch-diameter corrugated metal storm sewer outfall from subbasin MR365 with a 36-inch storm sewer	65,000	-60
- -	Total	$264,000	$1,160

[a] *All new and replacement storm sewers are reinforced concrete pipe.*

[b] *Includes 35 percent for engineering, administration, and contingencies. Costs are for year 1991 with Engineering News-Record CCI = 5,015.*

[c] *Costs were noted to be zero when the alternative proposed replacement of a component with a component having similar operation and maintenance cost. Negative costs were noted when the replacement component was estimated to have a lower operation and maintenance cost than that of the existing facility.*

Source: SEWRPC.

costs of the recommended plan are set forth in Table 9. The approximate location, alignment, and configuration of the recommended facilities, including measures for the control of nonpoint source pollution, are shown graphically on Map 14. The total present value cost of this plan is $264,000, consisting of an estimated capital cost of $261,000 and an estimated annual operation and maintenance cost increase of $200.

The recommended plan includes the storm sewers proposed to be constructed under Wisconsin Department of Transportation Project No. 1410-01-70 for improvement of West Washington Street. In general, the storm sewers proposed by WisDOT were determined to be adequately sized within the context of this plan. The only difference between the storm sewers proposed under the WisDOT project and those recommended herein occurs near the intersection of Washington Street (STH 33) and 8th Avenue, where the WisDOT project calls for a 44-foot-long, 18-inch-diameter storm sewer and an 85-foot-long, 18-inch-diameter storm sewer, while the recommended plan calls for a 44-foot-long, 21-inch-diameter storm sewer and an 85-foot-long, 30-inch-diameter storm sewer. The existing storm sewer in Beech Street downstream from the proposed 85-foot-long storm sewer is a 164-foot-long, 18-inch-diameter clay pipe with a

Table 56

COMPARISON OF EXISTING AND PROPOSED FLOWS AND HYDRAULIC CAPACITIES OF STORM SEWERS: ALTERNATIVE AF-1, STORM SEWER CONVEYANCE

Storm Sewer Location[a]	Existing Size[b] (inches)	Existing Capacity (cubic feet per second)	Planned Size[b] (inches)	Existing Length (feet)	Proposed[c] Length (feet)	Planned Capacity (cubic feet per second)	Existing and Planned 10-Year Storm Flow (cubic feet per second)	Frequency Storm Used for Evaluation of Existing Storm Sewers and Replacement of Inadequate Storm Sewers (years)
Main Street at Martin Court (137)	12	6	21	99	99	26	24	10
Main Street North of Martin Court (137)	15	6	24	134	134	22	24	10
Main Street South of Silverbrook Drive (137)	15	8	24	288	288	28	27	10
Silverbrook Drive Extended. Subbasin MR367 outlet (137)	18	8	36	95	95	52	36	10
Washington Street (STH 33)	- -	- -	18	- -	57	16	1	10
Washington Street (STH 33)	12	8	18	357	336	24 to 25	< 20	10
Washington Street (STH 33)	12	8	21 at 2.0 percent	357	44	23	20	10
Intersection of Washington Street (STH 33) and 8th Avenue (137)	- -	- -	30 at 0.41 percent	- -	85	26	22	10
Beech Street (137)	18 clay	10	30 at 0.41 percent	164	164	26	27	10
Beech Street (137)	18 clay	24	Retain existing	305	305	- -	27	10
Beech Street (137)	18 clay	25	Retain existing	39	39	- -	27	10
Main Street (137)	18 clay	13	27	58	58	39	42	10
Beech Street Extended. Subbasin MR154 Outlet (137)	18 clay	22	27	214	214	56	42	10
Washington Street (STH 33) (137)	- -	- -	18	- -	40	20	18	10
Washington Street (STH 33) (137)	12	6	21	115	81	34	14	10
Washington Street (STH 33) (137)	15	11	21	230	120	33	14	10
Washington Street (STH 33) (137)	15	4	21	23	140	23	14	10
Washington Street (STH 33) (137)	15	15	21	61	123	21	14	10
Washington Street (STH 33) (137)	15	6	21	93	75	21	14	10
Washington Street (STH 33) (137)	15	6	21	106	85	23	14	10

[a] *City storm sewer system plan street number in parentheses.*

[b] *Diameter of circular reinforced concrete pipe unless noted otherwise.*

[c] *Certain proposed lengths differ from existing because of changes in manhole locations under Wisconsin Department of Transportation Project No. 1410-01-70, "Proposed Improvement of West Washington Street," November 23, 1992, design.*

Source: SEWRPC.

capacity similar to that of the 18-inch-diameter reinforced concrete pipe called for under the WisDOT design. The 164-foot-long, 18-inch-diameter clay storm sewer in Beech Street is recommended to be replaced. Because the limits of the WisDOT project do not include Beech Street, it appears that the 85-foot-long storm sewer was sized to have a capacity equal to that of the existing downstream 18-inch clay pipe. The larger storm sewers recommended herein are required to convey adequately the peak rate of runoff from the 10-year recurrence interval storm and also to insure full utilization of the proposed hydraulic capacity of the recommended downstream replacement storm sewers in Main Street and Beech Street extended.

Hydrologic Units MR-AG and AH

Evaluation of the Stormwater Management System: Hydrologic Units MR-AG and AH comprise a 0.07-square-mile area located along the Milwaukee River, as shown on Map 1 in

Table 57

COMPARISON OF EXISTING AND PROPOSED FLOWS AND HYDRAULIC CAPACITIES OF STORM SEWERS: ALTERNATIVE AG-AH-1, STORM SEWER CONVEYANCE

Subbasin	Storm Sewer Location[a]	Existing Size[b] (inches)	Existing Capacity (cubic feet per second)	Planned Size[b] (inches)	Length (feet)	Planned Capacity (cubic feet per second)	Existing and Planned 10-Year Storm Flow (cubic feet per second)	Frequency Storm Used for Evaluation of Existing Storm Sewers and Replacement of Inadequate Storm Sewers (years)
MR302	Barton Avenue (STH 144) northeast of Commerce Street	12	6	Retain existing pipe	120	- -	7	10
	Barton Avenue southwest of Commerce Street (100)	12	8	21	56	34	30	10
	Barton Avenue southwest of Commerce Street (100)	12	8	21	35	34	30	10
	Barton Avenue southwest of Commerce Street (100)	12	14	21	50	59	30	10
MR305	Monroe Street between Salisbury Road and Commerce Street (100)	12	6	18 at 3.6 percent	318	20	20	10
	Monroe Street between Salisbury Road and Commerce Street (100)	Varies	- -	18 at 3.6 percent	187	20	20	10
MR303	Barton Avenue (STH 144) northeast of Salisbury Road (100)	12	9	Retain existing pipe[c]	1,082	- -	12	10
	Schmidt Road southeast of Barton Avenue (STH 144) (100)	12 PVC pipe	8	Retain existing pipe[d]	149	- -	14	10
	Schmidt Road southeast of Barton Avenue (STH 144) (100)	15	15	18	161	24	19	10
	Schmidt Road southeast of Barton Avenue (STH 144) (100)	24	16	30	255	29	24	10
	Schmidt Road southeast of Barton Avenue (STH 144) (100)	27	22	45 by 29 HE	342	49	32	10
	Outlet	30	40	Retain existing pipe	98	- -	36	10

NOTE: The following abbreviations have been used: HE = horizontal elliptical and PVC = polyvinyl chloride.

[a] *City storm sewer system plan sheet number in parentheses.*

[b] *Diameter of circular reinforced concrete pipe unless noted otherwise.*

[c] *Allowable street capacity is nine cubic feet per second per Objective No. 1, Standard 3, of Volume One of this report. Southeast side of 32-foot-wide street would convey almost all flow in excess of the storm sewer capacity.*

[d] *Allowable street capacity is 17 cubic feet per second per Objective No. 1, Standard 3, of Volume One of this report.*

Source: SEWRPC.

Chapter I of this volume. These hydrologic units were analyzed together because they are hydraulically interconnected. Under existing land use conditions, 89 percent of the two hydrologic units is developed in urban land uses. Under planned year 2010 land use conditions, the hydrologic unit would be about 96 percent developed for urban uses, predominantly commercial, industrial, and residential. The existing stormwater management system consists of roadway curbs and gutters, storm sewer inlets, storm sewers, and open ditches. There are no identified intermittent or perennial streams within the hydrologic unit and the storm sewers discharge directly to the Milwaukee River.

The major drainage system has adequate capacity. Problems with inadequate minor system hydraulic capacities were identified in parts of this hydrologic unit. As seen in Table 57, a comparison of the planned 10-year recurrence interval storm flows with the capacities of the existing storm sewers shows that several sewers have inadequate capacities to meet the minor system requirement of passing the peak rate of runoff from a 10-year storm. Several existing storm sewers have inadequate capacity to convey the peak runoff from a 10-year recurrence interval storm; however, the overall minor system capacity of the sewers and a portion of the street is adequate because that capacity meets the requirements of Standard No. 3 of Objective No. 1 as set forth in Chapter IV of Volume One of this report. That standard calls for the provision of two clear 10-foot-wide lanes for moving traffic on existing arterial streets and one clear 10-foot-wide lane for moving traffic on existing collector and land access streets during storm events up to and including the 10-year recurrence interval event. The application of that standard to this hydrologic unit avoids the replacement of 1,082 feet of 12-inch-diameter storm sewer in Barton Avenue (STH 144) northeast of Salisbury Road and 149 feet of 12-inch-diameter polyvinyl chloride pipe in Schmidt Road. A capital cost savings of about $67,000 is realized by avoiding replacement of these storm sewers. Replacement storm sewers located downstream from the storm sewer reaches listed above must be designed to provide adequate inlet capacity to handle local inflow plus the flow in the street from the upstream reaches where street flow is allowed.

Alternative Stormwater Drainage Plans: Because of the lack of available open space in locations where detention storage facilities might be effective, the only practicable solution to the stormwater drainage problems of this hydrologic unit is to upgrade the storm sewer conveyance system.

Recommended Stormwater Management Plan: The recommended storm sewer conveyance plan calls for the provision of replacement storm sewers to abate existing and future stormwater runoff problems. This plan includes 1,400 lineal feet of replacement storm sewer, ranging in size from 18-inch-diameter to 45-inch-wide by 29-inch-high horizontal elliptical reinforced concrete pipe. Table 57 presents a comparison of peak flows and existing and proposed storm sewer hydraulic capacities. The components and costs of the recommended plan are set forth in Table 9. The approximate location, alignment, and configuration of the recommended facilities, including measures for the control of nonpoint source pollution, are shown graphically on Map 14. The total present value cost of this plan is $175,000, consisting of an estimated capital cost of $176,000 and an estimated annual operation and maintenance cost decrease of $60.

Hydrologic Unit MR-AI

Evaluation of the Stormwater Management System: Hydrologic Unit MR-AI is a 0.10-square-mile area located along the Milwaukee River, as shown on Map 1 in Chapter I of this volume. Under existing land use conditions, the entire hydrologic unit is developed in urban land uses, with medium density residential and two-family residential uses being predominant. The existing stormwater management system consists of roadway curbs and gutters, storm sewer inlets, and storm sewers. There are no identified intermittent or perennial streams within the hydrologic unit and the storm sewers discharge directly to the Milwaukee River.

The major drainage system has adequate capacity. Problems with inadequate minor system hydraulic capacities were identified in parts of this hydrologic unit. As seen in Table 58, a comparison of the existing and planned 10-year recurrence interval storm flows with the capacities of the existing storm sewers shows that several sewers have inadequate capacities to meet the minor system requirement of passing the peak rate of runoff from a 10-year storm. Several existing storm sewers have inadequate capacity to convey the peak runoff from a 10-year recurrence interval storm, however, the overall minor system capacity of the sewers and a portion of the street is adequate because that capacity meets the requirements of Standard No. 3 of Objective No. 1 as set forth in Chapter IV of Volume One of this report. That standard calls for the provision of two clear 10-foot-wide lanes for moving traffic on existing arterial streets and one clear 10-foot-wide lane for moving traffic on existing collector and land access streets during storm events up to and including the 10-year recurrence interval event. The application of that standard to this hydrologic unit avoids the replacement of 329 feet of 15-inch-diameter clay storm sewer in Mayer Street, a total of 608 feet of 12-inch-diameter clay storm sewer in Edgewood Lane, and 122 feet of 24-inch-diameter clay and reinforced concrete storm sewer in East Washington Street (STH 33). A capital cost savings of about $100,000 is realized by avoiding replacement of

Table 58

COMPARISON OF EXISTING AND PROPOSED FLOWS AND HYDRAULIC CAPACITIES OF STORM SEWERS: ALTERNATIVE AI-1, STORM SEWER CONVEYANCE

Branch	Reach	Storm Sewer Location[a]	Existing Size[b] (inches)	Existing Capacity (cubic feet per second)	Planned Size[b] (inches)	Length (feet)	Planned Capacity (cubic feet per second)	Existing and Planned 10-Year Storm Flow (cubic feet per second)	Frequency Storm Used for Evaluation of Existing Storm Sewers and Replacement of Inadequate Storm Sewers (years)
1	0	Mayer Street (136)	15 clay	9	Retain existing[c]	329	- -	15	10
1	2	Mayer Street (136)	15 clay	7	24 at 1.3 percent	126	26	22	10
1	2	Mayer Street (136)	15 clay	9	24 at 1.3 percent	70	26	22	10
1	2	Mayer Street (136)	15 clay	6	24 at 1.3 percent	80	26	22	10
1	3	Mayer Street (136)	15 clay	13	21	162	32	29	10
1	4	Wilson Street ((136)	18 clay	14	27 at 2.2 percent	144	46	44	10
1	4	Intersection of Wilson Street and North Street (136)	18 clay	<14	27 at 2.2 percent	52	46	44	10
1	6	North Street between Wilson Street and E. Washington Street (136)	18 clay	20	27 at 3.7 percent	291	60	59	10
1	8	Intersection of North Street and E. Washington Street (136)	18	25	27	60	69	61	10
2	0	Intersection of Forest Avenue and Edgewood Lane (153)	12 clay	6	Retain existing pipe[d]	47	- -	12	10
2	2	Edgewood Lane (153)	12 clay	5	Retain existing pipe[d]	224	14	12	10
2	2	Edgewood Lane (153)	12 PVC/clay	4	Retain existing pipe[d]	337	17	12	10
2	4	Intersection of Edgewood Lane and E. Wisconsin Street (153)	15 clay	6	27 at 0.82 percent	37	28	27	10
2	4	Wisconsin Street (153)	15	4	27 at 0.82 percent	33	28	27	10
2	4	Wisconsin Street (153)	18 clay	10	27 at 0.82 percent	335	28	27	10
2	6	E. Washington Street (153)	24 clay	26	Retain existing pipe[e]	48	- -	34	10
2	6	E. Washington Street (153)	24	39	Retain existing pipe[e]	74	- -	34	10
1	10	E. Washington Street (137)	36	140	Retain existing pipe	69	- -	94	10
1	10	E. Washington Street (137)	36	63	42	191	95	94	10

NOTE: The following abbreviation has been used: PVC = polyvinyl chloride [pipe].

[a] *City storm sewer system plan sheet number in parentheses.*

[b] *Diameter of circular reinforced concrete pipe unless noted otherwise.*

[c] *Allowable street capacity is nine cubic feet per second per Objective No. 1, Standard 3, of Volume One of this report.*

[d] *Allowable street capacity is seven cubic feet per second per Objective No. 1, Standard 3, of Volume One of this report.*

[e] *Allowable street capacity is 20 cubic feet per second per Objective No. 1, Standard 3, of Volume One of this report.*

Source: SEWRPC.

these storm sewers. Replacement storm sewers located downstream from the storm sewer reaches listed above must be designed to provide adequate inlet capacity to handle local inflow plus the flow in the street from the upstream reaches where street flow is allowed.

Alternative Stormwater Drainage Plans: Because of the lack of available open space in locations where detention storage facilities might be effective, the only practicable solution to the stormwater drainage problems of this hydrologic unit is to upgrade the storm sewer conveyance system.

Recommended Stormwater Management Plan: The recommended storm sewer conveyance plan calls for the provision of replacement storm sewers to abate existing and future stormwater runoff problems. This plan includes 1,580 lineal feet of replacement storm sewers, ranging in size from 24-inch- to 42-inch-diameter reinforced concrete pipe. Table 58 presents a comparison of peak flows and existing and proposed storm sewer hydraulic capacities. The components and costs of the recommended plan are set forth in Table 9. The approximate location, alignment, and configuration of the recommended facilities, including measures for the control of nonpoint

Table 59

COMPARISON OF EXISTING AND PROPOSED FLOWS AND HYDRAULIC CAPACITIES OF STORM SEWERS: ALTERNATIVE AJ-1, STORM SEWER CONVEYANCE

Storm Sewer Location[a]	Existing Size (inches)	Existing Capacity (cubic feet per second)	Planned Size[b] (inches)	Length (feet)	Planned Capacity (cubic feet per second)	Existing and Planned 10-Year Storm Flow (cubic feet per second)	Frequency Storm Used for Evaluation of Existing Storm Sewers and Replacement of Inadequate Storm Sewers (years)
Forest Avenue between Willow Lane and Water Street (153)	12 clay	4	18	513	11	11	10
Intersection of Water Street and Forest Avenue(153)	12 clay	3	30 by 19 HE	31	21	17	10
Water Street West of Forest Avenue (153)	12 clay	4	30 by 19 HE	342	22	20	10
Water Street West of Wisconsin Avenue (153)	12	3	24 at 1.9 percent	54	31	31	10
Water Street West of Wisconsin Avenue (153)	12 clay	<2	24 at 1.9 percent	133	31	31	10
Water Street West of Wisconsin Avenue (153)	12 clay	6	24 at 1.9 percent	231	31	31	10
Island Avenue (153)	12	8	24 at 2.7 percent	38	37	31	10
Island Avenue (153)	12	7	24 at 2.7 percent	78	37	31	10
Island Avenue (153)	12	3	24 at 2.7 percent	10	37	31	10

NOTE: The following abbreviation has been used: HE = horizontal elliptical.

[a] *City storm sewer system plan street number in parentheses.*

[b] *Diameter of circular reinforced concrete pipe unless noted otherwise.*

Source: SEWRPC.

source pollution, are shown graphically on Map 14. The total present value cost of this plan is $211,000, based on an estimated capital cost of $211,000 and no increase in annual operation and maintenance costs.

Hydrologic Unit MR-AJ

Evaluation of the Stormwater Management System: Hydrologic Unit MR-AJ is a 0.02-square-mile area located as shown on Map 1 in Chapter I of this volume. Under existing land use conditions, the hydrologic unit is completely developed in commercial, industrial, and residential urban land uses. The existing stormwater management system consists of roadway curbs and gutters, storm sewer inlets, and storm sewers. There are no identified intermittent or perennial streams within the hydrologic unit and the storm sewers discharge directly to the Milwaukee River.

The major drainage system has adequate capacity. Problems with inadequate minor system hydraulic capacities were identified in parts of this hydrologic unit. As seen in Table 59, a comparison of the existing and planned 10-year recurrence interval storm flows with the capacities of the existing storm sewers shows that several sewers have inadequate capacities to meet the minor system requirement of passing the peak rate of runoff from a 10-year storm.

Alternative Stormwater Drainage Plans: The only possible site for the provision of a detention storage facility is the industrial parking and storage area southwest of the intersection of Willow Lane and Forest Avenue. Because that site is actively used for industrial purposes it was considered impractical to locate a detention facility on the site. Therefore, the only practicable solution to the stormwater drainage problems of this hydrologic unit is to upgrade the storm sewer conveyance system.

Recommended Stormwater Management Plan: The recommended storm sewer conveyance plan calls for the provision of replacement storm sewers to abate existing stormwater runoff

Table 60

COMPARISON OF EXISTING AND PROPOSED FLOWS AND HYDRAULIC CAPACITIES OF STORM SEWERS: ALTERNATIVE AK-1, STORM SEWER CONVEYANCE

Storm Sewer Location[a]	Existing Size (inches)	Existing Capacity (cubic feet per second)	Planned Size[b] (inches)	Length (feet)	Planned Capacity (cubic feet per second)	Existing and Planned 10-Year Storm Flow (cubic feet per second)	Existing and Planned 100-Year Storm Flow (cubic feet per second)	Frequency Storm Used for Evaluation of Existing Storm Sewers and Replacement of Inadequate Storm Sewers (years)
Island Avenue between Water Street and E. Washington Street (STH 33) (153)	12	3	27 at 0.81 percent	200	28	16	25	100
Easement West of Island Avenue Outlet to Milwaukee River (153)	12	4	27 at 0.81 percent	210	28	16	25	100

[a] *City storm sewer system plan street number in parentheses.*

[b] *Diameter of circular reinforced concrete pipe unless noted otherwise.*

Source: SEWRPC.

problems. This plan includes 1,430 lineal feet of replacement storm sewer, ranging in size from 18- to 24-inch-diameter reinforced concrete pipe. Table 59 presents a comparison of peak flows and existing and proposed storm sewer hydraulic capacities. The components and costs of the recommended plan are set forth in Table 9. The approximate location, alignment, and configuration of the recommended facilities, including measures for the control of nonpoint source pollution, are shown graphically on Map 14. The total present value and capital costs of this plan are $149,000. The plan would result in no increase in annual operation and maintenance costs.

Hydrologic Unit MR-AK

Evaluation of the Stormwater Management System: Hydrologic Unit MR-AK is a 0.03-square-mile area located along the Milwaukee River, as shown on Map 1 in Chapter I of this volume. Under existing land use conditions, the entire hydrologic unit is developed in urban land uses, with commercial uses being predominant. The existing stormwater management system consists of overland flow, roadway curbs and gutters, storm sewer inlets, storm sewers, and open swales. There are no identified intermittent or perennial streams within the hydrologic unit and the storm sewers discharge directly to the Milwaukee River.

Problems with inadequate major and minor system hydraulic capacities were identified. As seen in Table 60, a comparison of the existing and planned 10-year recurrence interval storm flows with the capacities of the existing storm sewers shows that a 12-inch-diameter storm sewer in Island Avenue and the downstream 12-inch-diameter outlet to the Milwaukee River have inadequate capacities to meet the minor system requirement of passing the peak rate of runoff from a 10-year storm. In addition, the inlets to these storm sewers are located at a sag in Island Avenue where runoff in excess of storm sewer capacities would collect during events producing peak flows greater than those capacities. Most of the overflow route from the sag to the Milwaukee River is blocked by an existing building on the west side of Island Avenue.

Alternative Stormwater Drainage Plans: The only possible site for the provision of a detention storage facility is along the Wisconsin Central Transportation Corporation line. Because that site is actively used and because the available space is limited, it was considered impractical to locate a detention facility on the site. Therefore, the only practicable solution to the stormwater drainage problems of this hydrologic unit is to upgrade the storm sewer conveyance system.

Recommended Stormwater Management Plan: The recommended storm sewer conveyance plan calls for the provision of replacement storm sewers to abate existing stormwater runoff problems. This plan includes 410 lineal feet of 27-inch-diameter replacement storm sewers. Table 60 presents a comparison of peak flows and existing and proposed storm sewer hydrau-

Table 61

COMPARISON OF PROPOSED FLOWS AND HYDRAULIC CAPACITIES OF STORM SEWERS: ALTERNATIVE AL-1, STORM SEWER CONVEYANCE

Storm Sewer Location[a]	Existing Size (inches)	Existing Capacity (cubic feet per second)	Planned Size[b] (inches)	Length (feet)	Planned Capacity (cubic feet per second)	Planned 10-Year Storm Flow (cubic feet per second)	Frequency Storm Used for Evaluation of Existing Storm Sewers and Replacement of Inadequate Storm Sewers (years)
Forest Avenue (153)	15 clay	5	21	261	12	11	10
Forest Avenue (153)	15 clay	4	38 by 24 HE	296	27	25	10
Forest Avenue (153)	15 clay	8	27	265	40	32	10
Forest Avenue (153)	18 CMP	6	27	33	35	32	10
Forest Avenue Extended Outlet to Milwaukee River	18 CMP	8	30	496	57	53	10
Forest Avenue	12 clay	7	23 by 14 HE	248	20	16	10
Forest Avenue	12 clay	6	23 by 14 HE	40	18	16	10
Forest Avenue	12	3	24	235	19	16	10

NOTE: The following abbreviations have been used: CMP = corrugated metal pipe and HE = horizontal elliptical.

[a] *City storm sewer system plan street number in parentheses.*

[b] *Diameter of circular reinforced concrete pipe unless noted otherwise.*

Source: SEWRPC.

lic capacities. The components and costs of the recommended plan are set forth in Table 9. The approximate location, alignment, and configuration of the recommended facilities, including measures for the control of nonpoint source pollution, are shown graphically on Map 14. The total present value and capital costs of this plan are $53,000. The plan would result in no increase in annual operation and maintenance costs.

Hydrologic Unit MR-AL

Evaluation of the Stormwater Management System: Hydrologic Unit MR-AL is a 0.05-square-mile area located along the Milwaukee River, as shown on Map 1 in Chapter I of this volume. Under existing land use conditions, the hydrologic unit is completely developed in commercial, industrial, and residential urban land uses, with industrial uses being predominant. Planned land year 2010 uses are expected to be similar to existing. The existing stormwater drainage system consists of roadway curbs and gutters, storm sewer inlets, storm sewers, and overland flow. There are no identified intermittent or perennial streams within the hydrologic unit and the storm sewers discharge directly to the Milwaukee River.

The major drainage system has adequate capacity. Problems with inadequate minor system hydraulic capacities were identified in parts of this hydrologic unit. As seen in Table 61, a comparison of the existing and planned 10-year recurrence interval storm flows with the capacities of the existing storm sewers shows that several sewers have inadequate capacities to meet the minor system requirement of passing the peak rate of runoff from a 10-year storm.

Alternative Stormwater Drainage Plans: The only possible site for the provision of a detention storage facility is the industrial storage area along Forest Avenue extended between Linwood Terrace and the Milwaukee River. That site was rejected as a detention site because it is actively used for industrial purposes and because it is unlikely that any significant cost saving over a storm sewer conveyance alternative would be achieved if detention were provided at that location. The capital cost of a detention basin would be similar to the storm sewer cost saving and the basin operation and maintenance costs would be greater than those for a storm sewer. Therefore, it is proposed to resolve the stormwater drainage problems of this hydrologic unit

Table 62

COMPARISON OF PROPOSED FLOWS AND HYDRAULIC CAPACITIES OF STORM SEWERS: ALTERNATIVE AM-1, STORM SEWER CONVEYANCE

Branch	Reach	Storm Sewer Location[a]	Existing Size[b] (inches)	Existing Capacity (cubic feet per second)	Planned Size[b] (inches)	Length (feet)	Planned Capacity (cubic feet per second)	Planned 10-Year Storm Flow (cubic feet per second)	Planned 100-Year Storm Flow (cubic feet per second)	Frequency Storm Used for Evaluation of Existing Storm Sewers and Replacement of Inadequate Storm Sewers (years)
1	0	Intersection of Washington Street and Indiana Avenue (153)	12	1	18 at 2.2 percent	26	16	11	18	10
1	0	Indiana Avenue (153)	15	11	18 at 2.2 percent	86	16	11	18	10
1	0	Indiana Avenue (153)	12	8	Retain existing pipe	268	- -	11	18	10
1	2	Indiana Avenue (153)	12	8	18	238	23	18	31	10
1	2	Indiana Avenue (153)	12	6	18	266	18	18	31	10
1	2	Indiana Avenue (153)	15 clay	7	24	251	24	18	31	10
1	4	Indiana Avenue (153)	15 clay	7	24	88	26	21	35	10
1	4	Indiana Avenue (153)	15	7	24	265	26	21	35	10
1	6	Indiana Avenue (153)	24	12	30 at 0.99 percent	311	41	39	62	10
1	6	Indiana Avenue (153)	24	14	30 at 0.99 percent	280	41	39	62	10
1	6	Indiana Avenue (153)	24	24	30 at 0.99 percent	241	41	39	62	10
1	6	Indiana Avenue (153)	21	23	30 at 0.99 percent	335	41	39	62	10
1	8	Indiana Avenue outlet to Milwaukee River	24	17	36	170	51	42	67	10

[a] *City storm sewer system plan sheet number in parentheses.*

[b] *Diameter of circular reinforced concrete pipe unless noted otherwise.*

Source: SEWRPC.

through improvements to the storm sewer conveyance system.

Recommended Stormwater Management Plan: The recommended storm sewer conveyance plan calls for the provision of replacement storm sewers to abate existing stormwater runoff problems. This plan includes 1,870 lineal feet of replacement storm sewer, ranging in size from 21- to 30-inch-diameter reinforced concrete pipe. Table 61 presents a comparison of peak flows and existing and proposed storm sewer hydraulic capacities. The components and costs of the recommended plan are set forth in Table 9. The approximate location, alignment, and configuration of the recommended facilities, including measures for the control of nonpoint source pollution, are shown graphically on Map 14. The total present value and capital costs of this plan are $237,000. The plan would result in no increase in annual operation and maintenance costs.

Hydrologic Unit MR-AM

Evaluation of the Stormwater Management System: Hydrologic Unit MR-AM is a 0.03-square-mile area located as shown on Map 1 in Chapter I of this volume. Under existing land use conditions, this hydrologic unit is essentially completely developed in urban land uses including government and institutional, residential, and industrial. Under planned year 2010 conditions, the land use distribution in the unit would be similar to the existing distribution. The existing stormwater management system consists of roadway curbs and gutters, storm sewer inlets, and storm sewers. There are no identified intermittent or perennial streams within the hydrologic unit and the storm sewers discharge directly to the Milwaukee River.

Problems with inadequate minor system hydraulic capacities were identified in parts of this hydrologic unit. As seen in Table 62, a comparison of the existing and planned 10-year recurrence interval storm flows with the capacities of the existing storm sewers shows that most sewers have inadequate capacities to meet the minor system requirement of passing the peak rate of runoff from a 10-year storm.

There is a mid-block sag in Indiana Avenue south of Water Street. Runoff at rates in excess

Table 63

ALTERNATIVE AM-1: COMPONENTS AND COSTS OF THE STORM SEWER CONVEYANCE STORMWATER DRAINAGE PLAN FOR WEST BEND HYDROLOGIC UNIT MR-AM

Hydrologic Unit	Project and Component Description[a]	Estimated Cost	
		Capital[b]	Annual Operation and Maintenance[c]
AM	1. Replace 26 feet of 12-inch storm sewer in the intersection of Washington Street (STH 33) with 18-inch storm sewer at a slope of 2.2 percent	$ 2,000	$ 0
	2. Replace 86 feet of 15-inch storm sewer in Indiana Avenue with 18-inch storm sewer at a slope of 2.2 percent	7,000	0
	3. Replace 504 feet of 12-inch storm sewer in Indiana Avenue with 18-inch storm sewer	42,000	0
	4. Replace 604 feet of 15-inch clay and reinforced concrete pipe storm sewer in Indiana Avenue with 24-inch storm sewer	68,000	0
	5. Replace 832 feet of 24-inch storm sewer in Indiana Avenue with 30-inch storm sewer at a slope of 0.99 percent	125,000	0
	6. Replace 335 feet of 21-inch storm sewer in Indiana Avenue with 30-inch storm sewer at a slope of 0.99 percent	50,000	0
	7. Replace 170 feet of 24-inch storm sewer in Indiana Avenue with 36-inch storm sewer	33,000	-30
- -	Total	$327,000	$-30

[a] *All new and replacement storm sewers are reinforced concrete pipe.*

[b] *Includes 35 percent for engineering, administration, and contingencies. Costs are for year 1991 with Engineering News-Record Construction Cost Index = 5,015.*

[c] *Costs were noted to be zero when the alternative proposed replacement of a component with a component having similar operation and maintenance cost. Negative costs were noted when the replacement component was estimated to have a lower operation and maintenance cost than that of the existing facility.*

Source: SEWRPC.

of the hydraulic capacity of the storm sewers could pond in this sag. The outlet for runoff ponded in the sag is overland flow across the large industrial parking lot on the east side of Indiana Avenue. As long as the parking lot grade is maintained at existing, or lower, elevations, and the existing storage volume in the street remains available, the major system should have adequate capacity to prevent flooding of buildings during storms with recurrence intervals up to, and including, 100 years.

Alternative Stormwater Drainage Plans: The following two alternative stormwater management plans were developed for Hydrologic Unit AM: 1) a storm sewer conveyance plan and 2) a storm sewer conveyance with centralized detention plan.

Alternative Plan No. AM-1, Storm Sewer Conveyance: The storm sewer conveyance alternative plan calls for the provision of replacement storm sewers to abate existing stormwater runoff problems. This alternative includes 2,560 lineal feet of replacement storm sewer, ranging in size from 18- to 36-inch-diameter reinforced concrete pipe. Map 9 shows the approximate location and alignment of the replacement storm sewers proposed under this alternative. Table 62 presents a comparison of peak flows and existing and proposed storm sewer hydraulic capacities. Table 63 presents the salient characteristics

Table 64

COMPARISON OF PROPOSED FLOWS AND HYDRAULIC CAPACITIES OF STORM SEWERS: ALTERNATIVE AM-2, STORM SEWER CONVEYANCE WITH CENTRALIZED DETENTION

Branch	Reach	Storm Sewer Location[a]	Existing Size[b] (inches)	Existing Capacity (cubic feet per second)	Planned Size[b] (inches)	Length (feet)	Planned Capacity (cubic feet per second)	Planned 10-Year Storm Flow (cubic feet per second)	Frequency Storm Used for Evaluation of Existing Storm Sewers and Replacement of Inadequate Storm Sewers (years)
1	0	Intersection of Washington Street and Indiana Avenue (153)	12	1	18 at 2.2 percent	26	16	11	10
1	0	Indiana Avenue (153)	15	11	18 at 2.2 percent	86	16	11	10
1	0	Indiana Avenue (153)	12	8	Retain existing pipe	268	- -	11	10
1	2	Indiana Avenue (153)	12	8	18	238	23	18	10
1	2	Indiana Avenue (153)	12	6	18	266	18	18	10
1	2	Indiana Avenue (153)	15 clay	7	24	251	24	18	10
1	4	Indiana Avenue (153)	15 clay	7	24	88	26	21	10
1	4	Indiana Avenue (153)	15	7	24	265	26	21	10
1	6	Indiana Avenue (153)	24	12	45 by 29 HE at 0.35 percent	311	41	39	10
1	6	Indiana Avenue (153)	24	14	Retain existing pipe	280	- -	14	10
1	6	Indiana Avenue (153)	24	24	Retain existing pipe	241	- -	14	10
1	6	Indiana Avenue (153)	21	23	Retain existing pipe	335	- -	14	10
1	8	Indiana Avenue outlet to Milwaukee River	24	17	Retain existing pipe	170	- -	18	10

NOTE: The following abbreviation has been used: HE = horizontal elliptical.

[a] *City storm sewer system plan sheet number in parentheses.*

[b] *Diameter of circular reinforced concrete pipe unless noted otherwise.*

Source: SEWRPC.

and estimated costs of the replacement storm sewers comprising this alternative plan. The total present value cost of this alternative plan is $326,500, consisting of an estimated capital cost of $327,000 and an estimated annual operation and maintenance cost decrease of $30.

Alternative Plan No. AM-2, Storm Sewer Conveyance with Centralized Detention: Map 10 shows the approximate location, alignment, and configuration of the facilities called for under this alternative. Because of the reduction in peak 10-year recurrence interval flood flows achieved through the provision of detention storage, this alternative enables the retention of 1,030 lineal feet of existing storm sewer which would be replaced under Alternative AM-1. This alternative calls for 2,260 lineal feet of replacement storm sewers ranging in size from 18-inch-diameter reinforced concrete pipe to 45-inch-wide by 29-inch-high horizontal elliptical reinforced concrete pipe.

Proposed detention basin AM-1 would be located on currently private land in the Gehl Company parking lot southeast of the intersection of Indiana Avenue and Water Street. The detention basin is proposed to be a dry basin, which would drain between storm events. Construction of the basin would result in the loss of about 0.74 acre parking, or about 19 percent of the total parking lot area. Table 64 presents a comparison of peak flows and existing and proposed storm sewer hydraulic capacities. Table 65 presents the salient characteristics and estimated costs of the components of this alternative. The total present value cost of this alternative plan is $373,000, consisting of an estimated capital cost of

Table 65

ALTERNATIVE AM-2: COMPONENTS AND COSTS OF THE STORM SEWER CONVEYANCE WITH CENTRALIZED DETENTION STORMWATER DRAINAGE PLAN FOR WEST BEND HYDROLOGIC UNIT MR-AM

Hydrologic Unit	Project and Component Description[a]	Estimated Cost	
		Capital[b]	Annual Operation and Maintenance[c]
AM	1. Replace 26 feet of 12-inch storm sewer in the intersection of Washington Street (STH 33) with 18-inch storm sewer at a slope of 2.2 percent	$ 2,000	$0
	2. Replace 86 feet of 15-inch storm sewer in Indiana Avenue with 18-inch storm sewer at a slope of 2.2 percent	7,000	0
	3. Replace 504 feet of 12-inch storm sewer in Indiana Avenue with 18-inch storm sewer	42,000	0
	4. Replace 604 feet of 15-inch clay and RCP storm sewer in Indiana Avenue with 24-inch storm sewer	68,000	0
	5. Replace 311 feet of 24-inch storm sewer in Indiana Avenue with 45-inch-wide by 29-inch-high HE reinforced concrete pipe at a slope of 0.35 percent	65,000	-60
	6. Install 130 feet of 24-inch storm sewer to serve as the inlet pipe for dry detention basin AM-1	15,000	- -
	7. Install 600 feet of 12-inch storm sewer to serve as the outlet pipe for dry detention basin AM-1	31,000	- -
	8. Construct dry detention basin AM-1 with a 10-year recurrence interval storm storage volume of 0.4 acre-foot	120,000	1,500
- -	Total	$350,000	$1,440

NOTE: The following abbreviations have been used: HE = horizontal elliptical and RCP = reinforced concrete pipe.

[a] *All new and replacement storm sewers are reinforced concrete pipe.*

[b] *Includes 35 percent for engineering, administration, and contingencies. Costs are for year 1991 with Engineering News-Record Construction Cost Index = 5,015.*

[c] *Costs were noted to be zero when the alternative proposed replacement of a component with a component having similar operation and maintenance cost. Negative costs were noted when the replacement component was estimated to have a lower operation and maintenance cost than that of the existing facility.*

Source: SEWRPC.

$350,000, including land acquisition for the detention basin, and an estimated annual operation and maintenance cost increase of $1,440.

Evaluation of Alternative Stormwater Drainage Plans: The foregoing information provides a basis for a comparative evaluation of the two alternative stormwater drainage plans. Each alternative was designed to resolve potential existing and future drainage problems within the hydrologic unit. Each, when expanded to include the nonpoint source pollution control measures recommended in Chapter IV of this volume, would achieve the same degree of abatement of nonpoint source pollution. Thus, the principal criteria for the comparative evaluation were reduced to cost and implementability.

Alternative AM-1 is less costly and more easily implemented than Alternative AM-2 since it would involve replacement of storm sewers which are generally within existing rights-of-way and easements, would not require purchasing land or easements for the provision of the detention basin and appurtenances, and would not reduce the available parking area in the lot southeast of the intersection of Water Street and Indiana Avenue.

Recommended Stormwater Management Plan: Because of the lower cost and more favorable implementability of Alternative AM-1, Storm Sewer Conveyance, that alternative is recommended for adoption in this hydrologic unit. The components and costs of the recommended plan are set forth in Table 9. The approximate location, alignment, and configuration of the recommended facilities, including measures for the control of nonpoint source pollution, are shown graphically on Map 14.

Hydrologic Unit MR-AN

Evaluation of the Stormwater Management System: Hydrologic Unit MR-AN is a 0.05-square-mile area located along the Milwaukee River, as shown on Map 1 in Chapter I of this volume. Under existing land use conditions, virtually the entire hydrologic unit is developed in government and institutional and industrial land uses, with much of the government and institutional consisting of open space within the grounds of the Washington County Annex IV. Under planned year 2010 conditions, it is possible that the open space within the county grounds could be more intensively developed, possibly increasing runoff volumes and peak rates of flow. The existing drainage system consists of a storm sewer system and a dry detention basin serving the 10.2-acre Washington County Annex IV site and storm sewers in Water Street serving the remainder of the unit. There are no identified intermittent or perennial streams within the hydrologic unit. There are no known existing, significant stormwater drainage problems in the unit.

Alternative Stormwater Drainage Plans: The existing stormwater drainage system was evaluated under planned land use conditions and the major and minor systems were found to be adequate to accommodate runoff under those conditions. Thus, no alternative plans were developed.

Plan Recommendations: The existing stormwater drainage system is adequate to accommodate the runoff anticipated under planned land use development densities. The 283-foot-long, 36-inch-diameter corrugated metal pipe storm sewer in Water Street has a hydraulic capacity of 35 cfs while the peak rate of runoff from a 10-year recurrence interval storm is estimated to be 47 cfs. Standard No. 3 of Objective No. 1 in Table 15 of Volume One of this report sets forth criteria for allowable levels of street flooding to provide an acceptable level of access to property and of traffic service. When that standard is applied, the combined allowable hydraulic capacity of Water Street and the existing storm sewer is adequate to accommodate the peak rate of runoff under planned development densities. Therefore, no recommendations are made to upgrade the existing stormwater drainage system.

Hydrologic Unit MR-AO

Evaluation of the Stormwater Management System: Hydrologic Unit MR-AO is a 0.04-square-mile area located as shown on Map 1 in Chapter I of this volume. Under existing land use conditions, 40 percent of the hydrologic unit is developed in industrial land uses. Under planned year 2010 land use conditions, about 68 percent of the hydrologic unit would be developed for industrial uses. The remaining 32 percent would be part of the City's Riverside Park, which includes a portion of the primary environmental corridor along the Milwaukee River. Under existing conditions, runoff from industrial or open lands: 1) flows overland for several hundred feet, 2) concentrates in an approximately 400-foot-long overland drainageway that passes through the City's Riverside Park and the primary environmental corridor, 3) flows down the steep, eight-foot-high banks along the Milwaukee River floodplain, and 4) enters a wetland in the floodplain before to discharging to the River. There are no identified intermittent or perennial streams within the hydrologic unit.

Because the existing industrial area in the hydrologic unit is adequately served by the overland flow drainage system and because there is no development along the overland drainageway downstream of the developed area, there are no known existing, significant stormwater drainage problems in the unit.

Recommended Stormwater Management Plan: The portion of the hydrologic unit where additional industrial development is expected under planned land use conditions is located downslope from the existing industrial development in the unit. The configuration of the stormwater management system for such an area would, to a large extent, be dictated by a future building

Table 66

COMPARISON OF EXISTING AND PROPOSED FLOWS AND HYDRAULIC CAPACITIES OF STORM SEWERS: ALTERNATIVE AP-1, STORM SEWER CONVEYANCE

Storm Sewer Location[a]	Existing Size[b] (inches)	Existing Capacity (cubic feet per second)	Planned Size[b] (inches)	Length (feet)	Planned Capacity (cubic feet per second)	Existing and Planned 10-Year Storm Flow (cubic feet per second)	Existing and Planned 100-Year Storm Flow (cubic feet per second)	Frequency Storm Used for Evaluation of Existing Storm Sewers and Replacement of Inadequate Storm Sewers (years)
Hillcrest Street (171)	15	4	21	343	9	8	11	10
Hillcrest Street (171)	15	5	21	302	13	13	19	10
Hillcrest Street (171)	18	9	24	307	19	17	23	10
Eastern Avenue (171)	18	12	24	144	25	20	28	10
Eastern Avenue (171)	18	23	Retain existing pipe	228	- -	20	28	10
Outlet to Milwaukee River (171)	18	22	Retain existing pipe	427	- -	20	28	10

[a] *City storm sewer system plan street number in parentheses.*

[b] *Diameter of circular reinforced concrete pipe unless noted otherwise.*

Source: SEWRPC.

and street layout. To analyze specific stormwater drainage alternatives for such a development would only be an academic exercise in the absence of specific conceptual site plans. To base such an analysis on arbitrary assumptions regarding the future development pattern could unnecessarily constrain future development options which do not meet those assumptions, but may still be valid approaches to development of the site. Thus, no detailed stormwater drainage recommendations are made for this hydrologic unit. It is, however, recommended that the runoff from the existing industrial area be considered in the design of facilities for stormwater management in the remainder of the unit and that the stormwater management facilities include provisions to control erosion of the Milwaukee River banks where runoff passes over those banks. It is also recommended that the existing grade of the Gehl Company parking lot be maintained to insure the adequate functioning of the major drainage system in adjacent hydrologic unit MR-AM. Chapter IV of this volume includes a recommendation for sweeping of industrial parking and storage areas to reduce the amount of nonpoint source pollutants washed into the riparian wetland and the Milwaukee River.

Specific stormwater drainage facilities would be established by developers and City staff during the design and review processes for proposed development. Drainage improvements in this unit would have only a small impact on the City capital improvements budget since most, if not all, facilities would be paid for by private developers.

Hydrologic Unit MR-AP

Evaluation of the Stormwater Management System: Hydrologic Unit MR-AP is a 0.02-square-mile area located as shown on Map 1 in Chapter I of this volume. Under existing land use conditions, the entire hydrologic unit is developed in residential land uses. The existing stormwater management system consists of roadway curbs and gutters, storm sewer inlets, and storm sewers. There are no identified intermittent or perennial streams within the hydrologic unit and the storm sewers discharge directly to the Milwaukee River.

The major drainage system has adequate capacity. Problems with inadequate minor system hydraulic capacities were identified in parts of this hydrologic unit. As seen in Table 66, a comparison of the existing and planned 10-year recurrence interval storm flows with the capacities of the existing storm sewers shows that several sewers have inadequate capacities to meet the minor system requirement of passing the peak rate of runoff from a 10-year storm.

Table 67

COMPARISON OF PROPOSED FLOWS AND HYDRAULIC CAPACITIES OF STORM SEWERS: ALTERNATIVE AQ-1, STORM SEWER CONVEYANCE

Branch	Reach	Storm Sewer Location[a]	Existing Size[b] (inches)	Existing Capacity (cubic feet per second)	Planned Size[b] (inches)	Length (feet)	Planned Capacity (cubic feet per second)	Planned 10-Year Storm Flow (cubic feet per second)	Planned 100-Year Storm Flow (cubic feet per second)	Frequency Storm Used for Evaluation of Existing Storm Sewers and Replacement of Inadequate Storm Sewers (years)
1	4	Kilbourn Street west of Juniper Court (171)	58 by 36 CMP	45	53 by 34 HE	675	66	58	97	10
1	6	Supplemental hydrologic unit outlet (171)	- -	- -	21 at 3.6 percent	380	30	23[c]	- -	10

NOTE: The following abbreviations have been used: CMP = corrugated metal pipe and HE = horizontal elliptical.

[a] *City storm sewer system plan sheet number in parentheses.*

[b] *Diameter of circular reinforced concrete pipe unless noted otherwise.*

[c] *Difference between 10-year recurrence interval storm peak flow at hydrologic unit outlet and hydraulic capacity of existing 36-inch-diameter CMP at outlet.*

Source: SEWRPC.

Alternative Stormwater Drainage Plans: Because of the lack of available open space in which to construct detention storage facilities, the only practicable solution to the stormwater drainage problems of this hydrologic unit is to upgrade the storm sewer conveyance system.

Recommended Stormwater Management Plan: The recommended storm sewer conveyance plan calls for the provision of replacement storm sewers to abate existing stormwater runoff problems. This plan includes 1,100 lineal feet of replacement storm sewer, ranging in size from 21-inch- to 24-inch-diameter reinforced concrete pipe. Table 66 presents a comparison of peak flows and existing and proposed storm sewer hydraulic capacities. The components and costs of the recommended plan are set forth in Table 9. The approximate location, alignment, and configuration of the recommended facilities are shown graphically on Map 14. The total present value cost of this plan is $112,000, consisting of an estimated capital cost of $112,000 and no change in the annual operation and maintenance cost.

Hydrologic Unit MR-AQ

Evaluation of the Stormwater Management System: Hydrologic Unit MR-AQ is a 0.08-square-mile area located as shown on Map 1 in Chapter I of this volume. Under existing land use conditions, approximately 92 percent of the hydrologic unit is developed in urban land uses. Under planned year 2010 land use conditions, the unit is expected to be completely developed in single-family residential uses. The existing stormwater management system consists of roadway curbs and gutters, storm sewer inlets, and storm sewers. There are no identified intermittent or perennial streams within the hydrologic unit and the storm sewers discharge directly to the Milwaukee River.

The major drainage system has adequate capacity. Problems with inadequate minor system hydraulic capacities were identified in parts of this hydrologic unit. As seen in Table 67, a comparison of the existing and planned 10-year recurrence interval storm flows with the capacities of the existing storm sewers shows that several sewers have inadequate capacities to meet the minor system requirement of passing the peak rate of runoff from a 10-year storm.

Alternative Stormwater Drainage Plans: The following two alternative stormwater management plans were considered for Hydrologic Unit AQ: 1) a storm sewer conveyance plan and 2) a storm sewer conveyance with centralized detention plan.

Alternative Plan No. AQ-1, Storm Sewer Conveyance: The storm sewer conveyance alternative plan calls for the provision of new and replacement storm sewers to abate existing stormwater runoff problems. This alternative includes 675 lineal feet of 53-inch-wide by

34-inch-high reinforced concrete replacement storm sewer and 380 feet of new 21-inch-diameter reinforced concrete storm sewer. Map 14 shows the approximate location and alignment of the new and replacement storm sewers proposed under this alternative. The new storm sewer is recommended to provide a supplemental outlet to the Milwaukee River to be constructed through Riverside Park. There would only be limited, temporary disturbance of the park during construction. If the proposed supplemental outlet were constructed, the existing 285-foot-long, 58-inch-wide by 36-inch-high and 323-foot-long, 36-inch-diameter corrugated metal pipe storm sewers located in Kilbourn Street and Riverside Park downstream of the proposed supplemental outlet would not require replacement on the basis of hydraulic capacity considerations. Table 67 presents a comparison of peak flows and existing and proposed storm sewer hydraulic capacities. Table 9 presents the salient characteristics and estimated costs of the replacement storm sewers comprising this alternative plan. The total present value cost of this alternative plan is $214,000, consisting of an estimated capital cost of $212,000 and an estimated annual operation and maintenance cost increase of $150.

Alternative Plan No. AQ-2, Storm Sewer Conveyance with Centralized Detention: Because of the lack of available open space in which to construct detention storage facilities, the only possible site for such a facility would be in Riverside Park. The provision of such detention, like the provision of a supplemental outlet under Alternative AQ-1, would eliminate the need to replace the existing 285-foot-long, 58-inch-wide by 36-inch-high and 323-foot-long, 36-inch-diameter corrugated metal pipe storm sewers located in Kilbourn Street and Riverside Park. The costs of Alternatives AQ-1 and AQ-2 would be similar. Alternative AQ-1 would involve only temporary disruption of the park during construction, while Alternative AQ-2 would involve disruption of park activities both during construction and during storms following construction. Therefore, Alternative AQ-2 was eliminated from further consideration.

Recommended Stormwater Management Plan: As outlined above in the section which describes Alternative AQ-1, Storm Sewer Conveyance, the recommended plan calls for the provision of new and replacement storm sewers to abate existing stormwater runoff problems. The components and costs of the recommended plan are set forth in Table 9. The approximate location, alignment, and configuration of the recommended facilities are shown graphically on Map 14.

Hydrologic Unit MR-AR

Evaluation of the Stormwater Management System: Hydrologic Unit MR-AR is a 0.04-square-mile area located along the Milwaukee River, as shown on Map 1 in Chapter I of this volume. Under existing land use conditions, about 33 percent of the hydrologic unit is developed in medium-density residential uses, with the remainder in agricultural and other open space uses. Under planned year 2010 conditions, about 72 percent of the hydrologic unit would be developed in urban uses, predominantly medium-density residential. The remaining 28 percent would be wetlands and other open lands in the Milwaukee River floodplain and the primary environmental corridor along the River. The existing drainage patterns in the hydrologic unit consist of roadside swales along Scenic Drive and overland flow directly to the Milwaukee River. There are no identified intermittent or perennial streams within the hydrologic unit.

Owing to the relatively low development density of the hydrologic unit under existing conditions and to the existence of a drainage system adequate for such development, there are no known existing, significant stormwater drainage problems in the unit.

Recommended Stormwater Management Plan: The hydrologic unit concerned is partially developed and it has drainage patterns consisting primarily of overland flow directly to the Milwaukee River. Under planned development conditions, the unit could be adequately drained through a simple system of roadside swales and overland flow. The configuration of the stormwater management system for such an area would, to a large extent, be dictated by a future street and lot layout. Specific stormwater drainage facilities would be established by developers and City staff during the design and review processes for proposed development. Detention storage would not be required because increases in rates of runoff would have no significant impact on peak flows in the Milwaukee River; however, the provision of such storage could be considered at the time of development if it were possible to achieve a cost saving in the convey-

Table 68

COMPARISON OF PROPOSED FLOWS AND HYDRAULIC CAPACITIES OF STORM SEWERS: ALTERNATIVE AS-1, STORM SEWER CONVEYANCE

Branch	Reach	Storm Sewer Location[a]	Existing Size[b] (inches)	Existing Capacity (cubic feet per second)	Planned Size[b] (inches)	Length (feet)	Planned Capacity (cubic feet per second)	Planned 10-Year Storm Flow (cubic feet per second)	Planned 100-Year Storm Flow (cubic feet per second)	Frequency Storm Used for Evaluation of Existing Storm Sewers and Replacement of Inadequate Storm Sewers (years)
--	--	Municipal garage storage lot (156)	30	18	36	130	29	30	46	10
--	--	Municipal garage lot (156)	30	16	42	105	39	33	51	10
1	0	Municipal Drive (156)	30	32	36	428	52	44	68	10
1	2	Municipal Drive (156)	36	30	42 at 0.42 percent	291	65	60	93	10
1	2	Municipal Drive (156)	36	41	48 at 0.42 percent	250	93	72	112	10
1	2	Municipal Drive (156)	36	54	48 at 0.42 percent	299	93	72	112	10
1	2	Municipal Drive (156)	36	127	36 at 2.9 percent[c]	290	114	72	112	10
1	2	Municipal Drive (156)	36	79	Retain existing pipe	270	--	72	112	10

[a] City storm sewer system plan sheet number in parentheses.

[b] Diameter of circular reinforced concrete pipe unless noted otherwise.

[c] Storm sewer must be laid at a flatter slope to accommodate recommended upstream storm sewers.

Source: SEWRPC.

ance system through the reduction of peak flows within the hydrologic unit. Drainage improvements in this unit would have only a small impact on the City capital improvements budget since most facilities would be paid for by private developers.

Hydrologic Unit MR-AS

Evaluation of the Stormwater Management System: Hydrologic Unit MR-AS is located as shown on Map 1 of Chapter I of this volume. This hydrologic unit includes two subbasins: 1) subbasin MR48, which includes the City of West Bend Municipal Garage and commercial and residential lands tributary to the storm sewers in Municipal Drive and 2) subbasin MR50, which includes the City wastewater treatment plant and City lands available for possible future expansion of the plant. There are no identified intermittent or perennial streams within the hydrologic unit and the storm sewers discharge directly to the Milwaukee River.

Runoff from subbasin MR50 drains to the Milwaukee River through overland flow, through overland flow into an existing detention basin and then into storm sewers, and through direct runoff to storm sewers. Under existing land use conditions, 54 percent of this hydrologic unit is developed as the City wastewater treatment plant. The major and minor drainage systems appear adequate under existing conditions. Under planned land use conditions it is anticipated that the treatment plant and the small portion of the adjacent municipal garage lands within the subbasin may be expanded to comprise about 98 percent of the hydrologic unit. Because the stormwater management system serving the City wastewater treatment plant receives runoff only from City-owned lands and because details of any future expansion of the plant are unknown at this time, the evaluation of the stormwater management system can best be accomplished by City staff at such time as expansion is considered. It should be noted that the water quality management plan element presented in Chapter IV of this volume calls for runoff from this subbasin to be treated through the provision of wet detention basin WD7.

The existing stormwater management system in subbasin MR48 consists of roadway curbs and gutters, storm sewer inlets, and storm sewers in Municipal Drive and the municipal garage storage lot. Problems with inadequate minor system hydraulic capacities were identified in parts of this subbasin. As seen in Table 68, a comparison of the planned 10-year recurrence interval storm flows with the capacities of the existing storm sewers shows that some of the sewers have inadequate capacities to meet the minor system requirement of passing the peak rate of runoff from a 10-year storm.

Table 69

ALTERNATIVE AS-1: COMPONENTS AND COSTS OF THE STORM SEWER CONVEYANCE STORMWATER DRAINAGE PLAN FOR WEST BEND HYDROLOGIC UNIT MR-AS[a]

Hydrologic Unit	Project and Component Description[b]	Estimated Cost	
		Capital[c]	Annual Operation and Maintenance[d]
AS	1. Replace 130 feet of 30-inch storm sewer in the municipal garage storage lot with 36-inch storm sewer	$ 25,000	$ -20
	2. Replace 105 feet of 30-inch storm sewer in the municipal garage storage lot with 42-inch storm sewer	24,000	-20
	3. Replace 428 feet of 30-inch storm sewer in Municipal Drive with 36-inch storm sewer	83,000	-80
	4. Replace 291 feet of 36-inch storm sewer in Municipal Drive with 42-inch storm sewer at a slope of 0.42 percent	65,000	0
	5. Replace 549 feet of 36-inch storm sewer in Municipal Drive with 48-inch storm sewer at a slope of 0.42 percent	140,000	0
	6. Replace 290 feet of 36-inch storm sewer in Municipal Drive with 36-inch storm sewer relaid at a slope of 2.9 percent in order to accommodate the new upstream storm sewers	28,000	0
- -	Total	$365,000	$-120

[a] *Under this alternative plan, nonpoint source pollution control would be provided by wet detention basin WD7 in adjacent hydrologic unit MR-BE.*

[b] *All new and replacement storm sewers are reinforced concrete pipe.*

[c] *Includes 35 percent for engineering, administration, and contingencies. Costs are for year 1991 with Engineering News-Record Construction Cost Index = 5,015.*

[d] *Costs were noted to be zero when the alternative proposed replacement of a component with a component having similar operation and maintenance cost. Negative costs were noted when the replacement component was estimated to have a lower operation and maintenance cost than that of the existing facility.*

Source: SEWRPC.

Alternative Stormwater Drainage Plans: The following two alternative stormwater management plans were developed for subbasin MR48 of Hydrologic Unit AS: 1) a storm sewer conveyance plan and 2) a storm sewer conveyance with centralized detention plan.

Alternative Plan No. AS-1, Storm Sewer Conveyance: The storm sewer conveyance alternative plan calls for the provision of replacement storm sewers to abate existing stormwater runoff problems. This alternative includes 1,790 lineal feet of replacement storm sewer, ranging in size from 36- to 48-inch-diameter reinforced concrete pipe. This alternative calls for the replacement of a 290-foot-long, 36-inch-diameter storm sewer in Municipal Drive which has adequate capacity to convey the peak rate of runoff from a 10-year recurrence interval storm, but which must be re-laid at a flatter slope to accommodate the recommended upstream replacement storm sewers. The estimated cost for relaying the 290 feet of 36-inch storm sewer assumes that at least half of the storm sewer would be in adequate condition and could be salvaged. Map 9 shows the approximate location and alignment of the replacement storm sewers proposed under this alternative. Table 68 presents a comparison of

Table 70

ALTERNATIVE AS-2: COMPONENTS AND COSTS OF THE STORM SEWER CONVEYANCE WITH CENTRALIZED DETENTION STORMWATER DRAINAGE PLAN FOR WEST BEND HYDROLOGIC UNIT MR-AS

Hydrologic Unit	Project and Component Description[a]	Estimated Cost: Capital[b]	Estimated Cost: Annual Operation and Maintenance
AS	1. Detention basin WD28 with a 10-year live storage volume of 1.1 acre-foot. Water quantity control cost[c]	$23,000	$350
	2. 65 feet of 30-inch storm sewer for inlet to detention basin WD28	10,000	- -[d]
	3. 65 feet of 24-inch storm sewer for outlet from detention basin WD28	7,000	- -[d]
- -	Total	$40,000	$350

[a] *All new and replacement storm sewers are reinforced concrete pipe.*

[b] *Includes 35 percent for engineering, administration, and contingencies. Costs are for year 1991 with* *Engineering News-Record* *Construction Cost Index = 5,015.*

[c] *As set forth in Chapter IV of this Volume, the capital cost of the water quality control portion of basin WD28 is $85,000 and the annual operation and maintenance cost is $1,800.*

[d] *Annual operation and maintenance cost included under Item 1.*

Source: SEWRPC.

peak flows and existing and proposed storm sewer hydraulic capacities. Table 69 presents the salient characteristics and estimated costs of the replacement storm sewers comprising this alternative plan. The total present value cost of this alternative plan is $363,500, consisting of an estimated capital cost of $365,000 and an estimated annual operation and maintenance cost decrease of $120.

Alternative Plan No. AS-2, Storm Sewer Conveyance with Centralized Detention: Map 10 shows the approximate location, alignment, and configuration of the facilities called for under this alternative. Because of the reduction in peak 10-year recurrence interval flood flows achieved through the provision of detention storage, this alternative avoids replacement of any existing storm sewers. Proposed detention basin WD28 would be located on City property just south of the municipal garage on the east side of Municipal Drive. Table 70 presents the salient characteristics and estimated costs of the components of this alternative. The total present value cost of this alternative plan is $46,000, consisting of an estimated capital cost of $40,000, assuming no land acquisition cost since the detention basin would be located on City property, and an estimated annual operation and maintenance cost increase of $350.

The water quality management plan element presented in Chapter IV of this volume calls for runoff from subbasin MR48 to be treated through the use of wet detention basins. It would, therefore, be logical for the detention basin proposed under this alternative to be a dual-purpose basin for the control of both water quantity and quality. The detention basin capital cost assigned to this alternative is the incremental cost for controlling the peak rate of runoff from the tributary area. It is appropriate to use that incremental cost because under either of the two water quantity control alternatives presented here, there would be wet detention provided for water quality control. Thus, use of the incremental cost reasonably assumes a similar cost for control of the quality of runoff under either alternative plan, whether such control is provided at the proposed location for basin WD28, or elsewhere at a site with a larger tributary area.

Evaluation of Alternative Stormwater Drainage Plans: The foregoing information provides a basis for a comparative evaluation of the two alternative stormwater drainage plans. Each alternative was designed to resolve potential existing and future drainage problems within the hydrologic unit. Each, when expanded to include the nonpoint source pollution control measures recommended in Chapter IV of this volume, would achieve the same degree of abatement of nonpoint source pollution. Thus, the principal criteria for the comparative evaluation were reduced to cost and implementability.

Alternative AS-2 is less costly than Alternative AS-1 and Alternative AS-2 would be more easily implemented since it would involve construction of a relatively small detention basin on currently undeveloped City land, rather than the replacement of storm sewers in an existing street.

Recommended Stormwater Management Plan: Because of the lower cost and more favorable implementability of Alternative AS-2, Storm Sewer Conveyance with Centralized Detention, that alternative is recommended for adoption in this hydrologic unit. The components and costs of the recommended plan are set forth in Table 9. The approximate location, alignment, and configuration of the recommended facilities, including those for control of nonpoint source pollution, are shown graphically on Map 14.

Hydrologic Unit MR-AT

Evaluation of the Stormwater Management System: Hydrologic Unit MR-AT is a 0.09-square-mile area located as shown on Map 1 of Chapter I of this volume. This hydrologic unit is located within the West Bend Municipal Airport. The existing stormwater management system consists of open swales and culverts which provide drainage along, and across, runways. There are no identified intermittent or perennial streams within the hydrologic unit. There are no known reported stormwater drainage problems in the hydrologic unit.

Plan Recommendations: The City is currently considering alternatives for significant expansion of the Municipal Airport, including lengthening and expansion of runways. The future stormwater management system in this hydrologic unit will be greatly dependent on the airport expansion alternative selected by the City. To analyze specific stormwater drainage alternatives would be only an academic exercise in the absence of a specific conceptual site plan for the airport expansion. Thus, no detailed stormwater drainage recommendations are made for this hydrologic unit.

Specific stormwater drainage facilities to serve future development should be established by the City during the engineering design of the selected expansion alternative. Because the hydrologic unit does not receive runoff from lands outside the airport, the design of the drainage system need not account for runoff from planned development off the airport site.

Hydrologic Unit MR-AU

Evaluation of the Stormwater Management System: Hydrologic Unit MR-AU is a 0.11-square-mile area located along the Milwaukee River, as shown on Map 1 in Chapter I of this volume. Under existing land use conditions, the entire hydrologic unit is developed in commercial, industrial, residential, and government and institutional land uses. Under planned year 2010 conditions the types and distribution of development in the hydrologic unit would essentially be the same as under existing conditions. The existing stormwater management system consists of roadway curbs and gutters, storm sewer inlets, storm sewers, and a short reach of open channel in subbasin MR70. There are no identified intermittent or perennial streams within the hydrologic unit and the storm sewers discharge directly to the Milwaukee River.

Problems with both inadequate minor and major system hydraulic capacities were identified in parts of this hydrologic unit. As seen in Table 71, a comparison of the existing 10-year recurrence interval storm flows with the capacities of the existing storm sewers shows that many sewers have inadequate capacities to meet the minor system requirement of passing the peak rate of runoff from a 10-year storm. In addition, major system capacity problems were identified at 8th, 9th, and 10th Avenues just south of Cedar Street, where ponding at a mid-block sag could result in flooding of adjacent houses, businesses, and Holy Angels School.

Alternative Stormwater Drainage Plans: The following two alternative stormwater management plans were developed for this hydrologic unit: 1) a storm sewer conveyance plan and 2) a storm sewer conveyance with centralized detention plan.

Table 71

COMPARISON OF EXISTING AND PROPOSED FLOWS AND HYDRAULIC CAPACITIES OF STORM SEWERS: ALTERNATIVE AU-1, STORM SEWER CONVEYANCE

Branch	Reach	Storm Sewer Location[a]	Existing Size[b] (inches)	Existing Capacity (cubic feet per second)	Planned Size[b] (inches)	Length (feet)	Planned Capacity (cubic feet per second)	Existing 10-Year Storm Flow (cubic feet per second)	Planned 10-Year Storm Flow (cubic feet per second)	Existing 100-Year Storm Flow (cubic feet per second)	Planned 100-Year Storm Flow (cubic feet per second)	Frequency Storm Used for Evaluation of Existing Storm Sewers and Replacement of Inadequate Storm Sewers (years)
		Subbasin MR60										
1	0	Intersection of Elm Street and 10th Avenue (152)	12 clay	6	21 at 1.2 percent	12	17	9	9	14	14	100
		Elm Street (152)	15 clay	5	21 at 1.2 percent	283	17	9	9	14	14	100
1	2	Intersection of Elm Street and 9th Avenue (152)	15 clay	15	24 at 2.2 percent	38	41	19	19	33	33	100
		9th Avenue (152)	15 clay	7	30 at 0.76 percent	178	36	19	19	33	33	100
		9th Avenue (152)	15 clay[c]	6	30 at 0.76 percent	259	36	19	19	33	33	100
		9th Avenue (152)	15 clay[c]	7	30 at 0.76 percent	261	36	19	19	33	33	100
2	0	Intersection of Cedar Street and 10th Avenue (152)	6 clay	1	12	47	7	2	2	3	3	100
2	2	10th Avenue (152)	12 clay	4	12 at 2.6 percent	85	6	3	3	6	6	100
		Intersection of 10th Avenue and Cedar Street (152)	12 clay	9	12 at 3.0 percent	26	6	3	3	6	6	100
		Cedar Street between 9th and 10th Avenues (152)	15 clay	9	Retain existing pipe	289	--	5	5	9	9	100
1	4	Intersection of 9th Avenue and Cedar Street (152)	24 clay	30	30 at 2.5 percent	24	62	20	33	29	56	100
		Cedar Street between 8th and 9th Avenues (152)	24 clay	37	30 at 2.5 percent	312	62	27	33	36	56	100
--	--	Easement east of 8th Avenue (152)	18 clay	24[d]	21 at 4.9 percent	167	35	24	24	36	36	100
--	--	Alley south of Cedar Street between 7th and 8th Avenues (152)	12 clay	4	30 at 1.2 percent	148	45	26	26	40	40	100
--	--	Easement south of Cedar Street between alley and 7th Avenue (152)	12 clay	5	30 at 1.2 percent	152	45	26	26	40	40	100
1	6	Intersection of Cedar Street and 8th Avenue (152)	24	40	30 at 3.6 percent	30	78	46	50	69	84	100
		Cedar Street between 7th and 8th Avenues (152)	24 clay	44	30 at 3.6 percent	310	78	46	50	69	84	100
1	8	Cedar Street between 7th Avenue and Main Street (152)	24 clay	51	36	179	140	51	57	81	98	100
		Cedar Street between 7th Avenue and Main Street (152)	15 clay	12	36 at 1.7 percent	65	87	51	57	81	98	10
		Intersection of Cedar and Main Streets (152)	36	125	Retain existing	48	--	51	57	81	98	10
1	10	Main Street between Cedar and Mill Streets (152)	36	127	Retain existing	114	--	62	68	95	114	10
1	12	Mill Street (152)	36	126	Retain existing	92	--	86	92	130	149	10
		Mill Street (152)	36	136	Retain existing	54	--	86	92	130	149	10
		Mill Street (152)	36	139	Retain existing	71	--	86	92	130	149	10
		South of Mill Street (152)	36 CMP	Adverse slope	42 at 0.85 percent	208	93	86	92	130	149	10
		Outlet to Milwaukee River (152)	36 CMP	70	42 at 0.85 percent	75	93	86	92	130	149	10

Table 71 (continued)

Branch	Reach	Storm Sewer Location[a]	Existing Size[b] (inches)	Existing Capacity (cubic feet per second)	Planned Size[b] (inches)	Length (feet)	Planned Capacity (cubic feet per second)	Existing 10-Year Storm Flow (cubic feet per second)	Planned 10-Year Storm Flow (cubic feet per second)	Existing 100-Year Storm Flow (cubic feet per second)	Planned 100-Year Storm Flow (cubic feet per second)	Frequency Storm Used for Evaluation of Existing Storm Sewers and Replacement of Inadequate Storm Sewers (years)
Subbasins MR70 and MR80												
1	0	Hickory Street (152)	18	24	Retain existing pipe	41	- -	24	24	38	38	10
		Hickory Street (152)	36 by 30[e]	65	Retain existing pipe	192	- -	24	24	38	38	10
		Hickory Street (152)	36 by 30[e]	65	Retain existing pipe	55	- -	24	24	38	38	10
		Hickory Street (152)	18 clay	24	Retain existing pipe	22	- -	24	24	38	38	10
		Hickory Street (152)	18	25	Retain existing pipe	24	- -	24	24	38	38	10
		Hickory Street (152)	18	25	Retain existing pipe	41	- -	24	24	38	38	10
1	2	Hickory Street (152)	24	44	Retain existing pipe	128	- -	31	31	50	50	10
		Hickory Street (152)	24	44	Retain existing pipe	150	- -	31	31	50	50	10
		Hickory Street (152)	24	51	Retain existing pipe	41	- -	31	31	50	50	10
2	0	6th Avenue north of Hickory Street (152)	15	8	Retain existing pipe	35	- -	10	10	14	14	10
		Easement between 6th Avenue and Main Street (152)	24	51	Retain existing pipe	95	- -	10	10	14	14	10
		Easement between 6th Avenue and Main Street (152)	24	37	Retain existing pipe	129	- -	10	10	14	14	10
		Main Street (152)	12	4	18	38	11	10	10	14	14	10
2	2	Main Street (152)	18	8	24 at 0.89 percent	107	21	19	19	29	29	10
		Main Street (152)	18	12	24 at 0.89 percent	80	21	19	19	29	29	10
1	4	Main Street (152)	30	42	42 at 0.79 percent	126	89	62	62	96	96	10
		Main Street (152)	30	36	42 at 0.79 percent	242	89	62	62	96	96	10
1	6	Main Street (152	30	89	42 at 0.79 percent	18	89	70	70	108	108	10
		Easement east of Main Street (152)	30	77	Retain existing pipe	99	- -	70	70	108	108	10

NOTE: The following abbreviation has been used: CMP = corrugated metal pipe.

[a] *City storm sewer system plan sheet number in parentheses.*

[b] *Diameter of circular reinforced concrete pipe unless noted otherwise.*

[c] *Parallel 15-inch-diameter clay storm sewers.*

[d] *Actual capacity limited to four cubic feet per second by downstream 12-inch clay storm sewer in alley.*

[e] *Nonstandard size 36-inch-wide by 28-inch-high reinforced concrete pipe arch or 38-inch-wide by 24-inch-high horizontal elliptical reinforced concrete pipe assumed for hydraulic capacity determination.*

Source: SEWRPC.

Alternative Plan No. AU-1, Storm Sewer Conveyance: The storm sewer conveyance alternative plan calls for the provision of replacement storm sewers to abate existing stormwater runoff problems. This alternative includes 3,210 lineal feet of replacement storm sewer, ranging in size from 12- to 42-inch-diameter reinforced concrete pipe. Map 9 shows the approximate location and alignment of the replacement storm sewers proposed under this alternative. Table 71 presents a comparison of peak flows and existing and proposed storm sewer hydraulic capacities. As seen from Table 71, because of the three mid-block sags with no safe outlets as noted above, this alternative calls for the provision of 100-year recurrence flow capacity for significant portions of the recommended replacement storm sewer system. Table 72 presents the salient characteristics and estimated costs of the replacement storm sewers comprising this alternative plan. The total present value cost of this alternative plan is $488,000, consisting of an estimated capital cost of $489,000 and an estimated annual operation and maintenance cost decrease of $40.

Alternative Plan No. AU-2, Storm Sewer Conveyance with Centralized Detention: Map 10 shows the approximate location, alignment, and configuration of the facilities called for under this alternative. Because of the reduction in peak 100-year recurrence interval flood flows achieved through the provision of detention storage, this alternative avoids replacement of approximately 515 feet of existing storm sewer and it enables the use of 505 feet of smaller diameter pipes than are called for under Alternative AU-1. Proposed detention basin AU-1 would be located on the playground of Holy Angels School, southeast of the intersection of Cedar Street and Ninth Avenue. This basin would be a dry detention basin, which would drain completely between storms, minimizing disruption of use of the school playground.

Table 73 presents a comparison of peak flows and existing and proposed storm sewer hydraulic capacities. Table 74 presents the salient characteristics and estimated costs of the components of this alternative. The total present value cost of this alternative plan is $563,000, consisting of an estimated capital cost of $533,000 and an estimated annual operation and maintenance cost increase of $1,900.

Evaluation of Alternative Stormwater Drainage Plans: The foregoing information provides a basis for a comparative evaluation of the two alternative stormwater drainage plans. Each alternative was designed to resolve potential existing and future drainage problems within the hydrologic unit. Each, when expanded to include the nonpoint source pollution control measures recommended in Chapter IV of this volume, would achieve the same degree of abatement of nonpoint source pollution. Thus, the principal criteria for the comparative evaluation were reduced to cost and implementability.

Alternative AU-1 is less costly and more easily implemented than Alternative AU-2, since it would involve replacement of storm sewers in existing streets, rather than a combination of storm sewer replacement and detention basin construction on private property currently used for other purposes.

Recommended Stormwater Management Plan: Because of the lower cost and more favorable implementability of Alternative AU-1, Storm Sewer Conveyance, that alternative is recommended for adoption in this hydrologic unit. The components and costs of the recommended plan are set forth in Table 9. The approximate location, alignment, and configuration of the recommended facilities, including measures for the control of nonpoint source pollution, are shown graphically on Map 14.

Hydrologic Unit MR-AV

Evaluation of the Stormwater Management System: Hydrologic Unit MR-AV is a 0.07-square-mile area located as shown on Map 1 in Chapter I of this volume. Under existing land use conditions, approximately 9 percent of the hydrologic unit is developed in urban residential land use, with the remaining land in agricultural uses and other open space uses. Under planned year 2010 conditions, about 74 percent of the hydrologic unit would be developed in urban uses, predominantly medium-density residential, but would also include two-family residential and an elementary school. The remaining 26 percent would be devoted to wetlands and woodlands.

The hydrologic unit consists of internally drained subbasin MR202I. The existing stormwater drainage pattern consists of overland flow into wetlands located in a topographic depression. There are no identified intermittent or

Table 72

ALTERNATIVE AU-1 : COMPONENTS AND COSTS OF THE STORM SEWER CONVEYANCE STORMWATER DRAINAGE PLAN FOR WEST BEND HYDROLOGIC UNIT MR-AU

Hydrologic Unit	Project and Component Description[a]	Estimated Cost	
		Capital[b]	Annual Operation and Maintenance[c]
MR-AU	1. Replace 12 feet of 12-inch clay storm sewer in the intersection of Elm Street and 10th Avenue with 21-inch storm sewer at a slope of 1.2 percent	$ 1,000	$ 0
	2. Replace 283 feet of 15-inch clay storm sewer in Elm Street with 21-inch storm sewer at a slope of 1.2 percent	27,000	0
	3. Replace 38 feet of 15-inch clay storm sewer in the intersection of Elm Street and 9th Avenue with 24-inch storm sewer at a slope of 2.2 percent	4,000	0
	4. Replace 178 feet of 15-inch clay storm sewer in 9th Avenue with 30-inch storm sewer at a slope of 0.76 percent	27,000	0
	5. Replace 260 feet of two parallel 15-inch clay storm sewers in 9th Avenue with one 30-inch storm sewer at a slope of 0.76 percent	39,000	0
	6. Replace 47 feet of six-inch clay storm sewer in the intersection of Cedar Street and 10th Avenue with 12-inch storm sewer	2,000	0
	7. Replace 85 feet of 12-inch clay storm sewer in 10th Avenue with 12-inch storm sewer at a slope of 2.6 percent	4,000	0
	8. Replace 26 feet of 12-inch clay storm sewer in the intersection of Cedar Street and 10th Avenue with 12-inch storm sewer at a slope of 3 percent	1,000	0
	9. Replace 336 feet of 24-inch clay storm sewer in the intersection of Cedar Street and 9th Avenue and in Cedar Street between 8th and 9th Avenues with 30-inch storm sewer at a slope of 2.5 percent	51,000	0
	10. Replace 167 feet of 18-inch clay storm sewer in an easement east of 8th Avenue with 21-inch storm sewer at a slope of 4.9 percent	16,000	0
	11. Replace 300 feet of 12-inch clay storm sewer in an alley south of Cedar Street between 7th and 8th Avenues and in an easement between the alley and 7th Avenue with 30-inch storm sewer at a slope of 1.2 percent	45,000	0
	12. Replace 340 feet of 24-inch reinforced concrete and clay storm sewer in the intersection of Cedar Street and 8th Avenue and in Cedar Street between 7th and 8th Avenues with 30-inch storm sewer at a slope of 3.6 percent	50,000	0
	13. Replace 179 feet of 24-inch clay storm sewer in Cedar Street between 7th Avenue and Main Street with 36-inch storm sewer	35,000	-30
	14. Replace 65 feet of 15-inch clay storm sewer in Cedar Street between 7th Avenue and Main Street with 36-inch storm sewer at a slope of 1.7 percent	13,000	-10
	15. Replace 283 feet of 36-inch reinforced concrete and corrugated metal storm sewer in Mill Street and at the hydrologic unit outlet to the Milwaukee River with 42-inch storm sewer at a slope of 0.85 percent	64,000	0

Table 72 (continued)

Hydrologic Unit	Project and Component Description[a]	Estimated Cost	
		Capital[b]	Annual Operation and Maintenance[c]
MR-AU (continued)	16. Replace 38 feet of 12-inch storm sewer in Main Street with 18-inch storm sewer	$ 3,000	$ 0
	17. Replace 187 feet of 30-inch storm sewer in Main Street with 24-inch storm sewer at a slope of 0.89 percent	21,000	0
	18. Replace 386 feet of 30-inch storm sewer in Main Street with 42-inch storm sewer at a slope of 0.79 percent	86,000	0
- -	Total	$489,000	$-40

[a] *All new and replacement storm sewers are reinforced concrete pipe.*

[b] *Includes 35 percent for engineering, administration, and contingencies. Costs are for year 1991 with Engineering News-Record Construction Cost Index = 5,015.*

[c] *Costs were noted to be zero when the alternative proposed replacement of a component with a component having similar operation and maintenance cost. Negative costs were noted when the replacement component was estimated to have a lower operation and maintenance cost than that of the existing facility.*

Source: SEWRPC.

perennial streams within the hydrologic unit. There are no known reported stormwater drainage problems in the hydrologic unit.

The wetland in the unit includes an area of Class I, or high-value, wildlife habitat.

Recommended Stormwater Management Plan: Under planned development conditions, the unit could be adequately drained through a simple system of storm sewers and overland flow, discharging to the depression, which would be preserved as wetlands and woodlands. The depression has adequate volume to completely store, with no outflow, the runoff from a 100-year recurrence interval storm with a duration of 10 days. In order to provide two feet of freeboard between buildings and the 100-year recurrence interval ponding elevation during a 10-day storm, it is recommended that no development in the hydrologic unit be permitted below elevation 993.7 feet National Geodetic Vertical Datum (NGVD), 1929 adjustment. That elevation limit on development would also be expected to provide sufficient protection during successive, more frequent storms when the runoff accumulated in the depressions may not completely infiltrate or evaporate between storms.

The configuration of the stormwater management system for this area would, to a large extent, be dictated by a future street, lot, and building layout. Specific stormwater drainage facilities would be established by developers and City staff during the design and review processes for proposed development. Detention storage would not be required in this hydrologic unit because such facilities could not be practically implemented to reduce overall costs through provision of smaller conveyance facilities and because runoff from the unit would be collected in the depression area and would not be conveyed outside the unit.

In order to protect the wetlands and the area of high-value wildlife habitat in the hydrologic unit the stormwater management system should be designed to minimize concentration of flow and to achieve overland flow in order to: 1) promote infiltration of runoff and of the nonpoint source

Table 73

COMPARISON OF EXISTING AND PROPOSED FLOWS AND HYDRAULIC CAPACITIES OF STORM SEWERS: ALTERNATIVE AU-2, STORM SEWER CONVEYANCE WITH CENTRALIZED DETENTION

Branch	Reach	Storm Sewer Location[a]	Existing Size[b] (inches)	Existing Capacity (cubic feet per second)	Planned Size[b] (inches)	Length (feet)	Planned Capacity (cubic feet per second)	Existing 10-Year Storm Flow (cubic feet per second)	Planned 10-Year Storm Flow (cubic feet per second)	Existing 100-Year Storm Flow (cubic feet per second)	Planned 100-Year Storm Flow (cubic feet per second)	Frequency Storm Used for Evaluation of Existing Storm Sewers and Replacement of Inadequate Storm Sewers (years)
Subbasin MR60												
1	0	Intersection of Elm Street and 10th Avenue (152)	12 clay	6	21 at 1.2 percent	12	17	9	9	14	14	100
		Elm Street (152)	15 clay	5	21 at 1.2 percent	283	17	9	9	14	14	100
1	2	Intersection of Elm Street and 9th Avenue (152)	15 clay	15	24 at 2.2 percent	38	41	19	19	33	33	100
- -	- -	AU-1 inlet	- -	- -	24 at 2.2 percent	70	41	- -	19	- -	33	100
- -	- -	AU-1 outlet	- -	- -	15 at 1.2 percent	40	7	- -	<7	- -	7	100
1	2	9th Avenue (152)	15 clay	7	Retain existing pipe	178	- -	19	<7	33	7	100
		9th Avenue (152)	15 clay[c]	6	Retain existing pipe	259	- -	19	<7	33	7	100
		9th Avenue (152)	15 clay[c]	7	18 at 0.45 percent	261	7	19	<7	33	7	100
2	0	Intersection of Cedar Street and 10th Avenue (152)	6 clay	1	12	47	7	2	2	3	3	100
2	2	10th Avenue (152)	12 clay	4	12 at 2.6 percent	85	6	3	3	6	6	100
		Intersection of 10th Avenue and Cedar Street (152)	12 clay	9	12 at 3.0 percent	26	6	3	3	6	6	100
		Cedar Street between 9th and 10th Avenues (152)	15 clay	9	Retain existing pipe	289	- -	5	5	9	9	100
1	4	Intersection of 9th Avenue and Cedar Street (152)	24 clay	30	Retain existing pipe	24	- -	20	21	29	30	100
		Cedar Street between 8th and 9th Avenues (152)	24 clay	37	Retain existing pipe	312	- -	27	21	36	30	100
- -	- -	8th Avenue south of Cedar Street (152)	12 clay[d]	3	Retain existing	177	- -	24	24	36	36	100
- -	- -	8th Avenue south of Cedar Street (152)	12 clay[d]	Adverse slope	Retain existing	178	- -	24	24	36	36	100
- -	- -	Easement east of 8th Avenue (152)	18 clay	24[e]	21 at 4.9 percent	167	35	24	24	36	36	100
- -	- -	Alley south of Cedar Street between 8th and 9th Avenues (152)	12 clay	4	30 at 1.2 percent	148	45	26	26	40	40	100
- -	- -	Easement south of Cedar Street between alley and 9th Avenue (152)	12 clay	5	30 at 1.2 percent	152	45	26	26	40	40	100
1	6	Intersection of Cedar Street and 8th Avenue (152)	24	40	30 at 3.6 percent	30	78	46	38	69	62	100
		Cedar Street between 7th and 8th Avenues (152)	24 clay	44	30 at 3.6 percent	310	78	46	38	69	62	100
1	8	Cedar Street between 7th Avenue and Main Street (152)	24 clay	51	30	179	89	51	45	81	74	100
		Cedar Street between 7th Avenue and Main Street (152)	15 clay	12	30 at 2.5 percent	65	65	51	45±	81	74	10
		Intersection of Cedar and Main Streets (152)	36	125	Retain existing	48	- -	51	45±	81	74	10
1	10	Main Street between Cedar and Mill Streets (152)	36	127	Retain existing	114	- -	62	56±	95	89	10
1	12	Mill Street (152)	36	126	Retain existing	92	- -	86	80±	130	124	10
		Mill Street (152)	36	136	Retain existing	54	- -	86	80±	130	124	10

Table 73 (continued)

Branch	Reach	Storm Sewer Location[a]	Existing Size[b] (inches)	Existing Capacity (cubic feet per second)	Planned Size[b] (inches)	Length (feet)	Planned Capacity (cubic feet per second)	Existing 10-Year Storm Flow (cubic feet per second)	Planned 10-Year Storm Flow (cubic feet per second)	Existing 100-Year Storm Flow (cubic feet per second)	Planned 100-Year Storm Flow (cubic feet per second)	Frequency Storm Used for Evaluation of Existing Storm Sewers and Replacement of Inadequate Storm Sewers (years)
Subbasin MR60 (continued)												
1	12	Mill Street (152)	36	139	Retain existing	71	- -	86	80±	130	124	10
		South of Mill Street (152)	36 CMP	Adverse slope	42 at 0.77 percent	208	88	86	80±	130	124	10
		Outlet to Milwaukee River (152)	36 CMP	70	42 at 0.77 percent	75	88	86	80±	130	124	10
Subbasins MR70 and MR80												
1	0	Hickory Street (152)	18	24	Retain existing pipe	41	- -	24	24	38	38	10
		Hickory Street (152)	36 by 30[f]	65	Retain existing pipe	192	- -	24	24	38	38	10
		Hickory Street (152)	36 by 30[f]	65	Retain existing pipe	55	- -	24	24	38	38	10
		Hickory Street (152)	18 clay	24	Retain existing pipe	22	- -	24	24	38	38	10
		Hickory Street (152)	18	25	Retain existing pipe	24	- -	24	24	38	38	10
		Hickory Street (152)	18	25	Retain existing pipe	41	- -	24	24	38	38	10
1	2	Hickory Street (152)	24	44	Retain existing pipe	128	- -	31	31	50	50	10
		Hickory Street (152)	24	44	Retain existing pipe	150	- -	31	31	50	50	10
		Hickory Street (152)	24	51	Retain existing pipe	41	- -	31	31	50	50	10
2	0	6th Avenue north of Hickory Street (152)	15	8	Retain existing pipe	35	- -	10	10	14	14	10
		Easement between 6th Avenue and Main Street (152)	24	51	Retain existing pipe	95	- -	10	10	14	14	10
		Easement between 6th Avenue and Main Street (152)	24	37	Retain existing pipe	129	- -	10	10	14	14	10
		Main Street (152)	12	4	18	38	11	10	10	14	14	10
2	2	Main Street (152)	18	8	24 at 0.89 percent	107	21	19	19	29	29	10
		Main Street (152)	18	12	24 at 0.89 percent	80	21	19	19	29	29	10
1	4	Main Street (152)	30	42	42 at 0.79 percent	126	89	62	62	96	96	10
		Main Street (152)	30	36	42 at 0.79 percent	242	89	62	62	96	96	10
1	6	Main Street (152)	30	89	42 at 0.79 percent	18	89	70	70	108	108	10
		Easement east of Main Street (152)	30	77	Retain existing pipe	99	89	70	70	108	108	10

NOTE: The following abbreviation has been used: CMP = corrugated metal pipe.

[a] *City storm sewer system plan sheet number in parentheses.*

[b] *Diameter of circular reinforced concrete pipe unless noted otherwise.*

[c] *Parallel 15-inch-diameter clay storm sewers.*

[d] *Parallel 12-inch-diameter clay storm sewers.*

[e] *Actual capacity limited to four cubic feet per second by downstream 12-inch clay storm sewer in alley.*

[f] *Nonstandard size 36-inch-wide by 28-inch-high reinforced concrete pipe arch or 38-inch-wide by 24-inch-high horizontal elliptical reinforced concrete pipe assumed for hydraulic capacity determination.*

Source: SEWRPC.

Table 74

ALTERNATIVE AU-2: COMPONENTS AND COSTS OF THE STORM SEWER CONVEYANCE WITH CENTRALIZED DETENTION STORMWATER DRAINAGE PLAN FOR WEST BEND HYDROLOGIC UNIT MR-AU

Hydrologic Unit	Project and Component Description[a]	Estimated Cost	
		Capital[b]	Annual Operation and Maintenance[c]
MR-AU	1. Replace 12 feet of 12-inch clay storm sewer in the intersection of Elm Street and 10th Avenue with 21-inch storm sewer at a slope of 1.2 percent	$ 1,000	$ 0
	2. Replace 283 feet of 15-inch clay storm sewer in Elm Street with 21-inch storm sewer at a slope of 1.2 percent	27,000	0
	3. Replace 38 feet of 15-inch clay storm sewer in the intersection of Elm Street and 9th Avenue with 24-inch storm sewer at a slope of 2.2 percent	4,000	0
	4. Replace 261 feet of 15-inch clay storm sewer in 9th Avenue with 18-inch storm sewer at a slope of 0.45 percent	21,000	0
	5. Replace 47 feet of six-inch clay storm sewer in the intersection of Cedar Street and 10th Avenue with 12-inch storm sewer	2,000	0
	6. Replace 85 feet of 12-inch clay storm sewer in 10th Avenue with 12-inch storm sewer at a slope of 2.6 percent	4,000	0
	7. Replace 26 feet of 12-inch clay storm sewer in the intersection of Cedar Street and 10th Avenue with 12-inch storm sewer at a slop of 3 percent	1,000	0
	8. Replace 167 feet of 18-inch clay storm sewer in an easement east of 8th Avenue with 21-inch storm sewer at a slope of 4.9 percent	16,000	0
	9. Replace 300 feet of 30-inch clay storm sewer in an alley south of Cedar Street between 8th 9th Avenues and in an easement between the alley and 9th Avenue with 30-inch storm sewer at a slope of 1.2 percent	45,000	0
	10. Replace 340 feet of 24-inch reinforced concrete and clay storm sewer in the intersection of Cedar Street and 8th Avenue and in Cedar Street between 7th and 8th Avenues with 30-inch storm sewer at a slope of 3.6 percent	50,000	0
	11. Replace 179 feet of 24-inch clay storm sewer in Cedar Street between 7th Avenue and Main Street with 30-inch storm sewer	27,000	0
	12. Replace 65 feet of 15-inch clay storm sewer in Cedar Street between 7th Avenue and Main Street with 30-inch storm sewer at a slope of 2.5 percent	10,000	-10
	13. Replace 283 feet of 36-inch reinforced concrete and corrugated metal storm sewer at the hydrologic unit outlet to the Milwaukee River with 42-inch storm sewer at a slope of 0.77 percent	64,000	0
	14. Replace 38 feet of 12-inch storm sewer in Main Street with 18-inch storm sewer	3,000	0
	15. Replace 187 feet of 30-inch storm sewer in Main Street with 24-inch storm sewer at a slope of 0.89 percent	21,000	0

Table 74 (continued)

Hydrologic Unit	Project and Component Description[a]	Estimated Cost	
		Capital[b]	Annual Operation and Maintenance[c]
MR-AU (continued)	16. Replace 386 feet of 30-inch storm sewer in Main Street with 42-inch storm sewer at a slope of 0.79 percent	$ 86,000	$ 0
	17. Construct detention basin AU-1 with a 100-year storm storage volume of 0.6 acre-feet	140,000	1,900
	18. 70 feet of 24-inch-diameter storm sewer for basin AU-1 inlet	8,000	0
	19. 40 feet of 15-inch-diameter storm sewer for basin AU-1 outlet	3,000	0
- -	Total	$533,000	$1,900

[a] *All new and replacement storm sewers are reinforced concrete pipe.*

[b] *Includes 35 percent for engineering, administration, and contingencies. Costs are for year 1991 with Engineering News-Record Construction Cost Index = 5,015.*

[c] *Costs were noted to be zero when the alternative proposed replacement of a component with a component having similar operation and maintenance cost. Negative costs were noted when the replacement component was estimated to have a lower operation and maintenance cost than that of the existing facility.*

Source: SEWRPC.

pollutants carried by the runoff, and 2) to avoid erosion of the steep banks adjacent to the wetland depressions and the resulting sedimentation in the wetlands. It is also essential that the City construction erosion control ordinance be strictly enforced to prevent erosion and sedimentation during construction within the hydrologic unit.

Hydrologic Unit MR-AW

Evaluation of the Stormwater Management System: Hydrologic Unit MR-AW is a 0.10-square-mile area located along the Milwaukee River, as shown on Map 1 in Chapter I of this volume. Existing land uses in the hydrologic unit are agricultural and wetlands. Under planned year 2010 conditions, about 50 percent of the hydrologic unit would be developed for urban uses, predominantly medium-density residential, with a small amount of industrial land. The remaining 50 percent would be devoted to wetlands and other open lands in the Milwaukee River floodplain and the primary environmental corridor along the River. The existing drainage patterns in the hydrologic unit consist of roadside swales and overland flow directly to the Milwaukee River. There are no identified intermittent or perennial streams within the hydrologic unit.

Owing to the relatively low development density of the hydrologic unit under existing conditions and to the existence of a drainage system adequate for such development, there are no known existing, significant stormwater drainage problems in the unit.

Recommended Stormwater Management Plan: The hydrologic unit concerned is undeveloped and has drainage patterns consisting primarily of overland flow directly to the Milwaukee River. On the basis of planned development densities, the unit could be adequately drained through a simple system of storm sewers and overland flow. The configuration of the stormwater management system for such an area would, to a large extent, be dictated by a future street and lot layout. Specific stormwater drainage facilities would be established by developers and City staff during the design and review processes for proposed development. Detention storage would not be required because increases in rates of runoff would have no significant impact on peak flows in the Milwaukee River; however, the provision of such storage could be considered at the time of development if it were possible to achieve a cost saving in the conveyance system through the reduction of peak flows within the hydrologic unit. Drainage improvements in this unit would have only a small impact on the City capital improvements budget since most facilities would be paid for by private developers.

Hydrologic Unit MR-AX

Evaluation of the Stormwater Management System: Hydrologic Unit MR-AX is a 0.01-square-mile area located along the Milwaukee River, as shown on Map 1 in Chapter I of this volume. Under existing land use conditions, the hydrologic unit is essentially in rural uses which are wetlands, agricultural, and pasture. Part of the hydrologic unit is located within the 100-year recurrence interval floodplain of the Milwaukee River. Under planned year 2010 conditions, the hydrologic unit would essentially remain in rural open space uses and no urban development is planned. The existing drainage patterns in the hydrologic unit consist of overland flow directly to the Milwaukee River and there are no known existing, significant stormwater drainage problems in the unit.

Plan Recommendation: Because no urban development is planned for the hydrologic unit and no increase in stormwater runoff is expected, the recommended plan contains no new stormwater management measures for this Hydrologic Unit.

Hydrologic Unit MR-AY

Evaluation of the Stormwater Management System: Hydrologic Unit MR-AY is a 0.19-square-mile area located along the Milwaukee River, as shown on Map 1 in Chapter I of this volume. Under existing land use conditions, approximately 6 percent of the hydrologic unit is developed in urban land uses. Under planned year 2010 conditions, approximately 64 percent of the unit is anticipated to be developed in urban land uses, predominantly medium-density residential. The remaining 36 percent would be devoted to prime agricultural land and the primary environmental corridor along the Milwaukee River. The existing stormwater management system consists of roadway swales and cross culverts. There are no identified intermittent or perennial streams within the hydrologic unit. Owing to the low development density of the hydrologic unit under existing conditions and to the existence of a drainage system adequate for such development, there are no known existing, significant stormwater drainage problems in the unit.

Alternative Stormwater Drainage Plans: The following two alternative stormwater management plans were developed to serve planned development in this hydrologic unit: 1) a storm sewer conveyance plan and 2) a storm sewer conveyance with centralized detention plan.

Alternative Plan No. AY-1, Storm Sewer Conveyance: The storm sewer conveyance alternative plan calls for the provision of new storm sewers to serve planned development. This alternative includes 4,720 lineal feet of new storm sewer, ranging in size from 12- to 36-inch-diameter reinforced concrete pipe. The alternative also calls for turf-lined open channels with lengths of 25 and 35 feet at two proposed storm sewer outfalls. Map 9 shows the approximate location and alignment of the facilities proposed under this alternative. Table 75 presents the salient characteristics and estimated costs of the storm sewers and open channels comprising this alternative plan. The total present value cost of this alternative plan is $415,000, consisting of an estimated capital cost of $386,000 and an estimated annual operation and maintenance cost of $1,860.

Alternative Plan No. AY-2, Storm Sewer Conveyance with Centralized Detention: Map 10 shows the approximate location, alignment, and configuration of the facilities called for under this alternative. Because of the reduction in peak 10-year recurrence interval flood flows achieved through the provision of dry detention basin AY-1 in subbasin MR247 northeast of the intersection of Salisbury Road and Woodford Drive, this alternative avoids the installation of approximately 575 feet of storm sewer proposed under Alternative AY-1 and enables the use of 685 feet of smaller diameter pipes than are called for under Alternative AY-1. Table 76 presents the salient characteristics and estimated costs of the components of this alternative. The total present value cost of this alternative plan is $464,000, consisting of an estimated capital cost of $405,000, and an estimated annual operation and maintenance cost increase of $3,780.

Table 75

ALTERNATIVE AY-1: COMPONENTS AND COSTS OF THE STORM SEWER CONVEYANCE STORMWATER DRAINAGE PLAN FOR WEST BEND HYDROLOGIC UNIT AY

Hydrologic Unit	Project and Component Description[a]	Estimated Cost	
		Capital[b]	Annual Operation and Maintenance
AY	1. Install 660 feet of 12 inch storm sewer	$ 33,000	$ 270
	2. Install 1,220 feet of 15-inch storm sewer	76,000	490
	3. Install 1,130 feet of 18-inch storm sewer	76,000	450
	4. Install 425 feet of 21-inch storm sewer	29,000	170
	5. Install 35 feet of 24-inch storm sewer	3,000	10
	6. Install 370 feet of 27-inch storm sewer	34,000	100
	7. Install 555 feet of 30-inch storm sewer	71,000	230
	8. Install 325 feet of 36-inch storm sewer	63,000	60
	9. Construct 35 foot-long, turf-lined open channel from 24-inch-diameter storm sewer to Milwaukee River	500	30
	10. Construct 25 foot-long, turf-lined open channel from 18-inch-diameter storm sewer to Milwaukee River	400	50
- -	Total	$385,900	$1,860

[a] *All new and replacement storm sewers are reinforced concrete pipe.*

[b] *Includes 35 percent for engineering, administration, and contingencies. Costs are for year 1991 with Engineering News-Record Construction Cost Index = 5,015.*

Source: SEWRPC.

Table 76

ALTERNATIVE AY-2: COMPONENTS AND COSTS OF THE STORM SEWER CONVEYANCE WITH CENTRALIZED DETENTION STORMWATER DRAINAGE PLAN FOR WEST BEND HYDROLOGIC UNIT MR-AY

Hydrologic Unit	Project and Component Description[a]	Estimated Cost	
		Capital[b]	Annual Operation and Maintenance
AY	1. Install 1,020 feet of 12 inch storm sewer	$ 51,000	$ 410
	2. Install 1,220 feet of 15-inch storm sewer	76,000	490
	3. Install 845 feet of 18-inch storm sewer	53,000	340
	4. Install 750 feet of 21-inch storm sewer	60,000	300
	5. Install 35 feet of 24-inch storm sewer	3,000	10
	6. Install 275 feet of 27-inch storm sewer	26,000	100
	7. Construct 35 foot-long, turf-lined open channel from 24-inch-diameter storm sewer to Milwaukee River	500	30
	8. Construct 25 foot-long, turf-lined open channel from 18-inch-diameter storm sewer to Milwaukee River	400	50
	9. Construct dry detention basin AY-1 with a 10-year recurrence interval storm volume of 1.5 acre-feet	135,000	2,050
- -	Total	$404,900	$3,780

[a] *All new and replacement storm sewers are reinforced concrete pipe.*

[b] *Includes 35 percent for engineering, administration, and contingencies. Costs are for year 1991 with Engineering News-Record Construction Cost Index = 5,015.*

Source: SEWRPC.

Evaluation of Alternative Stormwater Drainage Plans: The foregoing information provides a basis for a comparative evaluation of the two alternative stormwater drainage plans. Each alternative was designed to resolve potential existing and future drainage problems within the hydrologic unit. Thus, the principal criteria for the comparative evaluation were reduced to cost and implementability.

Alternative AY-1 is less costly than Alternative AY-2. Alternative AY-1 would enable more land to be developed in medium-density residential uses because it would not require the construction of detention basin AY-1. Thus, Alternative AY-1 might be somewhat more easily implemented than Alternative AY-2.

Recommended Stormwater Management Plan: Because of the lower cost and more favorable implementability of Alternative AY-1, Storm Sewer Conveyance, that alternative is recommended for adoption in this hydrologic unit. The components and costs of the recommended plan are set forth in Table 9. The approximate location, alignment, and configuration of the recommended facilities are shown graphically on Map 14.

Hydrologic Unit MR-AZ

Evaluation of the Stormwater Management System: Hydrologic Unit AZ is a 0.04-square-mile area located along the Milwaukee River, as shown on Map 1 in Chapter I of this volume. Under existing land use conditions, the hydrologic unit is essentially entirely rural, including agricultural, woodland, and wetland uses. Under planned year 2010 conditions, the hydrologic unit would be about 89 percent developed for urban use, predominantly government and institutional with some low- and medium-density residential. The remaining 11 percent would be devoted to wetlands and woodlands in the Milwaukee River floodplain and the primary environmental corridor along the River. Under existing conditions, runoff from the unit is conveyed to the Milwaukee River through overland flow, roadside swales, and culverts. There are no identified intermittent or perennial streams within the hydrologic unit.

Owing to the relatively low development density of the hydrologic unit under existing conditions and to the existence of a drainage system adequate for such development, there are no known existing, significant stormwater drainage problems in the unit.

Recommended Stormwater Management Plan: The hydrologic unit concerned is undeveloped and it has drainage patterns consisting primarily of overland flow to the Milwaukee River. On the basis of planned development densities, the planned urban portions of the unit could be adequately drained through a simple system of overland flow, swales, and open channels. The configuration of the stormwater management system for such an area would, to a large extent, be dictated by a future street, building, and lot layout. It is recommended that a trapezoidal, turf-lined open channel with a minimum length of 285 feet, a three-foot bottom width and average side slopes of one vertical on four horizontal, or other equivalent shape, be constructed through the area of proposed low-density residential development north of Woodford Drive. A small, meandering low-flow channel could be provided within the flood channel. In the final design stage, the channel cross-section shape and the channel alignment could be refined to provide an attractively landscaped feature within the planned residential setting. Any realignment would involve changes in the minimum channel length.

The channel would convey runoff from the proposed upstream government and institutional development as well as from the low-density residential areas. The existing 25-foot-long, 30-inch-diameter steel pipe under the Wisconsin Central Transportation Corporation at the downstream end of the proposed open channel would be adequate to convey the estimated peak rate of runoff from a 100-year recurrence interval storm under planned land use and drainage conditions.

A 0.25-acre wet detention basin for the control of nonpoint source pollution, designated basin WD20, is recommended under the water quality management plan element set forth in Chapter IV of this volume. That basin would be located on the south side of Woodford Drive. The need to control the peak two-year recurrence interval rate of runoff under planned land use conditions through the provision of expanded live storage detention basin WD20 was investigated. That investigation was made because an increase in the peak flood flows of the more frequent floods could increase erosion in the wooded primary environmental corridor along the banks of the Milwaukee River at the unit outlet. It was found that the two-year flood flow would be approximately equal under existing and planned conditions. Thus, expansion of basin WD20 to control the runoff from frequent storms was not considered to be necessary.

The recommended drainage plan, along with nonpoint source control measures recommended in Chapter IV of this volume, is summarized in graphic form on Map 14. The components and costs of the recommended plan, including measures for the control of nonpoint source pollution, are set forth in Table 9. The total present value of this plan is about $4,500, consisting of an estimated capital cost of $3,000, and an estimated annual operation and maintenance cost increase of $100.

Hydrologic Unit MR-BA

Evaluation of the Stormwater Management System: Hydrologic Unit MR-BA is a 0.02-square-mile area located along the Milwaukee River, as shown on Map 1 in Chapter I of this volume. Under existing land use conditions, the hydrologic unit is entirely cropland. Under planned year 2010 conditions, about 79 percent of the hydrologic unit would be developed in urban uses, predominantly medium-density residential. The remaining 21 percent would be devoted to open lands in the Milwaukee River floodplain and the primary environmental corridor along the River. The existing drainage patterns in the hydrologic unit consist of overland flow and concentrated overland flow to the Milwaukee River. There are no identified intermittent or perennial streams within the hydrologic unit.

Owing to the low development density of the hydrologic unit under existing conditions and to the existence of a drainage system adequate for such development, there are no known existing, significant stormwater drainage problems in the unit.

Recommended Stormwater Management Plan: On the basis of planned development densities and under planned conditions, the hydrologic unit could be adequately drained through a simple system of storm sewers and overland flow. The configuration of the stormwater management system for such an area would, to a large extent, be dictated by a future street and lot layout. Specific stormwater drainage facilities would be established by developers and City staff during the design and review processes for proposed development.

Detention storage would not be required because increases in rates of runoff would have no significant impact on peak flows in the Milwaukee River; however, the provision of such storage could be considered at the time of development if it were possible to achieve a cost saving in the conveyance system through the reduction of peak flows within the hydrologic unit. Drainage improvements in this unit would have only a small impact on the City capital improvements budget since most facilities would be paid for by private developers.

Hydrologic Unit MR-BB

Evaluation of the Stormwater Management System: Hydrologic Unit MR-BB is a 0.02-square-mile area located along the Milwaukee River, as shown on Map 1 of Chapter I of this volume. Under existing land use conditions, 5 percent of the hydrologic unit is developed in medium-density residential uses, with the remaining land consisting of woodlands, wetlands, and open lands. The hydrologic unit is located almost completely within the 100-year recurrence interval floodplain of the Milwaukee River and within a primary environmental corridor. Under planned year 2010 conditions, 95 percent of the hydrologic unit would remain as woodlands, wetlands, and open lands.

The existing drainage patterns in the hydrologic unit consist of overland flow directly to the Milwaukee River; because of the low density of development there are no known existing, significant stormwater drainage problems in the unit.

Plan Recommendation: Because no new urban development is planned for the hydrologic unit and no increase in stormwater runoff is expected, the recommended plan contains no new stormwater management measures for this hydrologic unit.

Hydrologic Unit MR-BC

Evaluation of the Stormwater Management System: Hydrologic Unit MR-BC is a 0.46-square-mile area and is located on the Milwaukee River, as shown on Map 1 in Chapter I of this volume. This hydrologic unit includes the following twelve subbasins: MR46D (35.3 acres), MR53D (23.4 acres), MR54 (62.0 acres), MR55D (4.7 acres), MR56 (41.0 acres), MR56A (5.0 acres), MR297-1 (29.3 acres), MR389D (41.5 acres), MR390D (10.9 acres), MR400D (20.2 acres), MR454D (7.3 acres), and MR603D (14.3 acres). There are no intermittent or perennial streams identified on existing large-scale topographic maps prepared by the Regional Planning Commission for the City of West Bend in 1988 or on the 7.5-minute-quadrangle map of the area prepared by the U. S. Geological Survey. However, on the basis of field inspection and upon review of the 1990 Regional Planning Commission ratioed and rectified aerial photograph for the Northeast one-quarter of U. S. Public Land Survey Section 13, Township 11 North, Range 19 East, there is a stream located in subbasin MR56.

Subbasins MR46D and MR54: Under existing conditions, the land in these subbasins is predominantly cropland. Under planned year 2010 conditions, 87 percent of the subbasins would be developed in medium-density single- and two-family residences. The remaining 13 percent would be devoted to primary environmental corridor and open space uses. Conceptual street layouts for future development in these subbasins were obtained from the City of West Bend and were used to size stormwater drainage facilities for those subbasins. Those facilities are described below.

Subbasins MR56 and MR297-1: Runoff from existing governmental and institutional development in subbasin MR297-1 drains to the south, passing under Washington Street (STH 33) in a 42-inch-diameter reinforced concrete pipe culvert which discharges to the unnamed stream which flows through rural portions of subbasin MR56 before discharging to the Milwaukee River. Under existing conditions, the land use in these subbasins is about 64 percent urban, consisting primarily of government and institutional uses. Under planned year 2010 conditions, these subbasins would be about 87 percent developed for urban uses, predominantly government and institutional. The remaining 13 percent would be devoted to primary environmental corridor and park and recreation uses. The stormwater drainage needs of these subbasins under planned land use conditions were evaluated in order to determine the best alternative plan for providing drainage. That evaluation is described below.

Subbasins MR389D, MR390D, and MR400D: These subbasins are located in Riverside Park, with the exception of the extreme eastern and southern portions of MR389D, where medium-density residential development is proposed in Addition No. 5 to the Gatewood Highlands subdivision. The City has received a grading plan for the proposed addition to the subdivision which calls for runoff to be collected in a detention basin which would discharge to Riverside Park through a shallow grassed swale. The proposed stormwater drainage facilities appear to be adequate and no further recommendations are considered to be necessary.

Subbasins MR53D, MR55D, MR56A, MR454D, and MR603D: Under existing conditions, runoff from these subbasins drains to the Milwaukee River through overland flow and concentrated overland flow. Under planned year 2010 land use conditions, the portions of these subbasins which are not developed for urban uses would be part of the primary environmental corridor along the Milwaukee River and Riverside Park.

Existing land use in subbasin MR53D is entirely rural, consisting primarily of cropland and woodlands. Under planned land use conditions it is anticipated that 64 percent of the subbasin will be developed for medium-density single-family residential uses. The remaining 36 percent would be devoted to primary environmental corridor and park and recreation uses.

Existing land use in subbasin MR55D is entirely rural, consisting primarily of cropland and open lands. Under planned land use conditions it is anticipated that 89 percent of the subbasin will be developed for medium-density single- and two-family residential uses. The remaining 11 percent would be devoted to primary environmental corridor.

Existing land use in subbasin MR56A is 83 percent rural, with the remainder devoted to industrial uses. Under planned land use conditions it is anticipated that 55 percent of the subbasin will be developed for industrial uses. The remaining 45 percent would be devoted to primary environmental corridor and park and recreation uses.

Existing land use in subbasin MR454D is 73 percent rural, with the remainder in industrial uses. Under planned land use conditions it is anticipated that 46 percent of the subbasin will be developed for industrial uses. The remaining 54 percent would be devoted to primary environmental corridor and park and recreation uses.

Owing to the relatively low development densities under existing conditions and to the existence of a drainage system adequate for such development, there are no known existing, significant stormwater drainage problems in these subbasins.

On the basis of planned development densities, these subbasins could be adequately drained through a simple system of storm sewers, swales, and overland flow. The configuration of the stormwater management system for such areas would, to a large extent, be dictated by future building, street, and lot layouts. Specific stormwater drainage facilities would be established by developers and City staff during the design and review processes for proposed development.

Detention storage would not be required because increases in rates of runoff would have no significant impact on peak flows in the Milwaukee River; however, the provision of such storage could be considered at the time of development if it were possible to achieve a cost savings in the conveyance system through the reduction of peak flows within the subbasins. Drainage improvements in this unit would have only a small impact on the City capital improvements budget since most facilities would be paid for by the private sector.

Alternative Stormwater Drainage Plans: As stated above, detailed stormwater management alternative plans were considered for subbasins MR46D and MR54, acting as a unit, and for subbasins MR56D and MR297-1, acting as a unit.

Subbasins MR46D and MR54: The following two alternative stormwater management plans were considered for these subbasins: 1) a storm sewer conveyance plan and 2) a storm sewer conveyance with decentralized detention plan. Conceptual street layouts for future development in these subbasins were obtained from the City of West Bend and were used to size stormwater drainage facilities.

Alternative Plan No. BC-1, Storm Sewer Conveyance: The storm sewer conveyance alternative plan calls for the provision of new storm sewers to serve planned development. This alternative includes 2,975 lineal feet of new storm sewer, ranging in size from 12- to 42-inch-diameter reinforced concrete pipe. The water quality management plan presented in Chapter IV of this volume calls for the construction of wet detention basin WD24 at the outlet of subbasin MR54. While some degree of water quantity control may be provided by that detention basin because of the need to excavate to accommodate the proposed inflowing storm sewer, the basin is intended for the control of nonpoint source pollution and the provision of quantity control is not essential. Map 9 shows the approximate location and alignment of the new storm sewers proposed under this alternative. Table 77 presents the salient characteristics and estimated costs of the storm sewers comprising this alternative plan. The total present value cost of this alternative plan is $335,000, consisting of an estimated capital cost of $319,000 and an estimated annual operation and maintenance cost of $1,010.

Alternative Plan No. BC-2, Storm Sewer Conveyance with Decentralized Detention: Map 11 shows the approximate location, alignment, and configuration of the facilities called for under this alternative. Because of the reduction in peak 10-year recurrence interval flood flows achieved through the provision of 0.45-acre-foot of detention storage in dry detention basin BC-1, this alternative enables the use of smaller diameter storm sewers. In addition to dry detention basin BC-1, this alternative calls for the installation of 2,865 lineal feet of new storm sewer, ranging in size from 12- to 36-inch-diameter reinforced concrete pipe. As under Alternative BC-1, wet detention basin WD24 would be constructed at the outlet of subbasin MR54. Table 78 presents the salient characteristics and estimated costs of the components of this alternative. The total present value cost of this alternative plan is $393,000, consisting of an estimated capital cost of $354,000, including land acquisition for the dry detention basin, and an estimated annual operation and maintenance cost increase of $2,480.

Evaluation of Alternative Stormwater Drainage Plans: The foregoing information provides a

Table 77

ALTERNATIVE BC-1: COMPONENTS AND COSTS OF THE STORM SEWER CONVEYANCE STORMWATER DRAINAGE PLAN FOR WEST BEND HYDROLOGIC UNIT MR-BC

Hydrologic Unit	Project and Component Description[a]	Estimated Cost	
		Capital[b]	Annual Operation and Maintenance
MR-BC	1. Install 205 feet of 12-inch storm sewer	$ 9,000	$ 80
	2. Install 370 feet of 18-inch storm sewer	23,000	150
	3. Install 360 feet of 24-inch storm sewer	30,000	140
	4. Install 940 feet of 27-inch storm sewer	88,000	350
	5. Install 570 feet of 36-inch storm sewer	75,000	110
	6. Install 530 feet of 42-inch storm sewer	84,000	100
	7. Construct 75-foot-long, riprap-lined open channel from detention basin WD24 outlet to Milwaukee River	4,000	30
	8. Construct 120-foot-long, riprap-lined open channel from 27-inch storm sewer outfall to Milwaukee River	6,000	50
- -	Total	$319,000	$1,010

[a] *All new and replacement storm sewers are reinforced concrete pipe.*

[b] *Includes 35 percent for engineering, administration, and contingencies. Costs are for year 1991 with Engineering News-Record Construction Cost Index = 5,015.*

Source: SEWRPC.

Table 78

ALTERNATIVE BC-2: COMPONENTS AND COSTS OF THE STORM SEWER CONVEYANCE WITH DECENTRALIZED DETENTION STORMWATER DRAINAGE PLAN FOR WEST BEND HYDROLOGIC UNIT MR-BC

Hydrologic Unit	Project and Component Description[a]	Estimated Cost	
		Capital[b]	Annual Operation and Maintenance
MR-BC	1. Install 205 feet of 12-inch storm sewer	$ 9,000	$ 80
	2. Install 330 feet of 15-inch storm sewer	17,000	130
	3. Install 690 feet of 18-inch storm sewer	43,000	250
	4. Install 360 feet of 24-inch storm sewer	30,000	140
	5. Install 750 feet of 27-inch storm sewer	70,000	300
	6. Install 530 feet of 36-inch storm sewer	70,000	100
	7. Construct 75-foot-long, riprap-lined open channel from detention basin WD24 outlet to Milwaukee River	4,000	30
	8. Construct 120-foot-long, riprap-lined open channel from 27-inch storm sewer outfall to Milwaukee River	6,000	50
	9. Construct dry detention basin BC-1 with a 10-year recurrence interval storm storage volume of 0.45 acre-foot	105,000	1,400
- -	Total	$354,000	$2,480

[a] *All new and replacement storm sewers are reinforced concrete pipe.*

[b] *Includes 35 percent for engineering, administration, and contingencies. Costs are for year 1991 with Engineering News-Record Construction Cost Index = 5,015.*

Source: SEWRPC.

basis for a comparative evaluation of the two alternative stormwater drainage plans. Each alternative was designed to serve planned development within the subbasins. Each, when expanded to include the nonpoint source pollution control measures recommended in Chapter IV of this volume, would achieve the same degree of abatement of nonpoint source pollution. Thus, the principal criteria for the comparative evaluation were reduced to cost and implementability.

Alternative BC-1 is less costly than Alternative BC-2 and would be more easily implemented since it would involve installation of storm sewers in new streets, rather than a combination of storm sewer installation and detention basin construction on private property which could be developed if dry basin BC-1 were not constructed.

Recommended Stormwater Management Plan: Because of the lower cost and more favorable implementability of Alternative BC-1, Storm Sewer Conveyance, that alternative is recommended for adoption in these subbasins. The components and costs of the recommended plan are set forth in Table 9. The approximate location, alignment, and configuration of the recommended facilities, including those for the control of nonpoint source pollution, are shown graphically on Map 14.

Subbasins MR56 and MR297-1: Because there is ample existing open land along the unnamed stream which traverses subbasin MR56, the alternative of utilizing the existing system of open channels and culverts was analyzed under planned development conditions. It was found that the existing 42-inch-diameter reinforced concrete culvert under Washington Street (STH 33) has adequate hydraulic capacity to convey the runoff from storms with recurrence intervals up to, and including, 100 years. The existing access road on the grounds of the Washington County Home and Hospital would be overtopped during a 100-year recurrence interval flood. That road is currently closed and is not required for access to the hospital. Thus, overtopping would not be create access problems.

The 100-year floodplain along the stream in subbasin MR56 would occupy a relatively narrow band along the stream. As shown on Map 14, during a 100-year flood the peak stage in the stream would rise to a level which would overtop the drainage divide along the east side of subbasin 56, resulting in flow through Riverside Park to the Milwaukee River. Reservation of the park land and the narrow band of land adjacent to the stream as floodplain is an appropriate and beneficial use of those open lands. Thus, preservation of the open lands in the 100-year recurrence interval floodplain of the stream is recommended as a viable means of providing stormwater drainage for these subbasins under planned land use conditions. It is also recommended that the existing culvert under Washington Street (STH 33) be retained. There are no costs assigned to this alternative because all the lands to be preserved as floodplain are owned by either the City or by Washington County. It is assumed that the County would be receptive to excluding development from the floodplain along the unnamed stream in lieu of incurring the expense associated with construction of an engineered stormwater drainage system.

Hydrologic Unit MR-BD

Evaluation of the Stormwater Management System: Hydrologic Unit MR-BD is a 0.09-square-mile area located along the Milwaukee River, as shown on Map 1 in Chapter I of this volume. Existing land uses in the hydrologic unit are 90 percent rural, including agricultural land, open lands, woodlands, and wetlands. The urban land use in the unit is comprised of a portion of the West Bend municipal wastewater treatment plant. Under planned year 2010 conditions, only about 39 percent of the hydrologic unit would be developed for urban uses, predominantly medium-density residential, but would include the existing portion of the municipal wastewater treatment facility. The remaining 61 percent would be devoted to wetlands and other open lands in the Milwaukee River floodplain and the primary environmental corridor along the River. The existing drainage patterns in the hydrologic unit consist of overland flow directly to the Milwaukee River. There are no identified intermittent or perennial streams within the hydrologic unit.

Owing to the relatively low development density of the hydrologic unit under existing conditions and to the existence of a drainage system adequate for such development, there are no known existing, significant stormwater drainage problems in the unit.

Recommended Stormwater Management Plan: The hydrologic unit concerned is undeveloped and it has drainage patterns consisting primarily of overland flow directly to the Milwaukee River. On the basis of planned development densities, the planned urban portions of the unit could be adequately drained through a simple system of storm sewers and overland flow. The configuration of the stormwater management system for such an area would, to a large extent, be dictated by a future street and lot layout. Specific stormwater drainage facilities would be established by developers and City staff during the design and review processes for proposed development. Detention storage would not be required because increases in rates of runoff would have no significant impact on peak flows in the Milwaukee River; however, the provision of such storage could be considered at the time of development if it were possible to achieve a cost savings in the conveyance system through the reduction of peak flows within the hydrologic unit. Drainage improvements in this unit would have only a small impact on the City capital improvements budget since most facilities would be paid for by private developers.

Hydrologic Unit MR-BE

Evaluation of the Stormwater Management System: Hydrologic Unit MR-BE is a 0.16-square-mile area located along the Milwaukee River, as shown on Map 1 in Chapter I of this volume. Under existing land use conditions, the hydrologic unit is almost entirely in rural uses, with agricultural use predominant. Under planned year 2010 conditions, about 80 percent of the hydrologic unit would be developed for commercial and industrial use. The remaining 20 percent would be devoted to primary environmental corridor and open space uses. Also, as noted in Chapter II of this volume, it is assumed that about 21 acres of land which currently drain to Wingate Creek would be filled and regraded as they are developed, so as to drain directly to the Milwaukee River. This area is shown on Map 10 and would be entirely tributary to this hydrologic unit. Thus, the recommended stormwater drainage facilities have been sized to account for this increase in tributary area.

The existing stormwater management system for this hydrologic unit generally consists of direct overland flow paths to the Milwaukee River. There are no identified intermittent or perennial streams located within the unit. Because of the low development density of the unit under existing conditions, there are no known existing stormwater drainage problems.

Alternative Stormwater Drainage Plans: Because planned development in the hydrologic unit is anticipated to be primarily commercial and industrial, storm sewer drainage facilities would be provided as requested by the City for commercial and industrial areas. The recommended water quality management plan presented in Chapter IV of this volume calls for the provision of wet basin WD7 near the outlet of subbasin MR51 and wet basin WD8 near the outlet of subbasin MR385, with both basins being located outside the 100-year recurrence interval floodplain of the Milwaukee River. Thus, on the basis of the planned land uses and the recommendation for the provision of wet detention, the only stormwater management option considered was storm sewer conveyance with centralized detention.

Recommended Stormwater Management Plan: The recommended plan calls for the provision of about 4,500 lineal feet of new storm sewers to serve planned development. These sewers would range in size from 24-inch reinforced concrete circular pipe to 58-inch-wide by 36-inch-high reinforced concrete pipe arch. Although intended strictly for water quality purposes, additional surcharge storage would be provided at wet basins WD7 and WD8 because of the need to excavate to an elevation at which the permanent pond would receive runoff from the upstream storm sewer system. This additional storage allows for a reduction in the length and size of downstream storm sewers from what would be required if the basins were not to be constructed.

The recommended drainage plan, along with nonpoint source control measures recommended in Chapter IV of this volume, is summarized in graphic form on Map 14. The components and costs of the recommended quantity control elements of the plan are set forth in Table 9. The total present value of this plan is about $824,000, consisting of an estimated capital cost of $777,000 and an estimated annual operation and maintenance cost increase of $3,010.

REFINEMENTS TO THE RECOMMENDED STORMWATER MANAGEMENT PLAN FOLLOWING REVIEW BY CITY STAFF

Some refinements were made in the recommended stormwater management plan as a result of review by City staff. Those refinements are described below.

Hydrologic Unit MR-K

At a November 23, 1993, interagency meeting of City and Regional Planning Commission staff, the City staff requested the evaluation of alternatives to locating proposed detention basin K-1 in an existing wetland. The request was made because of City concerns over the location of the basin in an area where infiltration of runoff to the groundwater could have adverse impacts on the quality of the municipal water supply. Two alternatives which are refinements of the recommended plan were developed.

Alternative Refinement No. 1 to the Recommended Plan, Storm Sewer Conveyance with Centralized Detention and Detention Basin K-1 Located to Serve Planned Development Only: To protect the municipal water supply from potential contamination, City staff suggested that the proposed site of detention basin K-1 be changed from the wetland south of Highland View Drive to the area west of the wetland. Locating the basin outside the wetland would enable the installation of a liner to seal the bottom and avoid infiltration of runoff. The installation of such a liner at the originally proposed wetland site would destroy the wetland and would, therefore, be undesirable and not feasible from a regulatory standpoint.

Changing the proposed site of the detention basin results in the detention of runoff from a smaller drainage area. It was assumed that the wetland would still store runoff from areas of existing medium-density residential development and from a woodland, both of which are tributary to the wetland.

This refinement to the recommended plan would change the recommended plan only with respect to the localized area upstream of the intersection of Highland View Drive and Bobolink Lane. Under the refinement, the existing 15- and 24-inch-diameter storm sewers in Highland View Drive would be maintained, but 514 feet of 18-inch-diameter storm sewer in Highland View Drive between Silverbrook Drive and Bobolink Lane would be replaced with 45-inch-wide by 29-inch-high elliptical storm sewer laid at a slope of 0.26 percent. Detention basin K-1 would have a 100-year recurrence interval storm peak storage volume of 0.7 acre-feet. The basin outlet would be a 140-foot-long, 12-inch-diameter reinforced concrete pipe connected to the existing 15-inch-diameter storm sewer in Highland View Drive. An impervious lining would be provided in the bottom and sides of the basin.

City staff also requested that the permanent pond for the control of nonpoint source pollution proposed to be incorporated in recommended detention basin WD4 be eliminated from the recommended plan. The reasons for elimination of the permanent pond are: 1) safety concerns regarding location of the proposed basin in a residential neighborhood on the grounds of Badger Middle School and 2) retaining usable dry-land open space which would be lost if a pond were constructed. The dry detention component of basin WD4 for water quantity control purposes would be retained under this refinement.

The total present value cost of this refined alternative plan is $4,097,000, consisting of an estimated capital cost of $4,011,000, including land acquisition for the detention basins, and an estimated annual operation and maintenance cost increase of $5,470. The capital and annual operation and maintenance costs include the total $279,000 and $1,900 costs, respectively, for basin WD4. Under Alternative Plan No. K-2, as described in the preceding section of this chapter, large portions of the total costs of basin WD4 were assigned to the water quality management element of the plan and up to 70 percent of the capital cost could have been paid with funds from the State of Wisconsin. With the water quality control benefits of the detention basin eliminated, State cost-sharing funds would no longer be available.

Alternative Refinement No. 2 to the Recommended Plan, Storm Sewer Conveyance with Centralized Detention and Detention Basin K-1 Eliminated: Under a second refinement to the recommended plan, detention basin K-1 would be eliminated. As under Alternative Refinement No. 1, it was assumed that the wetland would store runoff from areas of existing medium-density residential development and from a woodland, both of which are tributary to the wetland.

This refinement would change the recommended plan only in the localized area upstream of proposed dry detention basin K-2, which is to be located in Decorah Hills City Park. Under the refinement, 1) 90 feet of new 18-inch-diameter storm sewer would be installed in Highland View Drive upstream of the existing 15-inch-diameter storm sewer, 2) the existing 287 feet of 15-inch-diameter storm sewer would be replaced with 18-inch-diameter storm sewer, 3) the existing 296 feet of 24-inch-diameter storm sewer in Highland View Drive would be kept, 4) 514 feet of 18-inch-diameter storm sewer in Highland View Drive between Silverbrook Drive and Bobolink Lane would be replaced with 53-inch-wide by 34-inch-high horizontal elliptical storm sewer laid at a slope of 0.28 percent, 5) the existing 159 feet of 18-inch-diameter storm sewer in Highland View Drive east of Bobolink Lane would be replaced with two parallel 53-inch-wide by 34-inch-high horizontal elliptical storm sewers at a slope of 0.28 percent, and 6) two parallel 53-inch-wide by 34-inch-high horizontal elliptical storm sewers at a slope of 0.28 percent would be installed as the inlet to proposed detention basin K-2. The storm sewers listed under Items 1 through 3 would convey the peak rate of runoff from a 10-year recurrence interval storm, while the storm sewers called for under Items 4 through 6 would convey the peak rate of runoff from a 100-year storm.

Basin K-2 would store a peak 100-year storm volume of 3.9 acre-feet, an 0.6-acre-foot increase over the volume envisioned under the initial recommended plan. The additional storage volume could be accommodated within the excavation required for the basin which was originally recommended. Thus, there would be no additional cost to construct basin K-2.

As under Alternative Refinement No. 1, the permanent pond which was proposed to be incorporated into recommended detention basin WD4 would be eliminated but the dry detention component of basin WD4 would be retained.

The total present value cost of this refined alternative plan is $4,080,000, consisting of an estimated capital cost of $4,013,000, including land acquisition for the detention basins and an estimated annual operation and maintenance cost increase of $4,280. As under Alternative Refinement No. 1, the capital and annual operation and maintenance costs include the total $279,000 and $1,900 costs, respectively, for basin WD4. State cost-sharing funds would no longer be available for that basin since the water quality control component would be eliminated.

<u>Evaluation of Alternative Refinements to the Recommended Plan for Hydrologic Unit MR-K</u>: Each alternative refinement would resolve the identified existing drainage problems, would serve anticipated future development, and would avoid potential contamination of the municipal groundwater supply due to future development. The capital and present value costs of the alternative refinements are essentially equal. Thus, the principal criterion for the comparative evaluation was reduced to implementability.

Alternative Refinement No. 2, which would eliminate detention basin K-1, would not require the reservation of land for the provision of a detention basin. Such reservation of land would be required under Alternative Refinement No. 1. The additional land available under Refinement No. 2 could be used for development.

<u>Recommended Refined Stormwater Management Plan</u>: Because Alternative Refinement No. 2 is considered to be more readily implementable, it is recommended for adoption in this hydrologic unit. The components and costs of the refined recommended plan are set forth in Table 9. The approximate location, alignment, and configuration of the refined recommended facilities, including nonpoint source pollution control measures, are shown graphically on Map 14.

SUMMARY

The recommended stormwater management plan for the Milwaukee River drainage area in the City of West Bend was synthesized from the plans recommended for each of the 57 hydrologic units in the study area shown on Map 1 in Chapter I of this volume. The stormwater drainage element of the recommended plan includes the following components: 1) storm sewer conveyance, 2) storm sewer conveyance with centralized detention, 3) storm sewer and open channel conveyance, 4) storm sewer and open channel conveyance with centralized detention, 5) storm sewer conveyance with decentralized detention, 6) open channel conveyance, and 7) open channel conveyance with centralized detention. The components and costs of the recommended stormwater drainage plan are set forth in Table 9. The total capital cost of the recommended plan is about $22,602,000 and the estimated annual operation and maintenance

Table 79

HYDROLOGIC AND HYDRAULIC CHARACTERISTICS OF RECOMMENDED DETENTION BASINS IN THE MILWAUKEE RIVER DRAINAGE AREA

Hydrologic Unit	Basin Designation	Permanent Pond Area (acres)	Permanent Pond Volume (acre-feet)	Incremental Peak Pond Volume for Control of a 10-Year Storm^a (acre-feet)	Peak Pond Volume During a 10-Year Storm (cubic feet per second)	Peak Outflow from Detention Basin During a 10-Year Storm (cubic feet per second)	Incremental Peak Pond Volume During a 100-Year Storm^a (cubic feet per second)	Peak Pond Volume During a 100-Year Storm (acre-feet)	Peak Outflow from Detention Basin During a 100-Year Storm (cubic feet per second)
A	WD9	2.20	11.20	4.3	15.5	25	7.7	18.9	57
B	B-1	- -	- -	0.5	0.5	3	- -	- -	- -
D	WD10	1.60	8.00	2.9	10.9	17	4.9	12.9	42
E	E-1	- -	- -	1.6	1.6	11	1.9	1.9	37
H	WD25	0.68	3.40	1.7	5.1	14	3.2	6.6	36
K	K-2	- -	- -	- -	- -	- -	3.9	3.9	3
	K-3	- -	- -	- -	- -	- -	3.9	3.9	10
	WD4	- -	- -	- -	- -	- -	4.2	4.2	59
M	M-1	- -	- -	2.4	2.4	16	4.6	4.6	40
N	WD3	3.20	15.80	10.3	26.1	70	17.4	33.2	99
O	WD6	0.64	3.20	1.9	5.1	22	3.2	6.4	29
T	WD26	0.25	1.25	0.3	1.6	17	0.5	1.8	29
	WD27	0.25	1.25	- -	- -	- -	0.8	2.1	4
AS	WD28	0.27	1.40	1.1	2.5	11	- -	- -	- -

[a]For wet detention basins, this is the incremental volume above the permanent pond volume.

Source: SEWRPC.

cost increase is $40,650. The hydrologic and hydraulic characteristics of the recommended dual-purpose detention basins for water quantity and quality control are set forth in Table 79.

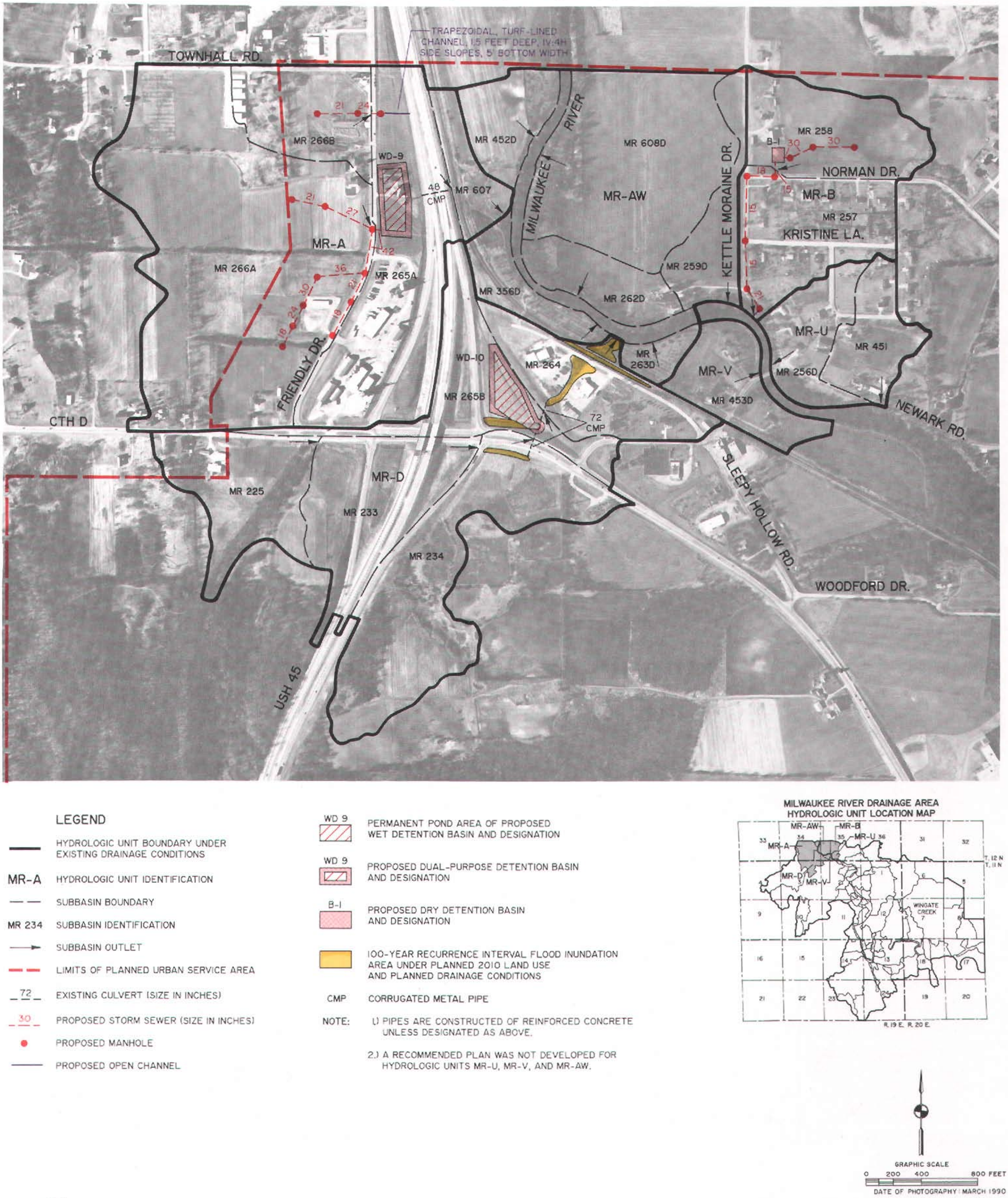
The recommended water quality management element of the plan, which is set forth in Chapter IV of this volume, includes 1) wet detention basins, 2) infiltration of runoff from parking lots serving hospitals, miscellaneous governmental and institutional facilities, and selected high-density residential development, 3) a street sweeping and catch basin cleaning program for commercial and industrial streets, 4) frequent sweeping of selected industrial parking and storage areas, and 5) continued enforcement of the City of West Bend construction erosion control ordinance. The stormwater drainage element and the water quality management plan element for the control of nonpoint source pollution were integrated into the comprehensive stormwater management plan shown in graphic form on Map 14.

Implementation of the recommended stormwater management system plan for the Milwaukee River drainage area will produce an adaptable and cost-effective stormwater management system which 1) provides minor and major stormwater drainage systems that are adequate to prevent the exposure of people to drainage-related inconvenience, nuisance flooding, and health and safety hazards during storms with recurrence intervals up to, and including, 10 years, and which reduce the exposure of real and personal property to damage during storms with recurrence intervals up to, and including, 100 years, 2) will effectively serve existing and proposed future land uses, and 3) will abate nonpoint source water pollution and help achieve the recommended water use objectives and supporting water quality standards for surface water bodies. The estimated total cost of the stormwater drainage and nonpoint source pollution control elements which comprise the recommended plan are set forth in Table 80.

Map 14

RECOMMENDED SYSTEM PLAN FOR STORMWATER MANAGEMENT FOR THE MILWAUKEE RIVER DRAINAGE AREA OUTSIDE THE WINGATE CREEK SUBWATERSHED IN THE CITY OF WEST BEND STUDY AREA

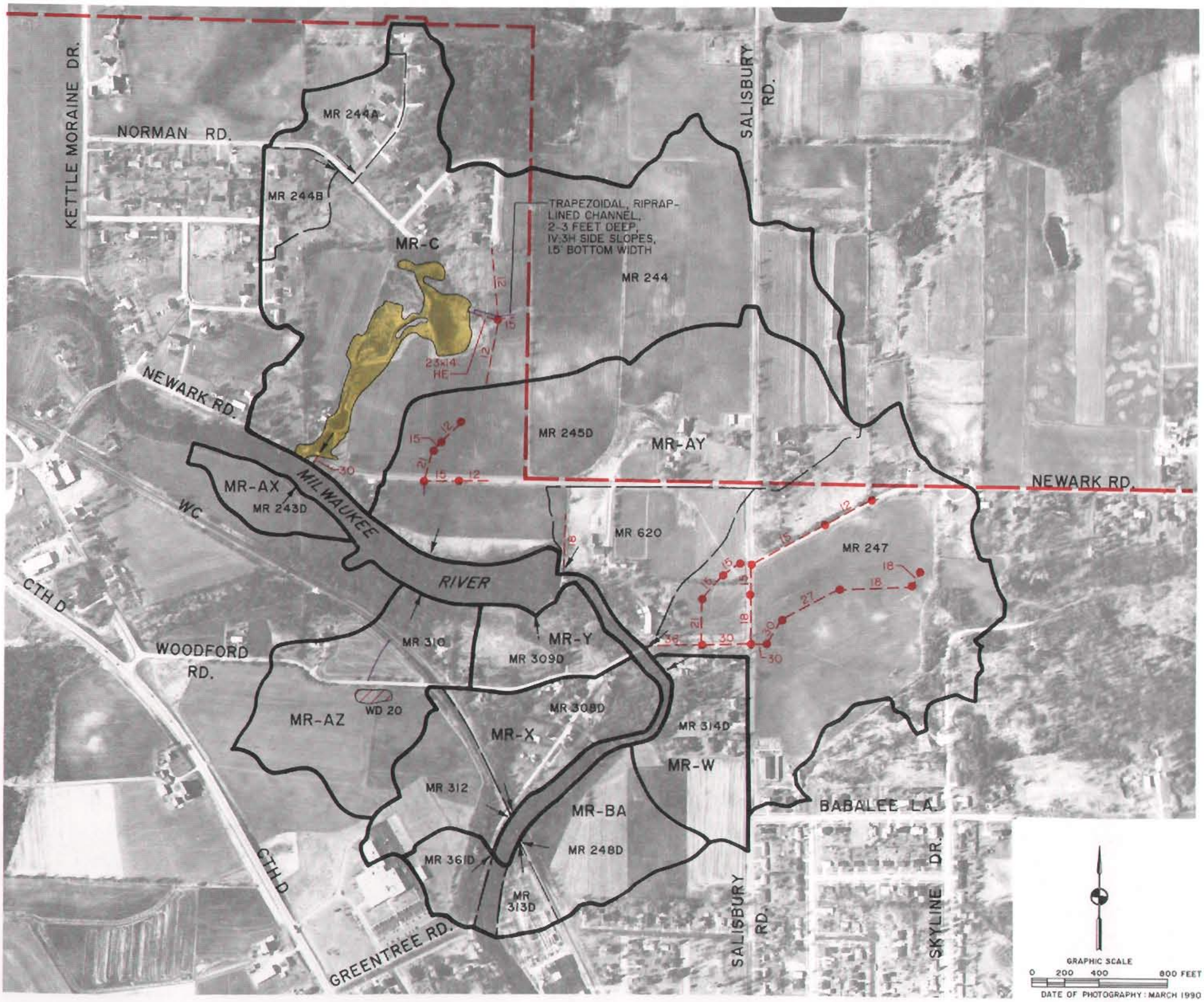
HYDROLOGIC UNITS MR-A, MR-B, MR-D, MR-U, MR-V, AND MR-AW



Map 14 (continued)

RECOMMENDED SYSTEM PLAN FOR STORMWATER MANAGEMENT FOR THE MILWAUKEE RIVER DRAINAGE AREA OUTSIDE THE WINGATE CREEK SUBWATERSHED IN THE CITY OF WEST BEND STUDY AREA

HYDROLOGIC UNITS MR-C, MR-W, MR-X, MR-Y, MR-AX, MR-AY, MR-AZ, AND MR-BA

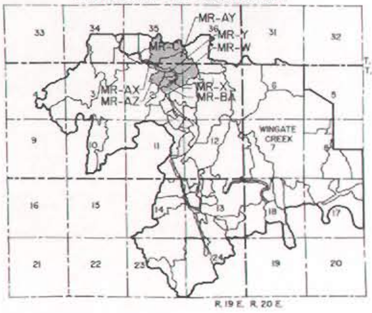


LEGEND

▬	HYDROLOGIC UNIT BOUNDARY UNDER EXISTING DRAINAGE CONDITIONS
MR-AY	HYDROLOGIC UNIT IDENTIFICATION
— —	SUBBASIN BOUNDARY
MR 310	SUBBASIN IDENTIFICATION
⟶	SUBBASIN OUTLET
▬ ▬	LIMITS OF PLANNED URBAN SERVICE AREA
30	PROPOSED REPLACEMENT CULVERT DESIGNED FOR 10-YEAR STORM (SIZE IN INCHES)
18	PROPOSED STORM SEWER (SIZE IN INCHES)
●	PROPOSED MANHOLE
—	PROPOSED OPEN CHANNEL
WD 20 ▨	PERMANENT POND AREA OF PROPOSED WET DETENTION BASIN AND DESIGNATION
🟨	100-YEAR RECURRENCE INTERVAL FLOOD INUNDATION AREA UNDER PLANNED 2010 LAND USE AND PLANNED DRAINAGE CONDITIONS
HE	HORIZONTAL ELLIPTICAL REINFORCED CONCRETE PIPE

NOTE:
1.) PIPES ARE CONSTRUCTED OF REINFORCED CONCRETE UNLESS DESIGNATED AS ABOVE.
2.) A RECOMMENDED PLAN WAS NOT DEVELOPED FOR HYDROLOGIC UNITS MR-W, MR-X, MR-Y, MR-AX, AND MR-BA.

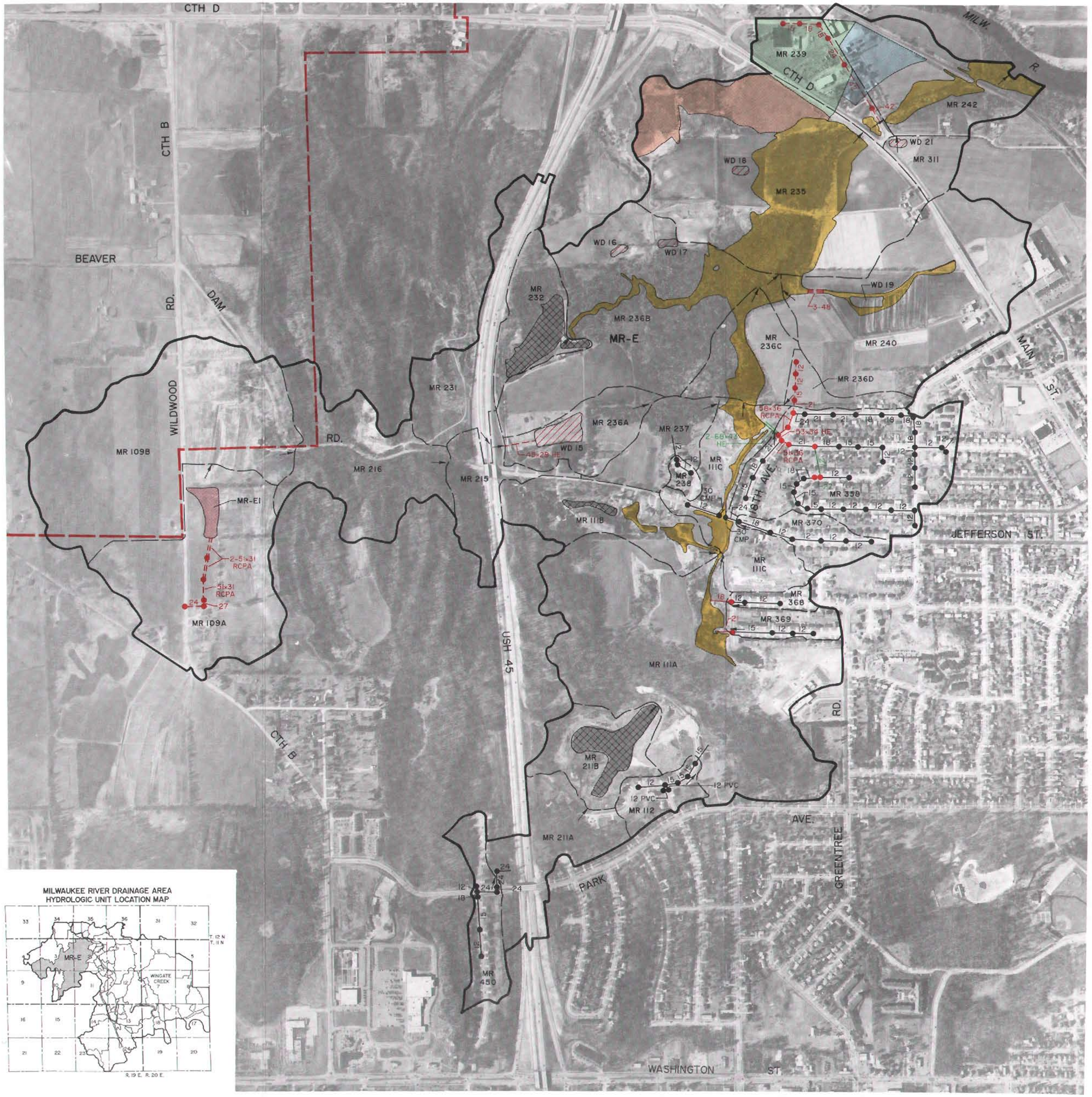
MILWAUKEE RIVER DRAINAGE AREA HYDROLOGIC UNIT LOCATION MAP



Map 14 (continued)

RECOMMENDED SYSTEM PLAN FOR STORMWATER MANAGEMENT FOR THE MILWAUKEE RIVER DRAINAGE AREA OUTSIDE THE WINGATE CREEK SUBWATERSHED IN THE CITY OF WEST BEND STUDY AREA

HYDROLOGIC UNIT MR-E



LEGEND

━	HYDROLOGIC UNIT BOUNDARY UNDER EXISTING DRAINAGE CONDITIONS
MR-E	HYDROLOGIC UNIT IDENTIFICATION
— —	SUBBASIN BOUNDARY
MR 236	SUBBASIN IDENTIFICATION
→	SUBBASIN OUTLET
— —	LIMITS OF PLANNED URBAN SERVICE AREA
21	EXISTING STORM SEWER TO BE RETAINED (SIZE IN INCHES)
●	EXISTING MANHOLE OR CATCHBASIN
30 CMP	EXISTING CULVERT (SIZE IN INCHES)
21	PROPOSED REPLACEMENT STORM SEWER DESIGNED FOR 10-YEAR STORM (SIZE IN INCHES)
27	PROPOSED REPLACEMENT STORM SEWER DESIGNED FOR 100-YEAR STORM (SIZE IN INCHES)
21	PROPOSED STORM SEWER OR CULVERT (SIZE IN INCHES)
●	PROPOSED MANHOLE
—	PROPOSED OPEN CHANNEL
▩	EXISTING CONSTRUCTED DETENTION BASIN
WD 15 ▨	PERMANENT POND AREA OF PROPOSED WET DETENTION BASIN AND DESIGNATION
MR-E1 🟥	PROPOSED DRY DETENTION BASIN AND DESIGNATION
🟧	100-YEAR RECURRENCE INTERVAL FLOOD INUNDATION AREA UNDER PLANNED 2010 LAND USE AND PLANNED DRAINAGE CONDITIONS
🟦	PROPOSED INFILTRATION SYSTEMS TO RETAIN RUNOFF FROM 50% OF PARKING LOT AREA
🟩	AREA TRIBUTARY TO STREET TO BE SWEPT 11 TIMES IN SPRING AND 11 TIMES IN FALL
🟥	AREA TRIBUTARY TO INDUSTRIAL OR COMMERCIAL PARKING LOT OR STORAGE AREA TO BE SWEPT WEEKLY IN SPRING, SUMMER, AND FALL
CMP	CORRUGATED METAL PIPE
CMPA	CORRUGATED METAL PIPE ARCH
HE	HORIZONTAL ELLIPTICAL REINFORCED CONCRETE PIPE
RCPA	REINFORCED CONCRETE PIPE ARCH
PVC	POLYVINYL CHLORIDE

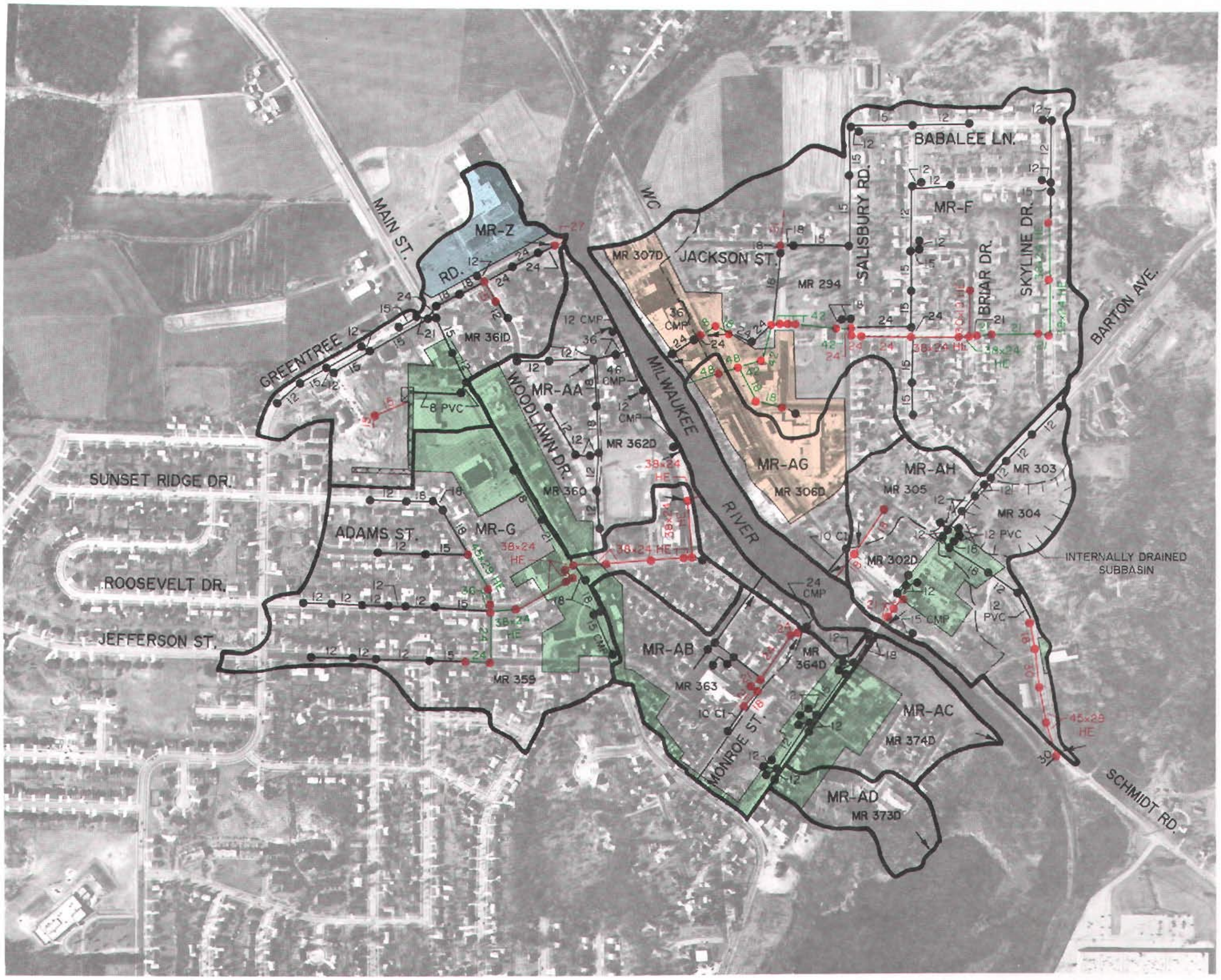
NOTE: 1.) PIPES ARE CONSTRUCTED OF REINFORCED CONCRETE UNLESS DESIGNATED AS ABOVE.

GRAPHIC SCALE
0 200 400 800 FEET
DATE OF PHOTOGRAPHY: MARCH 1990

Map 14 (continued)

RECOMMENDED SYSTEM PLAN FOR STORMWATER MANAGEMENT FOR THE MILWAUKEE RIVER DRAINAGE AREA OUTSIDE THE WINGATE CREEK SUBWATERSHED IN THE CITY OF WEST BEND STUDY AREA

HYDROLOGIC UNITS MR-F, MR-G, MR-Z, MR-AA, MR-AB, MR-AC, MR-AD, MR-AG, AND MR-AH



LEGEND

▬	HYDROLOGIC UNIT BOUNDARY UNDER EXISTING DRAINAGE CONDITIONS
MR-F	HYDROLOGIC UNIT IDENTIFICATION
— — —	SUBBASIN BOUNDARY
MR 294	SUBBASIN IDENTIFICATION
→	SUBBASIN OUTLET
18	EXISTING STORM SEWER TO BE RETAINED (SIZE IN INCHES)
●	EXISTING MANHOLE OR CATCHBASIN
15	PROPOSED REPLACEMENT STORM SEWER DESIGNED FOR 10-YEAR STORM (SIZE IN INCHES)
24	PROPOSED REPLACEMENT STORM SEWER DESIGNED FOR 100-YEAR STORM (SIZE IN INCHES)
_ 21 _	PROPOSED STORM SEWER (SIZE IN INCHES)
●	PROPOSED MANHOLE
▨	EXISTING CONSTRUCTED DETENTION BASIN
🟦	PROPOSED INFILTRATION SYSTEMS TO RETAIN RUNOFF FROM 50% OF PARKING LOT AREA
🟩	AREA TRIBUTARY TO STREET TO BE SWEPT 11 TIMES IN SPRING AND 11 TIMES IN FALL
🟧	AREA TRIBUTARY TO INDUSTRIAL PARKING LOT OR STORAGE AREA TO BE SWEPT WEEKLY IN SPRING, SUMMER, AND FALL
CMP	CORRUGATED METAL PIPE
HE	HORIZONTAL ELLIPTICAL REINFORCED CONCRETE PIPE
PVC	POLYVINYL CHLORIDE
CI	CAST IRON

NOTE:

1.) PIPES ARE CONSTRUCTED OF REINFORCED CONCRETE UNLESS DESIGNATED AS ABOVE.

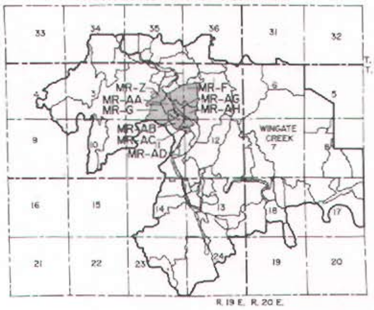
2.) A RECOMMENDED PLAN WAS NOT DEVELOPED FOR HYDROLOGIC UNITS MR-AA, MR-AC, MR-AD, AND MR-AG. THEREFORE, THE EXISTING STORM SEWER SYSTEM IS SHOWN FOR THOSE UNITS.

GRAPHIC SCALE

0 200 400 800 FEET

DATE OF PHOTOGRAPHY: MARCH 1990

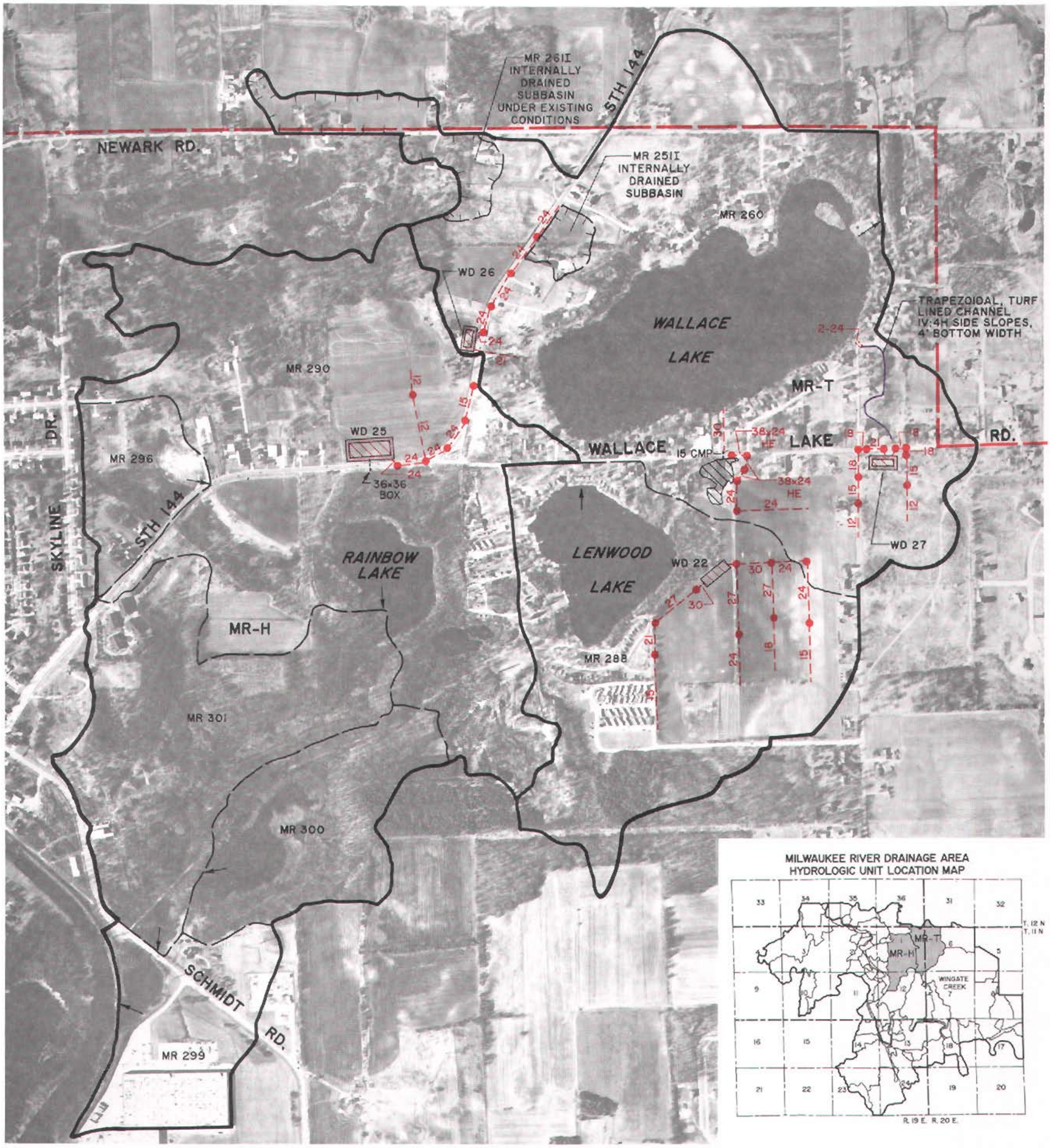
MILWAUKEE RIVER DRAINAGE AREA HYDROLOGIC UNIT LOCATION MAP



Map 14 (continued)

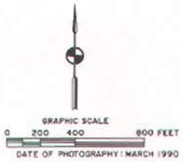
RECOMMENDED SYSTEM PLAN FOR STORMWATER MANAGEMENT FOR THE MILWAUKEE RIVER DRAINAGE AREA OUTSIDE THE WINGATE CREEK SUBWATERSHED IN THE CITY OF WEST BEND STUDY AREA

HYDROLOGIC UNITS MR-H AND MR-T



LEGEND

▬	HYDROLOGIC UNIT BOUNDARY UNDER EXISTING DRAINAGE CONDITIONS
MR-T	HYDROLOGIC UNIT IDENTIFICATION
— —	SUBBASIN BOUNDARY
MR 260	SUBBASIN IDENTIFICATION
→	SUBBASIN OUTLET
— —	LIMITS OF PLANNED URBAN SERVICE AREA
_ 15 _	EXISTING CULVERT (SIZE IN INCHES)
_ 18 _	PROPOSED STORM SEWER (SIZE IN INCHES)
●	PROPOSED MANHOLE
—	PROPOSED OPEN CHANNEL
WD 22 ▨	PERMANENT POND AREA OF PROPOSED WET DETENTION BASIN AND DESIGNATION
WD 27 ▨	PROPOSED DUAL-PURPOSE DETENTION BASIN AND DESIGNATION
▨	EXISTING NATURAL DETENTION OR RETENTION STORAGE AREA
HE	HORIZONTAL ELLIPTICAL REINFORCED CONCRETE PIPE
CMP	CORRUGATED METAL PIPE
NOTE:	1.) PIPES ARE CONSTRUCTED OF REINFORCED CONCRETE UNLESS DESIGNATED AS ABOVE.

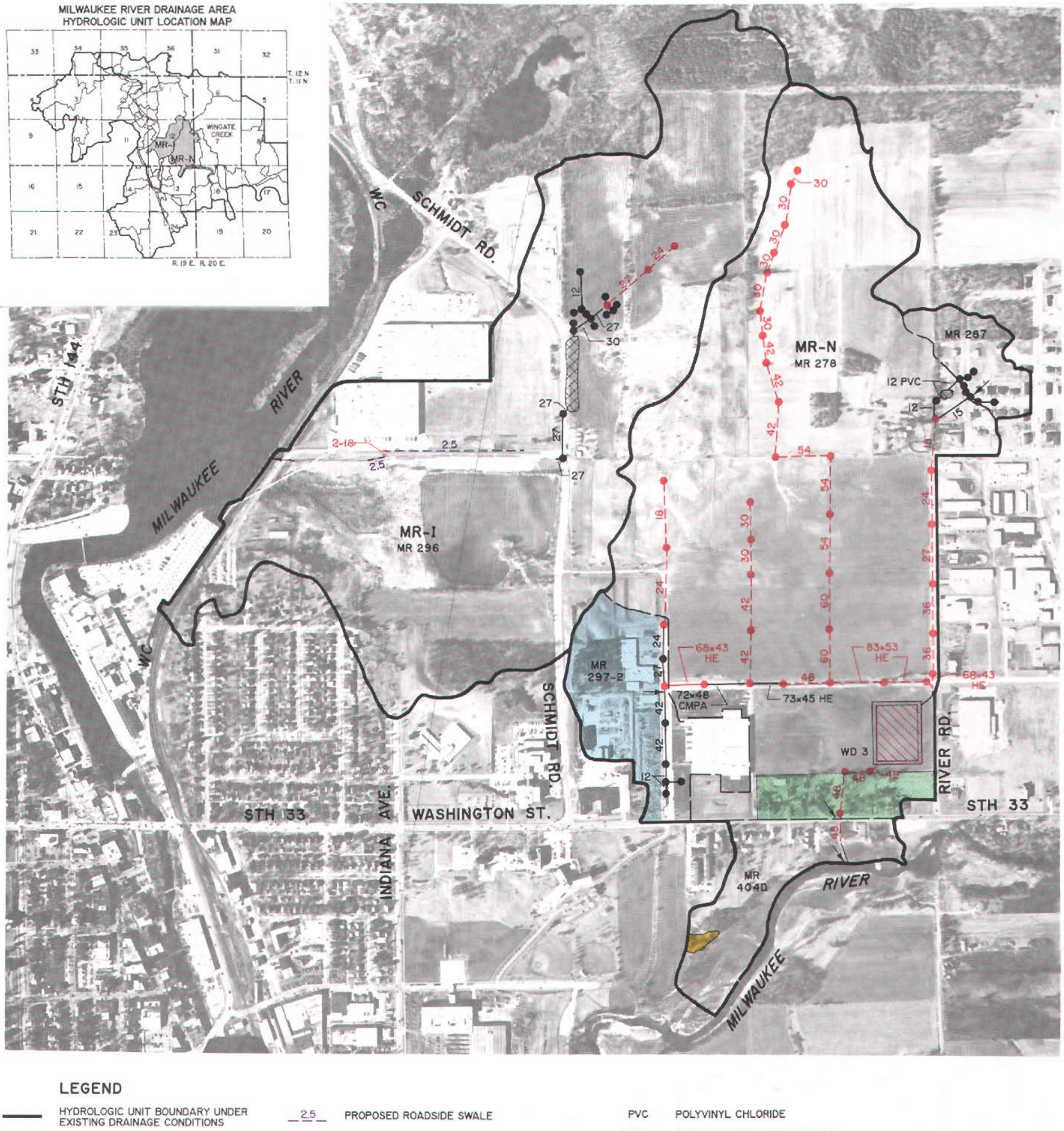


DATE OF PHOTOGRAPHY: MARCH 1990

Map 14 (continued)

RECOMMENDED SYSTEM PLAN FOR STORMWATER MANAGEMENT FOR THE MILWAUKEE RIVER DRAINAGE AREA OUTSIDE THE WINGATE CREEK SUBWATERSHED IN THE CITY OF WEST BEND STUDY AREA

HYDROLOGIC UNITS MR-I AND MR-N



LEGEND

▬	HYDROLOGIC UNIT BOUNDARY UNDER EXISTING DRAINAGE CONDITIONS
MR-N	HYDROLOGIC UNIT IDENTIFICATION
— —	SUBBASIN BOUNDARY
MR 278	SUBBASIN IDENTIFICATION
→	SUBBASIN OUTLET
24	EXISTING STORM SEWER TO BE RETAINED (SIZE IN INCHES)
●	EXISTING MANHOLE OR CATCHBASIN
68x43 HE	PROPOSED REPLACEMENT CULVERT DESIGNED FOR 10-YEAR STORM (SIZE IN INCHES)
_ 24 _	PROPOSED STORM SEWER OR CULVERT (SIZE IN INCHES)
●	PROPOSED MANHOLE
_ 2.5 _	PROPOSED ROADSIDE SWALE
—	PROPOSED OPEN CHANNEL
WD 3 ▨	PERMANENT POND AREA OF PROPOSED WET DETENTION BASIN AND DESIGNATION
WD 3 ▨	PROPOSED DUAL-PURPOSE DETENTION BASIN AND DESIGNATION
▩	EXISTING CONSTRUCTED DETENTION BASIN
🟦	PROPOSED INFILTRATION SYSTEMS TO RETAIN RUNOFF FROM 50% OF PARKING LOT AREA
🟩	AREA TRIBUTARY TO STREET TO BE SWEPT 11 TIMES IN SPRING AND 11 TIMES IN FALL
🟨	100-YEAR RECURRENCE INTERVAL FLOOD INUNDATION AREA UNDER PLANNED 2010 LAND USE AND PLANNED DRAINAGE CONDITIONS
PVC	POLYVINYL CHLORIDE
CMPA	CORRUGATED METAL PIPE ARCH
HE	HORIZONTAL ELLIPTICAL REINFORCED CONCRETE PIPE

NOTE: 1) PIPES ARE CONSTRUCTED OF REINFORCED CONCRETE UNLESS DESIGNATED AS ABOVE.

GRAPHIC SCALE

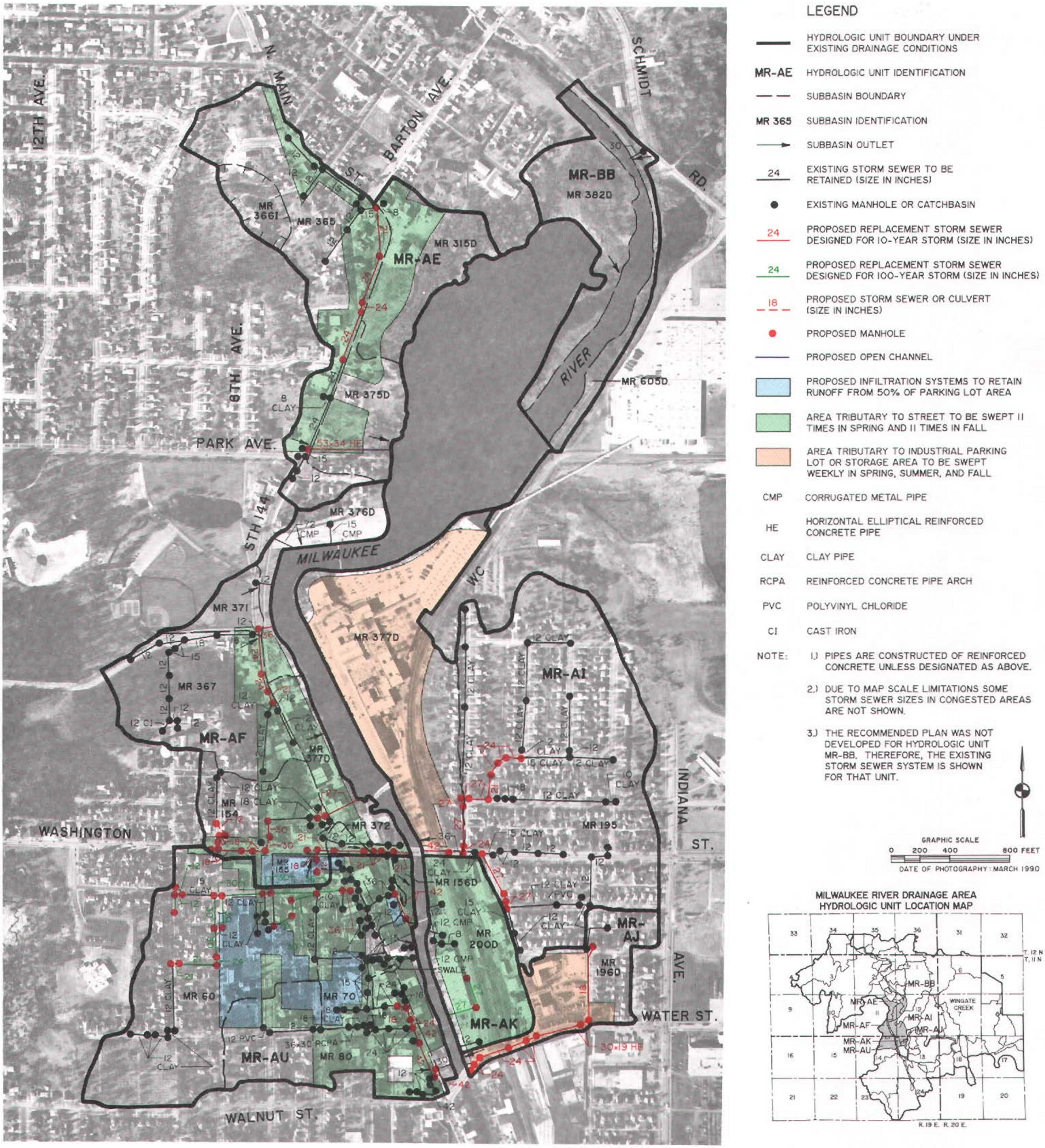
0 200 400 800 FEET

DATE OF PHOTOGRAPHY: MARCH 1990

Map 14 (continued)

RECOMMENDED SYSTEM PLAN FOR STORMWATER MANAGEMENT FOR THE MILWAUKEE RIVER DRAINAGE AREA OUTSIDE THE WINGATE CREEK SUBWATERSHED IN THE CITY OF WEST BEND STUDY AREA

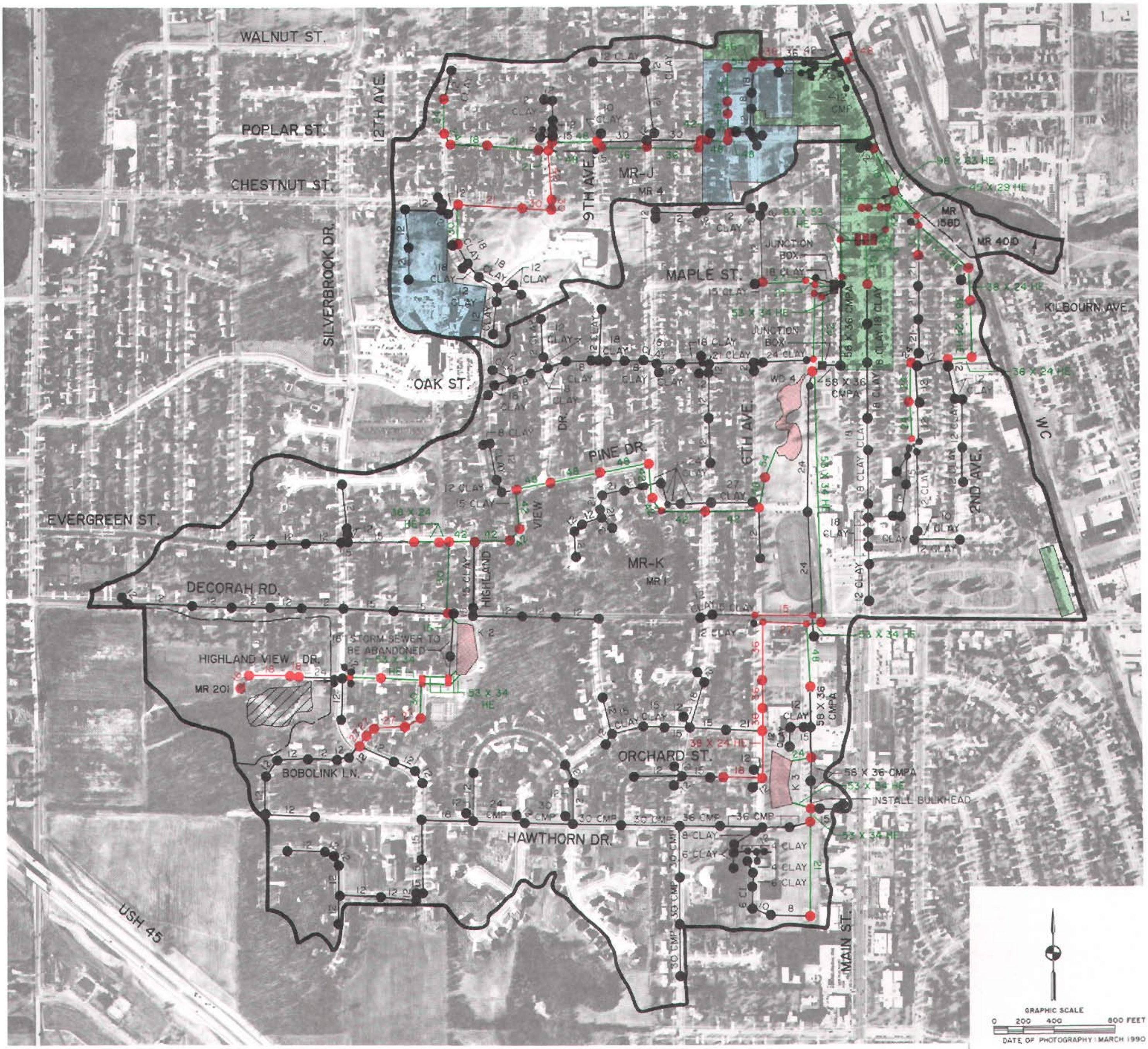
HYDROLOGIC UNITS MR-AE, MR-AF, MR-AI, MR-AJ, MR-AK, MR-AU, AND MR-BB



Map 14 (continued)

RECOMMENDED SYSTEM PLAN FOR STORMWATER MANAGEMENT FOR THE MILWAUKEE RIVER DRAINAGE AREA OUTSIDE THE WINGATE CREEK SUBWATERSHED IN THE CITY OF WEST BEND STUDY AREA

HYDROLOGIC UNITS MR-J AND MR-K



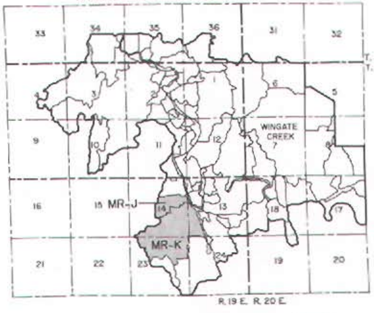
LEGEND

—	HYDROLOGIC UNIT BOUNDARY UNDER EXISTING DRAINAGE CONDITIONS
MR-J	HYDROLOGIC UNIT IDENTIFICATION
— —	SUBBASIN BOUNDARY
MR 4	SUBBASIN IDENTIFICATION
→	SUBBASIN OUTLET
18	EXISTING STORM SEWER TO BE RETAINED (SIZE IN INCHES)
●	EXISTING MANHOLE OR CATCHBASIN
42	PROPOSED REPLACEMENT STORM SEWER DESIGNED FOR 10-YEAR STORM (SIZE IN INCHES)
36	PROPOSED REPLACEMENT STORM SEWER DESIGNED FOR 100-YEAR STORM (SIZE IN INCHES)
18	PROPOSED STORM SEWER (SIZE IN INCHES)
●	PROPOSED MANHOLE

🟥	PROPOSED JUNCTION BOX
▨	EXISTING NATURAL DETENTION OR RETENTION STORAGE AREA
K 2 🟥	PROPOSED DRY DETENTION BASIN AND DESIGNATION
🟦	PROPOSED INFILTRATION SYSTEMS TO RETAIN RUNOFF FROM 50% OF PARKING LOT AREA
🟩	AREA TRIBUTARY TO STREET TO BE SWEPT 11 TIMES IN SPRING AND 11 TIMES IN FALL
CMP	CORRUGATED METAL PIPE
CMPA	CORRUGATED METAL PIPE ARCH
HE	HORIZONTAL ELLIPTICAL REINFORCED CONCRETE PIPE
CLAY	CLAY PIPE
CI	CAST IRON

NOTE: (,) PIPES ARE CONSTRUCTED OF REINFORCED CONCRETE UNLESS DESIGNATED AS ABOVE.

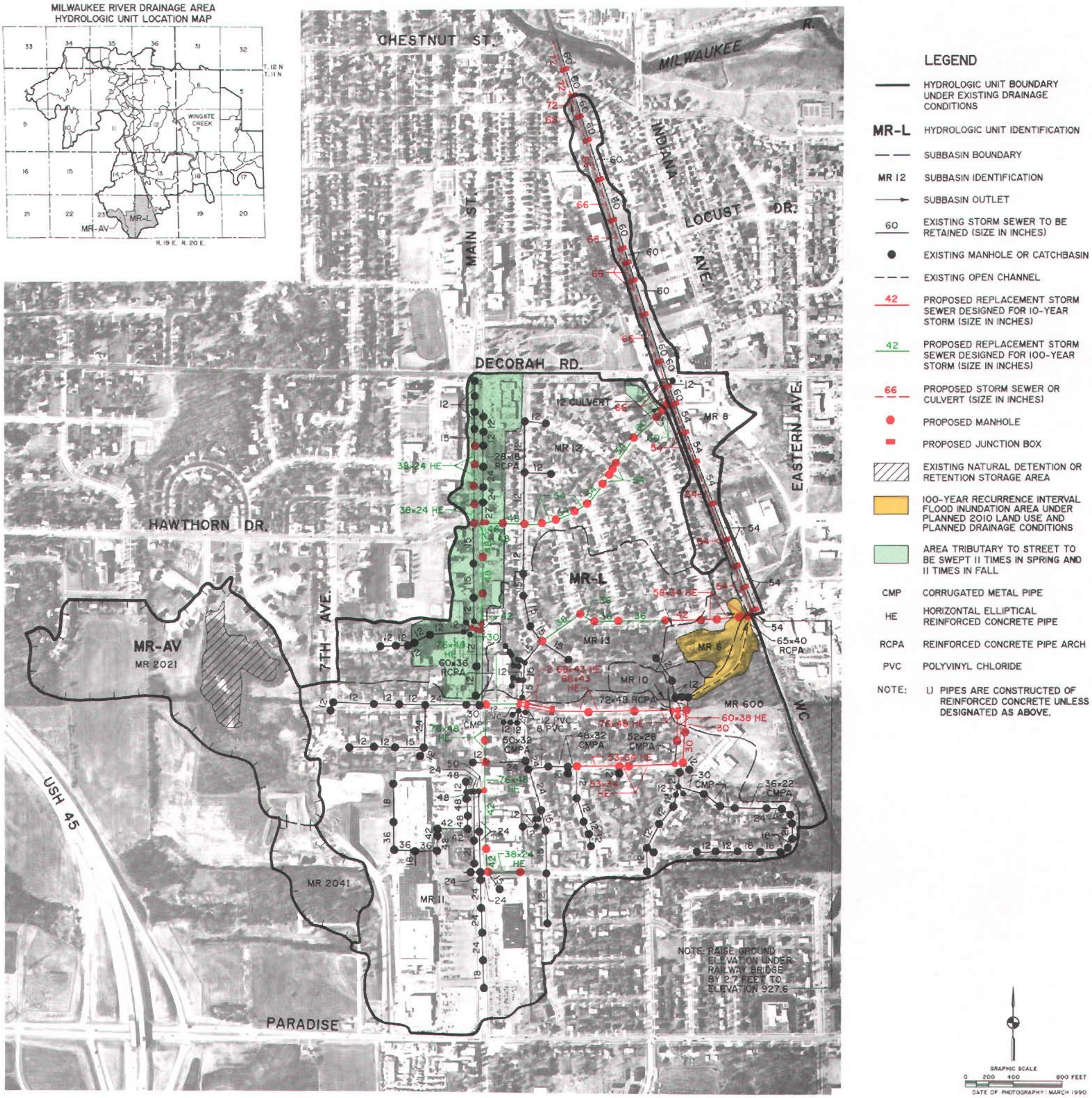
MILWAUKEE RIVER DRAINAGE AREA HYDROLOGIC UNIT LOCATION MAP



Map 14 (continued)

RECOMMENDED SYSTEM PLAN FOR STORMWATER MANAGEMENT FOR THE MILWAUKEE RIVER DRAINAGE AREA OUTSIDE THE WINGATE CREEK SUBWATERSHED IN THE CITY OF WEST BEND STUDY AREA

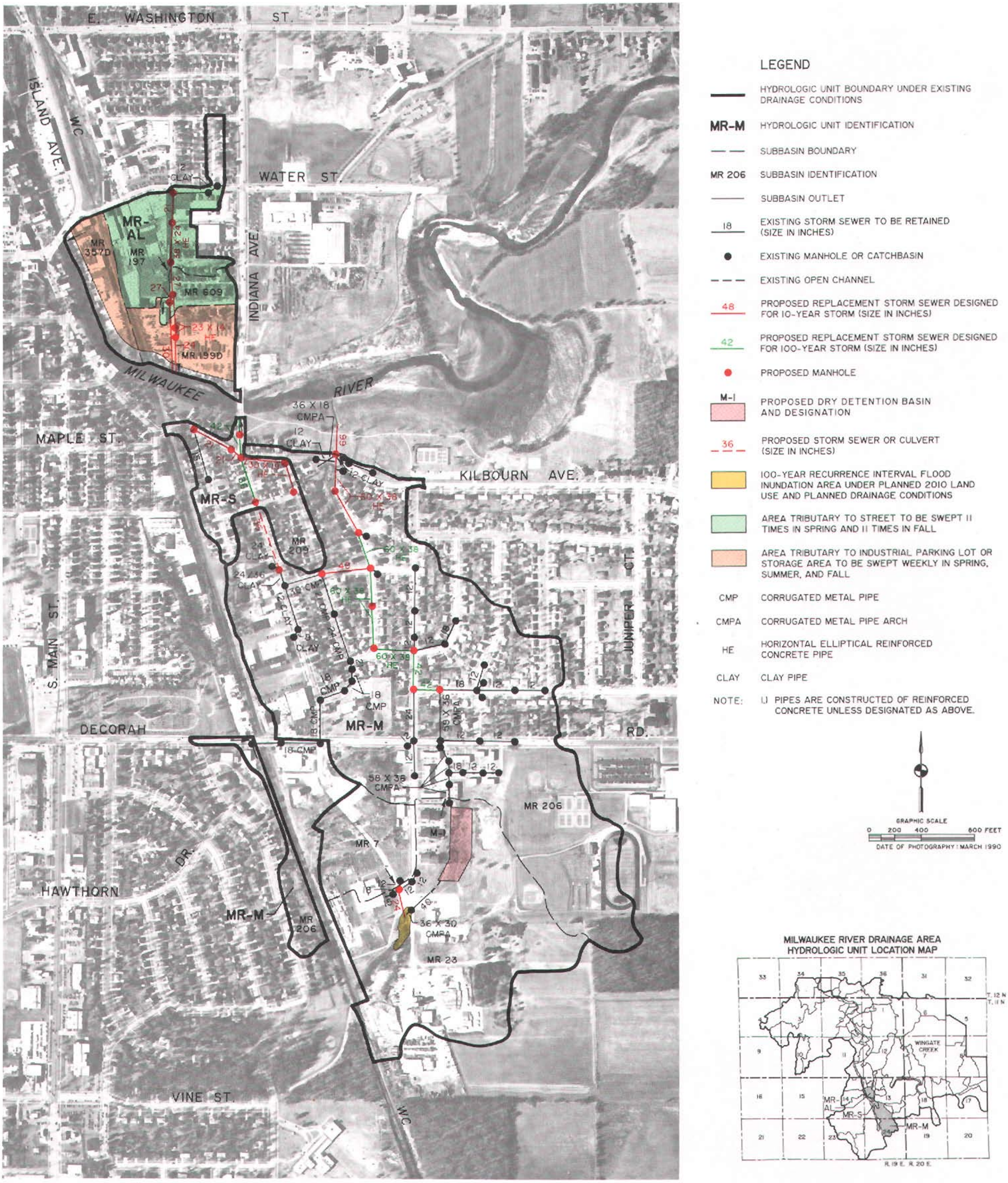
HYDROLOGIC UNITS MR-L AND MR-AV



Map 14 (continued)

RECOMMENDED SYSTEM PLAN FOR STORMWATER MANAGEMENT FOR THE MILWAUKEE RIVER DRAINAGE AREA OUTSIDE THE WINGATE CREEK SUBWATERSHED IN THE CITY OF WEST BEND STUDY AREA

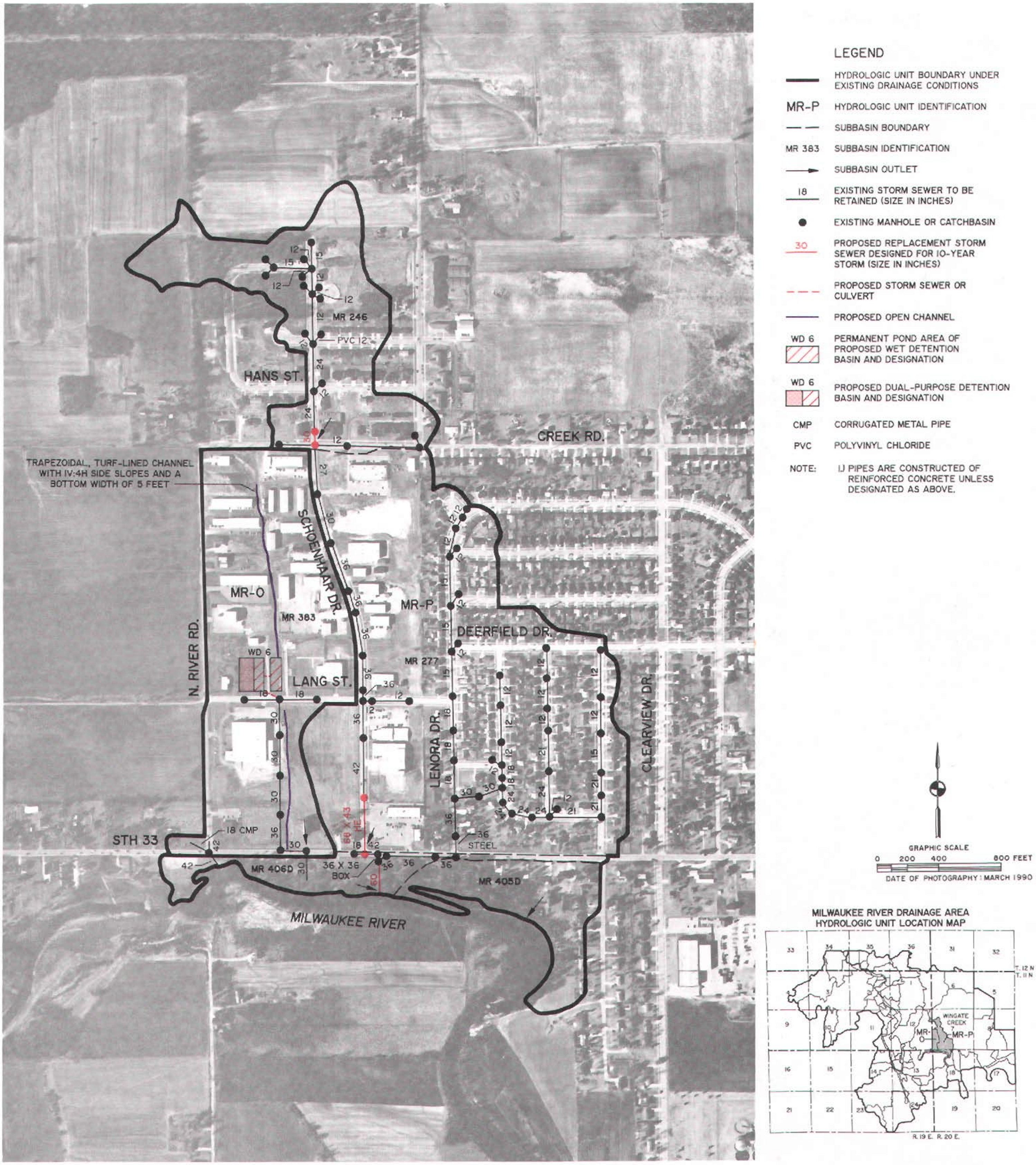
HYDROLOGIC UNITS MR-M, MR-S, AND MR-AL



Map 14 (continued)

RECOMMENDED SYSTEM PLAN FOR STORMWATER MANAGEMENT FOR THE MILWAUKEE RIVER DRAINAGE AREA OUTSIDE THE WINGATE CREEK SUBWATERSHED IN THE CITY OF WEST BEND STUDY AREA

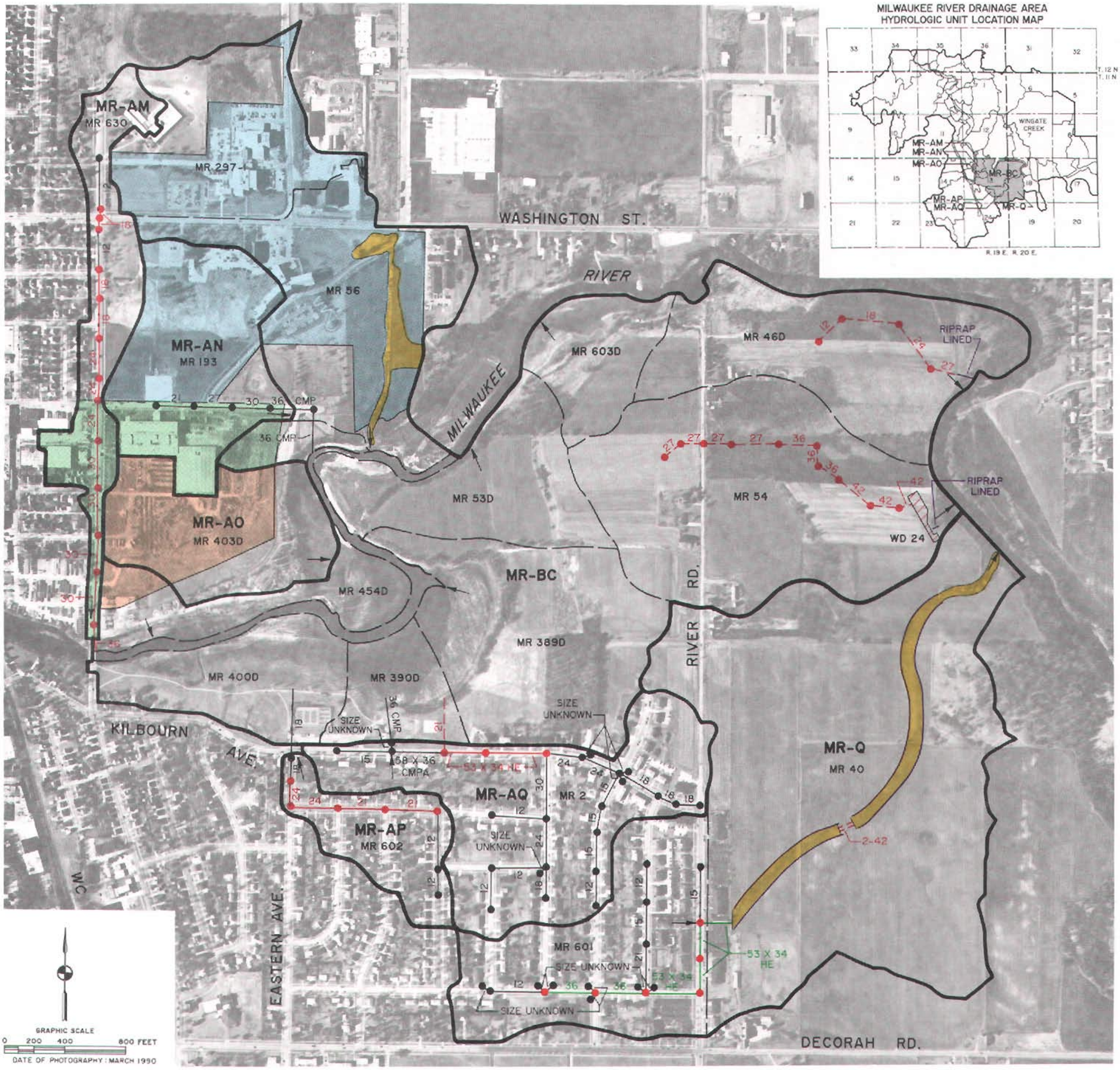
HYDROLOGIC UNITS MR-O AND MR-P



Map 14 (continued)

RECOMMENDED SYSTEM PLAN FOR STORMWATER MANAGEMENT FOR THE MILWAUKEE RIVER DRAINAGE AREA OUTSIDE THE WINGATE CREEK SUBWATERSHED IN THE CITY OF WEST BEND STUDY AREA

HYDROLOGIC UNITS MR-Q, MR-AM, MR-AN, MR-AO, MR-AP, MR-AQ, AND MR-BC



LEGEND

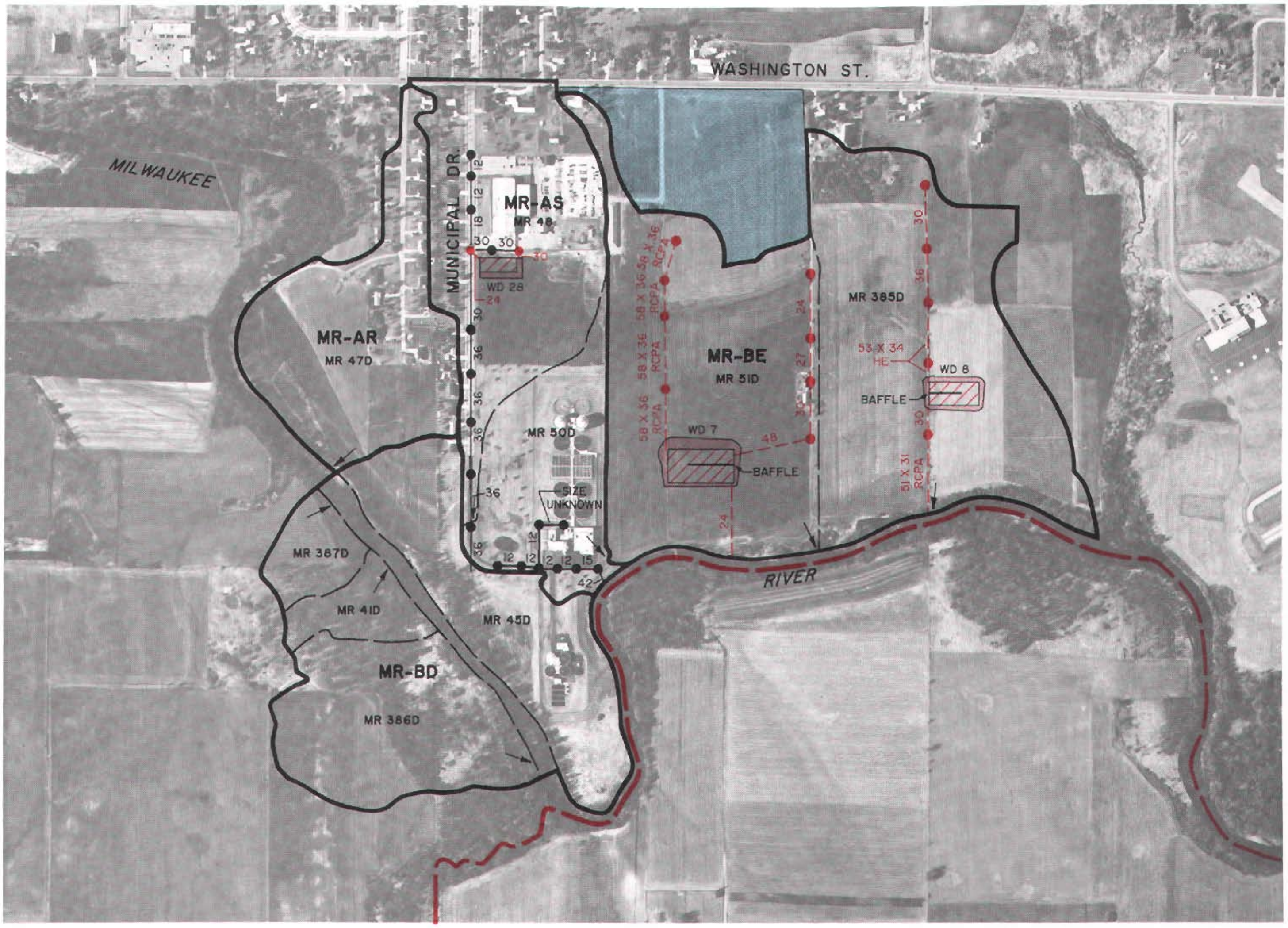
▬	HYDROLOGIC UNIT BOUNDARY UNDER EXISTING DRAINAGE CONDITIONS
MR-Q	HYDROLOGIC UNIT IDENTIFICATION
— —	SUBBASIN BOUNDARY
MR 602	SUBBASIN IDENTIFICATION
⟶	SUBBASIN OUTLET
12	EXISTING STORM SEWER TO BE RETAINED (SIZE IN INCHES)
●	EXISTING MANHOLE OR CATCHBASIN
21	PROPOSED REPLACEMENT STORM SEWER DESIGNED FOR 10-YEAR STORM (SIZE IN INCHES)
36	PROPOSED REPLACEMENT STORM SEWER DESIGNED FOR 100-YEAR STORM (SIZE IN INCHES)
21	PROPOSED STORM SEWER OR CULVERT (SIZE IN INCHES)
●	PROPOSED MANHOLE
—	PROPOSED OPEN CHANNEL
WD 24 ▨	PERMANENT POND AREA OF PROPOSED WET DETENTION BASIN AND DESIGNATION
🟨	100-YEAR RECURRENCE INTERVAL FLOOD INUNDATION AREA UNDER PLANNED 2010 LAND USE AND PLANNED DRAINAGE CONDITIONS
🟦	PROPOSED INFILTRATION SYSTEMS TO RETAIN RUNOFF FROM 50% OF PARKING LOT AREA
🟩	AREA TRIBUTARY TO STREET TO BE SWEPT 11 TIMES IN SPRING AND 11 TIMES IN FALL
🟧	AREA TRIBUTARY TO INDUSTRIAL PARKING LOT OR STORAGE AREA TO BE SWEPT WEEKLY IN SPRING, SUMMER, AND FALL
CMP	CORRUGATED METAL PIPE
CMPA	CORRUGATED METAL PIPE ARCH
HE	HORIZONTAL ELLIPTICAL REINFORCED CONCRETE PIPE

NOTE:
1.) PIPES ARE CONSTRUCTED OF REINFORCED CONCRETE UNLESS DESIGNATED AS ABOVE.
2.) A RECOMMENDED PLAN WAS NOT DEVELOPED FOR HYDROLOGIC UNITS MR-AN AND MR-AO. THEREFORE, THE EXISTING STORM SEWER SYSTEM IS SHOWN FOR THOSE UNITS.

Map 14 (continued)

RECOMMENDED SYSTEM PLAN FOR STORMWATER MANAGEMENT FOR THE MILWAUKEE RIVER DRAINAGE AREA OUTSIDE THE WINGATE CREEK SUBWATERSHED IN THE CITY OF WEST BEND STUDY AREA

HYDROLOGIC UNITS MR-AR, MR-AS, MR-BD, AND MR-BE

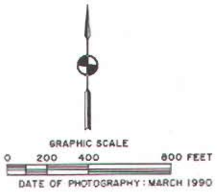


LEGEND

—	HYDROLOGIC UNIT BOUNDARY UNDER EXISTING DRAINAGE CONDITIONS
MR-AS	HYDROLOGIC UNIT IDENTIFICATION
— —	SUBBASIN BOUNDARY
MR 48	SUBBASIN IDENTIFICATION
→	SUBBASIN OUTLET
— —	LIMITS OF PLANNED URBAN SERVICE AREA
30	EXISTING STORM SEWER TO BE RETAINED (SIZE IN INCHES)
●	EXISTING MANHOLE OR CATCHBASIN
30	PROPOSED STORM SEWER (SIZE IN INCHES)
●	PROPOSED MANHOLE
WD 28 🟥	PERMANENT POND AREA OF PROPOSED WET DETENTION BASIN AND DESIGNATION
WD 28 ▨	PROPOSED DUAL-PURPOSE DETENTION BASIN AND DESIGNATION
🟦	AREA OF WINGATE CREEK SUBWATERSHED ASSUMED TO BE REGRADED SO AS TO DRAIN SOUTH TO HYDROLGIC UNIT MR-BE
HE	HORIZONTAL ELLIPTICAL
RCPA	REINFORCED CONCRETE PIPE ARCH

NOTE: 1.) PIPES ARE CONSTRUCTED OF REINFORCED CONCRETE UNLESS DESIGNATED AS ABOVE.

2.) A RECOMMENDED PLAN WAS NOT DEVELOPED FOR HYDROLOGIC UNITS MR-AR AND MR-BD.

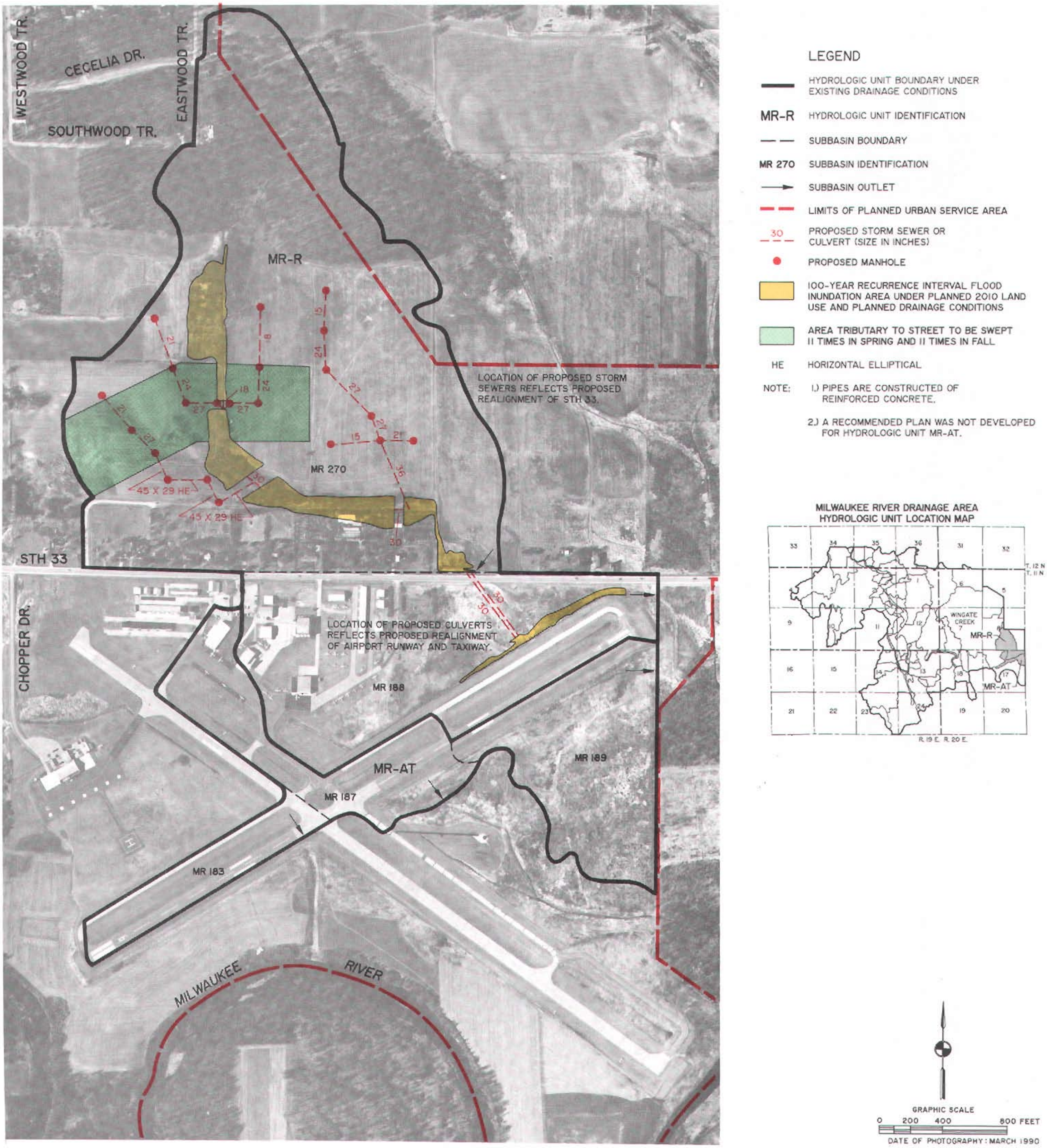


MILWAUKEE RIVER DRAINAGE AREA HYDROLOGIC UNIT LOCATION MAP

Map 14 (continued)

RECOMMENDED SYSTEM PLAN FOR STORMWATER MANAGEMENT FOR THE MILWAUKEE RIVER DRAINAGE AREA OUTSIDE THE WINGATE CREEK SUBWATERSHED IN THE CITY OF WEST BEND STUDY AREA

HYDROLOGIC UNITS MR-R AND MR-AT



Source: SEWRPC.

Table 80

COSTS OF THE RECOMMENDED STORMWATER MANAGEMENT PLAN FOR THE MILWAUKEE RIVER DRAINAGE AREA IN THE CITY OF WEST BEND STUDY AREA

Plan Element	Capital[a]	Annual Operation and Maintenance
Stormwater Drainage System		
Wingate Creek	$ 2,785,000	$ 21,300
Milwaukee River Drainage Area		
Outside of Wingate Creek	22,602,000	40,700
Water Quality Management Measures	4,151,000	162,600
Total	$29,538,000	$224,600

[a] Includes 35 percent for engineering, administration, and contingencies. Costs are for year 1991 with Engineering News-Record Construction Cost Index = 5,015.

Source: SEWRPC.

Chapter IV

WATER QUALITY MANAGEMENT PLAN ELEMENT

INTRODUCTION

This chapter presents the findings and recommendations of the stormwater management plan for the City of West Bend as that plan relates to control of nonpoint source pollution from the Milwaukee River drainage area, including the Wingate Creek subwatershed. The chapter describes the water quality objectives of the plan, provides estimates of nonpoint source pollutant loadings from the study area, presents the basis for the selection of the recommended water quality management measures, describes the components and costs of the recommended measures, and evaluates the recommended plan on the basis of how well it meets the objectives and supporting standards presented in Volume One of this report.

The recommended measures represent a refinement of the nonpoint source pollution abatement measures recommended in the areawide water quality management plan for Southeastern Wisconsin.[1] The recommended measures were also developed to be consistent, to the extent practical, with the pollutant loading reduction goals set forth in the nonpoint source priority watershed plan prepared for the Milwaukee River watershed.[2]

The recommended water quality control facilities and measures for the Milwaukee River drainage area were integrated with the recommended stormwater drainage measures to form the recommended stormwater management plan. The recommended stormwater management plan as presented on Map 6 in Chapter II of this volume for the Wingate Creek subwatershed and on Map 14 in Chapter III of this volume for the rest of the Milwaukee River drainage area thus includes both drainage and water quality management measures.

WATER USE OBJECTIVES AND WATER QUALITY STANDARDS

The water use objectives and supporting water quality standards to be met by surface waters of the West Bend study area are set forth in Chapter IV of Volume One of this report. The levels of control of nonpoint source pollutants determined to be needed to meet those objectives and standards provide the basis for selection of the recommended water quality management plan.

The free-flowing reaches of the Milwaukee River within and immediately downstream of the study area were found to be potentially capable of meeting the warmwater sport fish and full recreational water use objectives. Currently, these stream reaches are only partially meeting their full potential uses under existing conditions. The full achievement of the recommended water use objectives in the free-flowing reaches of the Milwaukee River is currently limited by sedimentation, excessive macrophyte growth, and high bacteria counts.

Additional reaches of free-flowing stream were created within the study area when the Woolen Mills dam on the Milwaukee River was removed in 1988 and the Young America dam was removed in 1992. The former impoundment area of the Woolen Mills dam was converted to a City park. The Wisconsin Department of Natural Resources intends to improve fish habitat and to stock fish in order to establish a high-quality sport fishery in the reach which formerly contained the impoundment. There are no known specific plans for the use and management of the former impoundment area of the Young America dam.

The remaining impounded reaches of the River within the study area include the Barton Millpond, located upstream of STH 144, and the West

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[1] *SEWRPC Planning Report No. 30, A Regional Water Quality Management Plan for Southeastern Wisconsin—2000, Volume One, Inventory Findings, September 1978; Volume Two, Alternative Plans, February 1979; and Volume Three, Recommended Plan, June 1979.*

[2] *Wisconsin Department of Natural Resources, A Nonpoint Source Control Plan for the East and West Branches of the Milwaukee River Priority Watershed Project, February 1989.*

Bend Pond, located upstream of STH 33. These impoundments were also found to be potentially capable of meeting the warmwater sport fish and full recreation water use objectives. The impoundments can support more tolerant forms of sport and forage fish and other aquatic life. However, these impounded areas are currently meeting their full potential uses only partially. The achievement of the recommended water use objectives for the impounded reaches of the River is currently limited by sedimentation; poor water quality, including elevated temperatures turbidity and low dissolved oxygen levels; and pollution of the sediments by copper, lead, cadmium, mercury, oil and grease, and arsenic.

The intermittent streams tributary to the Milwaukee River in the study area include Wingate Creek and an unnamed tributary entering the River in the northeast one-quarter of U. S. Public Land Survey Section 2, Township 11 North, Range 19 East. Those tributaries were found to be potentially capable of meeting limited objectives for fish and aquatic life and for recreational water use. Because of relatively low natural flow conditions, these tributaries can potentially support a forage fish community and provide spawning habitat for warmwater sport fish from the Milwaukee River itself. These two tributaries are only partially meeting their full potential uses under existing conditions. The full achievement of the recommended water use objectives in these tributaries is currently limited by sedimentation and limited habitat.

The study area also includes Wallace Lake, whose area of more than 50 acres classes it as a major natural lake. Smaller natural lakes in the study area include Lenwood and Rainbow Lakes. The three lakes are classified as being capable of meeting the warmwater sport fish and full recreation water use objectives.

Other significant water-related natural resource features in the study area which merit protection consist of the large wetlands shown on Map 4 of Chapter II of Volume One of this report.

POLLUTANT LOADING ANALYSIS

In order to assess the sources and magnitude of nonpoint source pollution in the Milwaukee River drainage area, annual pollutant loadings to surface waters under existing and planned future land use conditions were estimated for each of 15 subbasin groups within the planning area. Those subbasin groups, delineated on Map 15, include the same subbasin areas used for analysis of the stormwater drainage system in the study area as described in Chapters II and III of this volume, with the subbasins combined into 15 groups. The subbasins were aggregated to simplify the analysis of pollutant loadings and reductions in those loadings and are aggregated in a manner consistent with the analysis areas used for the priority watershed study.

The estimated nonpoint source pollutant loadings for each of these subbasin groups under existing, 1985, and planned, 2010, land use conditions are set forth in Tables 81, 82, and 83. The loadings were estimated by using unit area loading rates characteristic of the specific land use categories expected to be present under existing and planned land use conditions in each subarea group. These loadings are consistent with the results of the analyses conducted by the Department of Natural Resources under the priority watershed planning program.[3] According to the adopted land use plan for the City and environs, urban land use in the study area may be expected to increase by about 70 percent over the 25-year planning period. The conversion of land from rural to urban uses may be expected to result in a 16 percent reduction in the annual sediment loading and a 10 percent reduction in the annual phosphorus loading. However, the loading of metals and other pollutants contributed almost exclusively by urban sources, and represented in the analysis by lead, may be expected to increase by about 84 percent by the year 2010 if controls are not provided.

Lead was used in this analysis as an indicator of metals and other pollutants contributed primarily by urban sources. It should be noted that lead loadings have declined and are expected to continue to decline in the future as the use of leaded gasoline is totally discontinued. However, loadings of other metals from urban sources will not be affected by this change in motor fuel; in the analyses lead serves as a surrogate for these other toxic metals.

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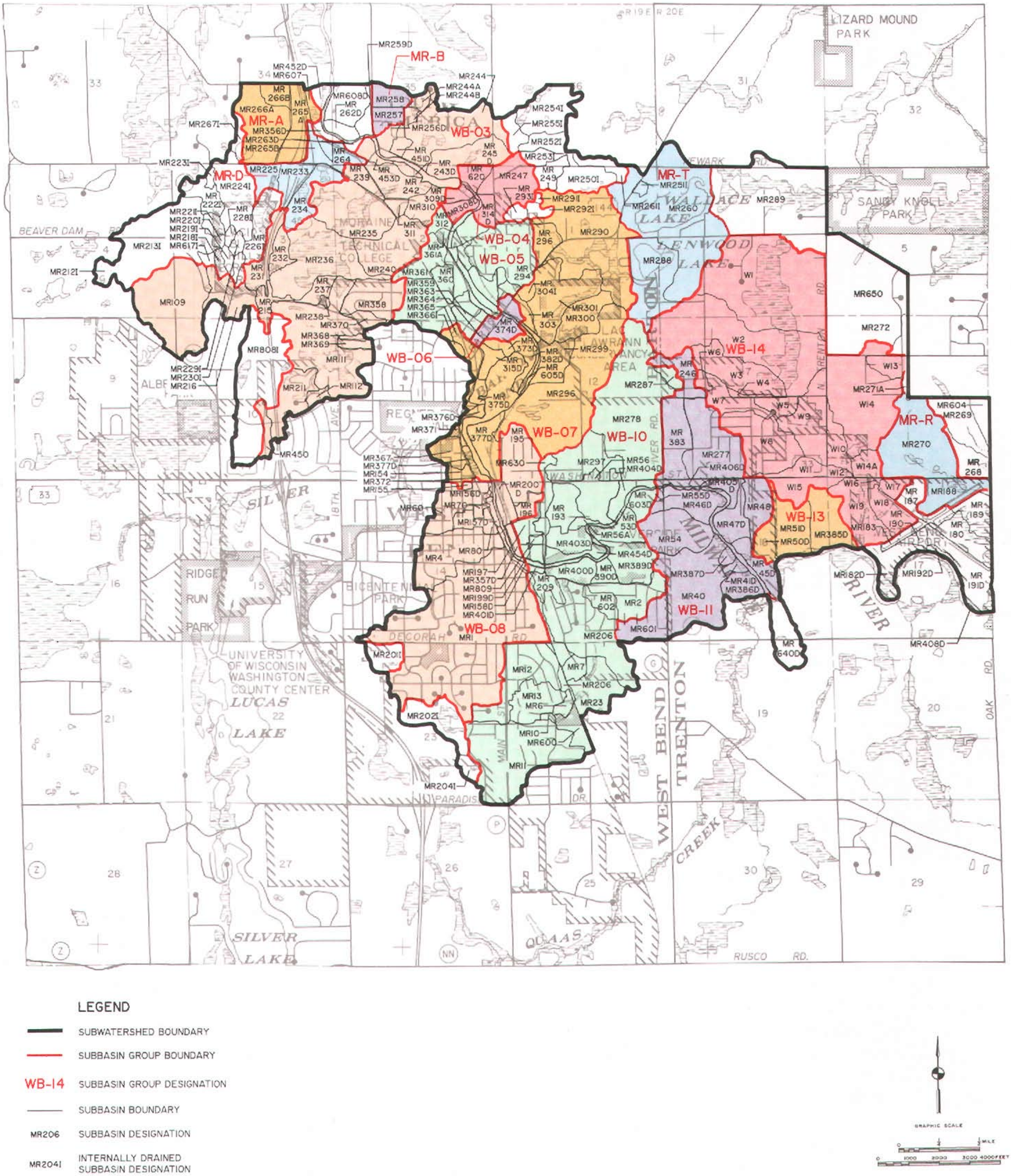
[3] *The Source Loading and Management Model is discussed on page 74 in Chapter IV of Volume One of this report.*

Map 15

SUBBASIN GROUPS FOR NONPOINT SOURCE POLLUTION CONTROL ANALYSES



LEGEND

▬ SUBWATERSHED BOUNDARY

🟥 SUBBASIN GROUP BOUNDARY

WB-14 SUBBASIN GROUP DESIGNATION

— SUBBASIN BOUNDARY

MR206 SUBBASIN DESIGNATION

MR204I INTERNALLY DRAINED SUBBASIN DESIGNATION

GRAPHIC SCALE

0 1000 2000 3000 4000 FEET

1 MILE

Source: Wisconsin Department of Natural Resources and SEWRPC.

Table 81

ANNUAL TOTAL SUSPENDED SOLIDS LOADINGS TO THE MILWAUKEE RIVER DRAINAGE AREA UNDER EXISTING, PLANNED UNCONTROLLED, AND PRELIMINARY RECOMMENDED PLAN CONDITIONS

	Existing 1985 Land Use				Planned Year 2010 Land Use with No Additional Nonpoint Source Controls							Preliminary Recommended Plan[a]	
Subbasin Grouping	Urban Loads (pounds)	Urban Area (acres)	Total Urban and Rural Loads (pounds)	Total Urban and Rural Area (acres)	Uncontrolled Urban Loads (pounds)	Percent Change in Urban Loads[b]	Urban Area (acres)	Percent Change in Urban Area[b]	Uncontrolled Total Urban and Rural Loads (pounds)	Percent Change in Total Urban and Rural Loads[b]	Total Urban and Rural Area (acres)	Total Urban and Rural Loads (pounds)	Percent Change in Total Urban and Rural Loads[b]
MR-A	7,750	20.1	57,650	137.1	52,720	580	98.3	389	69,850	21	137.1	11,310	-80
MR-B	1,570	24.4	6,690	35.8	2,130	36	35.4	45	2,160	-68	35.8	2,160	-68
MR-D	5,590	28.4	36,760	113.6	32,750	486	105.1	270	34,350	-7	113.6	13,710	-63
MR-T	8,520	109.0	72,210	317.0	15,770	85	177.5	63	37,040	-49	317.0	28,230	-61
MR-R	3,340	23.7	39,650	161.7	18,120	443	136.4	476	19,270	-51	161.7	16,780	-58
WB03	55,500	296.7	269,570	1,083.0	111,930	102	663.0	123	171,370	-36	1,083.0	102,760	-62
WB04	2,270	25.1	35,600	106.2	11,540	408	93.1	271	13,160	-63	106.2	13,160	-63
WB05	66,030	244.4	80,100	284.8	66,030	0	244.4	0	80,100	0	284.8	68,810	-14
WB06	8,670	29.9	8,950	32.4	15,670	81	29.9	0	15,720	76	32.4	13,580	52
WB07	87,020	275.7	187,600	706.7	152,160	75	453.8	65	157,720	-16	706.7	91,440	-51
WB08	231,620	631.2	244,240	676.0	231,330	0	666.1	6	231,370	-5	676.0	152,800	-37
WB10	235,350	737.4	301,520	1,112.2	410,340	74	1,019.2	38	410,870	36	1,112.2	143,810	-52
WB11[c]	53,520	252.4	160,400	528.9	98,320	84	480.4	90	112,020	-30	528.9	41,370	-74
WB13[d]	15,180	44.4	71,880	173.8	99,520	556	164.5	270	100,130	39	173.8	9,850	-86
WB14[e]	27,220	305.0	350,830	1,030.5	150,040	451	852.3	179	151,270	-57	1,030.5	115,630	-67
Total	809,150	3,047.8	1,923,650	6,499.7	1,468,370	81	5,219.4	71	1,606,400	-16	6,499.7	825,400	-57

[a] *Urban land areas and total urban and rural land areas for this condition are the same as for the planned uncontrolled condition.*

[b] *The percent change refers to the percent change relative to the existing loading.*

[c] *Excludes subbasin MR48, which was included in subbasin grouping WB11 under the priority watershed study.*

[d] *Includes subbasin MR48, which was included in WB11 under the priority watershed study, and 20.5 acres of subbasin W15, which were included in subbasin grouping WB14 under the priority watershed study.*

[e] *Excludes 20.5 acres of subbasin W15 which were included in subbasin grouping WB11 under the priority watershed study.*

Source: SEWRPC.

BASIS FOR THE SELECTION OF THE TARGETED LEVELS OF NONPOINT SOURCE POLLUTION CONTROL

With regard to the targeted nonpoint source pollutant loading reductions, the measures considered were directed toward reducing the pollutant loadings on the basis of two separate planning efforts. The primary objective was to provide reductions in nonpoint source pollutant loadings to the levels set forth in the regional water quality management plan. That level of control, when combined with the recommended level of control of point source loadings, would achieve the water quality standards associated with the water use objectives described earlier. These recommendations were based upon analyses, including extensive in-stream water quality simulation modeling conducted to establish needed pollutant reductions on a major subwatershed basis, and were recommended to be refined by subsequent second-level, more site-specific planning programs. For the subwatershed, including the West Bend study area, the recommended level of control was determined to be a reduction of about 25 percent of the nonpoint source loadings estimated under planned land use conditions.

The water quality modeling conducted to develop these recommendations included simulation of temperature, biochemical oxygen demand, dissolved oxygen, fecal coliforms, ammonia nitrogen, and phosphorus. The levels of reduction recommended were also determined through simulation modeling to be consistent with the downstream pollution reduction levels needed to achieve the recommended water use objectives in

Table 82

ANNUAL PHOSPHORUS LOADINGS TO THE MILWAUKEE RIVER DRAINAGE AREA UNDER EXISTING, PLANNED UNCONTROLLED, AND PRELIMINARY RECOMMENDED PLAN CONDITIONS

	Existing 1985 Land Use				Planned Year 2010 Land Use with No Additional Nonpoint Source Controls							Preliminary Recommended Plan[a]	
Subbasin Grouping	Urban Loads (pounds)	Urban Area (acres)	Total Urban and Rural Loads (pounds)	Total Urban and Rural Area (acres)	Uncontrolled Urban Loads (pounds)	Percent Change in Urban Loads[b]	Urban Area (acres)	Percent Change in Urban Area[b]	Uncontrolled Total Urban and Rural Loads (pounds)	Percent Change in Total Urban and Rural Loads[b]	Total Urban and Rural Area (acres)	Total Urban and Rural Loads (pounds)	Percent Change in Total Urban and Rural Loads[b]
MR-A	14	20.1	109	137.1	83	493	98.3	389	115	6	137.1	59	-46
MR-B	5	24.4	15	35.8	8	60	35.4	45	8	-47	35.8	8	-47
MR-D	11	28.4	72	113.6	57	418	105.1	270	61	-15	113.6	39	-46
MR-T	26	109.0	132	317.0	47	81	177.5	63	73	-45	317.0	59	-55
MR-R	8	23.7	78	161.7	40	400	136.4	476	42	-46	161.7	38	-51
WB03	126	296.7	540	1,083.0	289	129	663.0	123	409	-24	1,083.0	312	-42
WB04	7	25.1	71	106.2	34	386	93.1	271	37	-48	106.2	37	-48
WB05	142	244.4	168	284.8	142	0	244.4	0	168	0	284.8	153	-9
WB06	17	29.9	17	32.4	29	71	29.9	0	29	71	32.4	26	53
WB07	164	275.7	356	706.7	301	84	453.8	65	337	-5	706.7	260	-27
WB08	546	631.2	570	676.0	562	3	666.1	6	563	-1	676.0	442	-22
WB10	509	737.4	707	1,112.2	840	65	1,019.2	38	840	19	1,112.2	540	-24
WB11[c]	113	252.4	318	528.9	255	126	480.4	90	256	-19	528.9	184	-42
WB13[d]	30	44.4	138	173.8	172	473	164.5	270	173	25	173.8	85	-38
WB14[e]	90	305.0	604	1030.5	385	328	852.3	179	394	-35	1030.5	344	-43
Total	1,808	3,047.8	3,895	6,499.7	3,244	79	5,219.4	71	3,505	-10	6,499.7	2,586	-34

[a] *Urban land areas and total urban and rural land areas for this condition are the same as for the planned uncontrolled condition.*

[b] *The percent change refers to the percent change relative to the existing loading.*

[c] *Excludes subbasin MR48, which was included in subbasin grouping WB11 under the priority watershed study.*

[d] *Includes subbasin MR48, which was included in WB11 under the priority watershed study, and 20.5 acres of subbasin W15, which were included in subbasin grouping WB14 under the priority watershed study.*

[e] *Excludes 20.5 acres of subbasin W15 which were included in subbasin grouping WB11 under the priority watershed study.*

Source: SEWRPC.

the downstream reaches of the Milwaukee River in the Milwaukee Harbor estuary.[4]

In addition to the recommendations developed in the regional water quality management plan, nonpoint source pollutant reduction goals were established for the study area under the aforementioned priority watershed planning program. The latter nonpoint source pollutant reduction goals were established by the Wisconsin Department of Natural Resources staff, and considered primarily sediment, phosphorus, and lead as an indicator for metal loadings. The pollutant reduction goals were established on the basis of Department staff judgment, and considered field observations, stormwater quality sampling, and estimates of the degree of improvement needed for achievement of desired recreation and aquatic life uses of the surface waters in the study area.

The priority watershed planning program recommended that the total sediment, phosphorus, and lead loadings be reduced under planned conditions to about 50 percent of the existing condition loads. A secondary goal of keeping urban nonpoint source pollutant loads at 1988 levels through the year 2000 was set to prevent further degradation where the enhancement goal cannot be achieved.

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[4] *SEWRPC Planning Report No. 37, A Water Resources Management Plan for the Milwaukee Harbor Estuary, December 1987.*

Table 83

ANNUAL LEAD LOADINGS TO THE MILWAUKEE RIVER DRAINAGE AREA UNDER EXISTING, PLANNED UNCONTROLLED, AND PRELIMINARY RECOMMENDED PLAN CONDITIONS

	Existing 1985 Land Use				Planned Year 2010 Land Use with No Additional Nonpoint Source Controls							Preliminary Recommended Plan[a]	
Subbasin Grouping	Urban Loads (pounds)	Urban Area (acres)	Total Urban and Rural Loads (pounds)	Total Urban and Rural Area (acres)	Uncontrolled Urban Loads (pounds)	Percent Change in Urban Loads[b]	Urban Area (acres)	Percent Change in Urban Area[b]	Uncontrolled Total Urban and Rural Loads (pounds)	Percent Change in Total Urban and Rural Loads[b]	Total Urban and Rural Area (acres)	Total Urban and Rural Loads (pounds)	Percent Change in Total Urban and Rural Loads[b]
MR-A	19	20.1	20	137.1	131	589	98.3	389	131	555	137.1	44	120
MR-B	2	24.4	2	35.8	3	50	35.4	45	3	50	35.8	3	50
MR-D	14	28.4	15	113.6	92	557	105.1	270	92	513	113.6	48	220
MR-T	15	109.0	26	317.0	21	40	177.5	63	31	19	317.0	25	-4
MR-R	9	23.7	10	161.7	47	422	136.4	476	47	370	161.7	37	270
WB03	101	296.7	109	1,083.0	222	120	663.0	123	227	108	1,083.0	141	29
WB04	5	25.1	6	106.2	19	280	93.1	271	19	217	106.2	19	217
WB05	136	244.4	137	284.8	136	0	244.4	0	137	0	284.8	106	-23
WB06	20	29.9	20	32.4	40	100	29.9	0	40	100	32.4	32	60
WB07	212	275.7	218	706.7	363	71	453.8	65	370	70	706.7	212	-3
WB08	472	631.2	473	676.0	492	4	666.1	6	492	4	676.0	354	-25
WB10	540	737.4	548	1,112.2	941	74	1,019.2	38	942	72	1,112.2	426	-22
WB11[c]	120	252.4	136	528.9	246	105	480.4	90	247	82	528.9	119	-13
WB13[d]	36	44.4	23	173.8	243	575	164.5	270	243	957	173.8	71	209
WB14[e]	51	305.0	57	1,030.5	282	453	852.3	179	285	400	1,030.5	226	296
Total	1,752	3,047.8	1,800	6,499.7	3,278	87	5,219.4	71	3,306	84	6,499.7	1,863	4

[a] *Urban land areas and total urban and rural land areas for this condition are the same as for the planned uncontrolled condition.*

[b] *The percent change refers to the percent change relative to the existing loading.*

[c] *Excludes subbasin MR48, which was included in subbasin grouping WB11 under the priority watershed study.*

[d] *Includes subbasin MR48, which was included in WB11 under the priority watershed study, and 20.5 acres of subbasin W15, which were included in subbasin grouping WB14 under the priority watershed study.*

[e] *Excludes 20.5 acres of subbasin W15 which were included in subbasin grouping WB11 under the priority watershed study.*

Source: SEWRPC.

Under the current planning process, consideration was given to achieving the levels of nonpoint source pollution control recommended under both planning efforts described above. However, experience, including that gained during preparation of the Silver Creek stormwater management plan as presented in Volume Two of this report, indicates that the levels of pollutant reduction recommended under the enhancement objective set forth in the priority watershed planning program are not likely to be practically achievable. The inability to achieve the recommended reductions is due to conditions in the watersheds which constitute physical constraints on the locations of control measures. Such constraints include limitations on the provision of detention in areas of existing urban development because open lands for the location of detention ponds are generally not available and in developing areas because of topography and the need to avoid locating control measures within such natural resource features as certain woodland and wetland areas.

PROCEDURES USED FOR SELECTION OF THE RECOMMENDED MEASURES

The selection of the recommended control measures considered the estimated uncontrolled pollutant loading for each of the 15 subbasin groups in the planning area. Table 84 presents a ranking of the subbasin groups according to the estimated planned uncontrolled nonpoint source pollutant loadings of sediment, phosphorus, and lead. As already noted, lead has been used as an indicator of, or a surrogate for, metals

Table 84

RANKING OF UNIT AREA LOADINGS FROM SUBBASIN GROUPS WITHIN THE MILWAUKEE RIVER DRAINAGE AREA: PLANNED YEAR 2010 URBAN AND RURAL LAND USE WITHOUT NONPOINT SOURCE POLLUTION CONTROLS

Ranking	Subbasin Group	Unit Area Loading: Total Suspended Solids (pounds per acre per year)	Subbasin Group	Unit Area Loading: Phosphorus (pounds per acre per year)	Subbasin Group	Unit Area Loading: Lead (pounds per acre per year)
1	WB13	621	WB13	1.03	WB13	1.53
2	MR-A	509	WB6	0.90	WB6	1.22
3	WB6	485	MR-A	0.84	MR-A	0.96
4	WB10	369	WB8	0.83	WB10	0.85
5	WB8	342	WB10	0.76	MR-D	0.81
6	MR-D	302	WB5	0.59	WB8	0.73
7	WB5	253	MR-D	0.54	WB7	0.52
8	WB11	224	WB11	0.51	WB5	0.49
9	WB7	223	WB7	0.48	WB11	0.49
10	WB14	159	WB14	0.40	WB14	0.31
11	WB3	158	WB3	0.38	MR-R	0.29
12	WB4	124	WB4	0.35	WB3	0.21
13	MR-R	119	MR-R	0.26	WB4	0.18
14	MR-T	117	MR-T	0.23	MR-T	0.10
15	MR-B	60	MR-B	0.22	MR-B	0.08

Source: SEWRPC.

from urban sources. This ranking was useful in targeting subbasin groups which should be provided with nonpoint source pollution controls under the recommended plan.

The recommended water quality management measures were selected on the basis of required reductions in pollutant loadings, unit area pollutant loadings characteristics of the planned land uses in the tributary areas, cost-effectiveness of the measures, availability of suitable sites, consistence with City policies regarding the provision of curb and gutter drainage, and compatibility with needed stormwater drainage measures.

The measures considered in developing nonpoint source pollution abatement alternatives included: 1) wet detention basins, 2) infiltration of parking lot runoff, 3) increased street sweeping of industrial, commercial, and miscellaneous governmental and institutional areas and cleaning of catch basins twice a year in each of those areas, and 4) construction erosion control. The estimated nonpoint source pollutant removal effectiveness of the various measures is set forth in Table 85.

Wet detention basins are appropriate nonpoint source pollution abatement measures in areas of future urban development because of the availability of open lands in those areas and the high degree of pollutant removal possible through the use of such detention. The use of wet detention basins in areas of existing urban development is constrained by the general lack of suitable open space sites. The cost of providing a wet detention

Table 85

NONPOINT SOURCE POLLUTANT REMOVAL EFFECTIVENESS OF VARIOUS CONTROL MEASURES

Control Measures	Percent Reductions in Pollutant Loadings		
	Total Suspended Solids	Total Phosphorus	Lead[a]
Wet Detention Basins	90	50	70
Construction Site Erosion Control	75	75	- -
Sweeping Commercial and Industrial Streets 22 Times per Year plus Catch Basin Cleaning Twice a Year	20	20	30
Sweeping Industrial Parking and Storage Areas and Adjacent Streets Weekly	70	70	70
Infiltration of Runoff from Government Institutional Parking Lots and Commercial Parking Lots	40	30	50

[a] *Lead is used as in indicator of the pollutant loadings of metals because lead loadings and the removal of lead in land management systems have been well characterized.*

Source: Wisconsin Department of Natural Resources and SEWRPC.

basin in an area of intensive urban development may be ten times the cost of providing similar wet detention basin control in a developing area.[5]

Infiltration of runoff is a viable option in the West Bend area because of the predominance of well- to moderately well-drained soils, classified in Hydrologic Soil Groups A or B. Increased street sweeping was also considered a viable option and was expanded to include more intensive sweeping of industrial parking and storage areas as a relatively cost-effective means of reducing urban pollutant loads, particularly in areas where the provision of wet detention basins is not practical.

The City of West Bend has enforced a construction erosion control ordinance since May 6, 1985; continued enforcement of that ordinance should remain a key element of any nonpoint pollution source abatement plan.

A preliminary evaluation was made of potential sites for wet detention basins and infiltration facilities. Sites were considered suitable for the location of wet detention basins if they contained adequate open land for the excavation of a basin, were located on a well-defined drainage system, and drained an appropriately sized area to generate significant pollutant loadings. Wet detention basins were not placed on major streams, where the impoundment could impede fish migration or alter the natural temperature regimen of the stream. Also, where possible, wet detention basins were located outside wetlands as identified on the Regional Planning Commission land use inventory and the State of Wisconsin wetland inventory maps. As already noted, few suitable wet detention basin sites are available within the existing urban development areas; therefore, such basins are the most appropriate in areas of proposed new urban development. Infiltration systems are limited to areas with adequate open land covered by relatively permeable soils, where the depth to bedrock and to the seasonally high water table is greater than five feet, and where the land slopes do not exceed 5 percent. Infiltration systems are most feasible when the contributing drainage areas are less than five acres in size. In developed areas with limited open land available, infiltration trenches are usually more feasible than infiltration basins.

The recommended measures were selected to help achieve the recommended levels of control at the least cost. The cost-effectiveness of

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[5] *SEWRPC Technical Report No. 31, Costs of Urban Nonpoint Source Water Pollution Control Measures, June 1991.*

providing wet detention basins, infiltration systems, street sweeping, and construction erosion control measures was compared in Table 14 in Volume Two of this report. That table shows that of the three measures intended to provide long-term reductions of pollutant runoff from urban areas, as opposed to the temporary control afforded by construction erosion control measures, street sweeping is the most cost-effective for the removal of heavy metals, followed by infiltration and wet detention. For sediment and phosphorus removal, street sweeping and wet detention are similar in cost-effectiveness, while infiltration is less cost-effective. Construction erosion control is highly cost-effective for control of sediment and phosphorus, but not cost-effective for the removal of heavy metals due to the minimal contributions of heavy metals from construction sites. Infiltration of stormwater runoff from rooftops was not recommended because control of the low levels of pollutants in rooftop runoff did not justify the cost.

PRELIMINARY RECOMMENDED WATER QUALITY MANAGEMENT PLAN

Components and Level of Pollution Control of the Preliminary Recommended Plan

The preliminary recommended water quality management plan element for the Milwaukee River drainage area, including the Wingate Creek subwatershed, is shown in graphic summary form on Map 16. The control measures selected include the construction of 27 wet detention basins to control runoff from about 2,188 acres, or 33 percent of the Milwaukee River study area; the infiltration of runoff from parking lots serving hospitals, miscellaneous governmental and institutional facilities, and high-density residential development in selected areas; the treatment of runoff from about 415 acres of land, or 6 percent of the study area, through the sweeping of about 14 curb-miles of streets along with selected industrial parking and storage areas and twice-yearly catch basin cleaning in all areas to be swept; the use of natural vegetation where possible to filter pollutants in the runoff from the proposed West Bend Municipal Airport expansion; and continued enforcement of the City of West Bend construction erosion control ordinance. The estimated pollutant removal effectiveness and costs of the preliminary recommended measures are summarized in Tables 81, 82, and 83 and in Table 86.

The recommended 27 wet detention basins would have permanent ponds ranging in surface area from 0.25 acre to three acres and permanent storage volumes ranging from 1.25 acre-feet to 15 acre-feet. The average depth of the permanent ponds was assumed to be five feet. On an annual basis, the wet basins may be expected to remove 40 percent of the sediment, 21 percent of the phosphorus, and 32 percent of the heavy metals which would be contributed to surface waters in the Milwaukee River study area under planned land use conditions in the absence of nonpoint source pollution abatement measures.

Infiltration systems, which would probably consist of infiltration trenches with a pretreatment facility such as a grass filter strip or a sedimentation-flotation basin for the removal of oil and grease, are recommended to treat the stormwater runoff from about 50 percent of the school, hospital, and miscellaneous governmental and institutional parking areas in those basins shown on Map 16. Infiltration facilities are also recommended for 7.4 acres in high-density residential use. It is estimated that the infiltration systems would control the runoff from about 29 acres of the school, hospital, and miscellaneous governmental and institutional parking lots. On an annual basis, the infiltration facilities may be expected to remove 1 percent of the sediment, 1 percent of the phosphorus, and 1 percent of the heavy metals which would be contributed to surface waters in the Milwaukee River study area under planned land use conditions in the absence of nonpoint source pollution abatement measures.

An increased street sweeping program with an intensive street sweeping effort in spring, to reduce high street surface loadings prior to the onset of heavy spring rainstorms, and in fall, to reduce high loadings due to leaves and other vegetative debris, is recommended in the commercial and industrial areas shown on Map 16. Under the current street sweeping program within the City of West Bend, all streets are swept approximately four times per year. Leaf collection occurs twice during the fall. The preliminary recommended plan calls for the designated streets to be swept an additional nine times early in spring and nine times in fall,

Table 86

DESCRIPTION, POLLUTANT REMOVAL EFFECTIVENESS, AND COST OF THE PRELIMINARY RECOMMENDED WATER QUALITY MANAGEMENT PLAN ELEMENT

Subbasin Grouping	Plan Component Description	Estimated Percent Reduction in Planned (2010) Pollutant Loads			Capital Cost^a	Annual Operation and Maintenance Cost
		Total Suspended Sediment	Phosphorus	Lead		
MR-A	1. WD9, 2.2-acres, 11.2-acre-foot wet basin	3.6	1.6	2.6	$ 394,000	$ 5,100
	Subtotal	3.6	1.6	2.6	$ 394,000	$ 5,100
MR-B	No nonpoint source pollution control measures	- -	- -	- -	- -	- -
MR-D	1. WD10, 1.6-acres, 8.0-acre-foot wet basin	1.3	0.6	1.3	$ 185,000	$ 4,000
	Subtotal	1.3	0.6	1.3	$ 185,000	$ 4,000
MR-R	1. SW15, sweep 0.8 curb-mile of street	0.2	0.1	0.3	$ 400	$ 400
	Subtotal	0.2	0.1	0.3	$ 400	$ 400
MR-T	1. WD22, 0.31-acre, 1.6-acre-foot wet basin	0.2	0.1	0.1	$ 75,000	$ 1,700
	2. WD26, 0.25-acre, 1.25-acre-foot wet basin	0.3	0.2	0.1	71,000	1,500
	3. WD27, 0.25-acre, 1.25-acre-foot wet basin	0.1	0.1	<0.1	65,000	1,500
	Subtotal	0.6	0.4	0.2	$ 211,000	$ 4,700
WB-3	1. WD15, 2.4-acres, 12.0-acre-foot wet basin	1.8	1.1	0.5	$ 257,000	$ 5,400
	2. WD16, 0.25-acre, 1.25-acre-foot wet basin	0.1	0.1	0.1	71,000	1,500
	3. WD17, 0.25-acre, 1.25-acre-foot wet basin	0.1	0.1	0.1	71,000	1,500
	4. WD18, 0.25-acre, 1.25-acre-foot wet basin	0.2	0.1	0.2	71,000	1,500
	5. WD19, 0.7-acre, 3.5-acre-foot wet basin	0.8	0.5	0.4	109,000	2,300
	6. WD20, 0.25-acre, 1.25-acre-foot wet basin	0.4	0.3	0.2	81,000	1,500
	7. WD21, 0.25-acre, 1.25-acre-foot wet basin	0.2	0.1	0.1	81,000	1,500
	8. IF5, infiltrate runoff from 1.8 acres of parking lots	0.1	0.0	0.1	22,000	1,200
	9. SW11, sweep 3.4 acres of industrial parking and storage area	0.6	0.3	0.7	1,700	1,900
	10. SW12, sweep 1.1 curb-miles of street	0.2	0.1	0.3	500	600
	Subtotal	4.5	2.7	2.8	$ 765,200	$ 18,900
WB-4	No nonpoint source pollution control measures	- -	- -	- -	- -	- -
WB-5	1. IF7, infiltrate runoff from 3.8 acres of parking lots	0.1	0.1	0.1	$ 55,000	$ 2,600
	2. SW5, sweep 2.4 acres of industrial parking and storage area	0.5	0.2	0.5	1,200	1,400
	3. SW6, sweep 1.0 curb-mile of street	0.2	0.1	0.4	500	500
	Subtotal	0.7	0.4	0.9	$ 56,700	$ 4,500
WB-6	1. SW7, sweep 0.5 curb-mile of street	0.1	0.1	0.2	$ 300	$ 300
	Subtotal	0.1	0.1	0.2	$ 300	$ 300
WB-7	1. WD25, 0.68-acre, 3.4-acre-foot wet basin	1.0	0.5	0.8	$ 128,000	$ 2,600
	2. IF8, infiltrate runoff from 7.4 acres of high-density residential area	0.0	0.1	0.1	74,000	3,500
	3. SW1, sweep 2.7 curb-miles of street	0.4	0.3	0.7	1,300	1,400
	4. SW13, sweep 16.6 acres of industrial parking and storage area	2.7	1.4	3.2	8,400	9,300
	Subtotal	4.1	2.3	4.8	$ 211,700	$ 16,800
WB-8	1. WD4, 2.6-acres, 13.0-acre-foot wet basin	3.6	2.6	2.1	$ 377,000	$ 5,900
	2. IF1, infiltrate runoff from 3.2 acres of parking lots	0.1	0.1	0.2	42,000	2,000
	3. IF2, infiltrate runoff from 3.6 acres of parking lots	0.1	0.1	0.1	44,000	2,400
	4. SW2, sweep 4.2 curb-miles of street	0.7	0.5	1.4	2,000	2,300
	5. SW14, sweep 0.4 curb-mile of street and 5.6 acres of industrial parking and storage area	0.3	0.1	0.4	3,100	2,300
	Subtotal	4.8	3.4	4.2	$ 468,100	$ 14,900
WB-10	1. WD1, 2.5-acres, 12.4-acre-foot wet basin	4.2	2.2	3.4	$ 217,000	$ 5,500
	2. WD2, 2.5-acres, 12.6-acre-foot wet basin	4.4	2.3	3.8	355,000	5,800
	3. WD3, 3.2-acres, 15.8-acre-foot wet basin	5.9	2.7	5.3	644,000	6,500
	4. IF3, infiltrate runoff from 7.0 acres of parking lots	0.3	0.3	0.3	76,000	3,300
	5. IF4, infiltrate runoff from 4.4 acres of parking lots	0.1	0.1	0.2	59,000	2,800
	6. IF6, infiltrate runoff from 5.6 acres of parking lots	0.2	0.2	0.3	51,000	2,400
	7. SW3, sweep 2.1 curb-miles of street and 44.5 acres of industrial parking and storage area	1.2	0.7	1.6	12,100	13,300
	8. SW4, sweep 0.4 curb-mile of street	0.1	0.1	0.2	200	200
	9. SW8, sweep 0.6 curb-mile of street	0.2	0.1	0.4	300	300
	Subtotal	16.6	8.7	15.5	$1,414,600	$ 40,100

Table 86 (continued)

		Estimated Percent Reduction in Planned (2010) Pollutant Loads				
Subbasin Grouping	Plan Component Description	Total Suspended Sediment	Phosphorus	Lead	Capital Cost[a]	Annual Operation and Maintenance Cost
WB-11	1. WD5, 1.3-acres, 6.5-acre-foot wet basin	2.6	1.1	2.4	$ 285,000	$ 3,400
	2. WD6, 0.64-acre, 3.2-acre-foot wet basin	1.3	0.5	1.2	135,000	2,000
	3. WD24, 0.49-acre, 2.5-acre-foot wet basin	0.5	0.4	0.3	150,000	1,800
	4. WD28, 0.27-acre, 1.4-acre-foot wet basin	0.5	0.3	0.5	85,000	1,800
	Subtotal	4.9	2.3	4.4	$ 655,000	$ 9,000
WB-13	1. WD7, 1.6-acres, 8.0-acre-foot wet basin	3.5	1.5	3.3	$ 404,000	$ 3,900
	2. WD8, 0.83-acre, 4.1-acre-foot wet basin	1.6	0.7	1.5	219,000	2,600
	Subtotal	5.1	2.2	4.8	$ 623,000	$ 6,500
WB-14	1. WD11, 0.58-acre, 2.9-acre-foot wet basin	0.6	0.4	0.3	$ 94,000	$ 1,900
	2. WD12, 0.25-acre, 1.25-acre-foot wet basin	0.5	0.3	0.5	69,000	1,500
	3. WD14, 0.25-acre, 1.25-acre-foot wet basin	0.2	0.1	0.2	65,000	1,500
	4. WD23, 1.13-acres, 5.6-acre-foot wet basin	0.7	0.5	0.3	127,000	3,000
	5. SW9, sweep 0.1 curb-mile of street	0.1	0.1	0.3	100	100
	6. SW10, sweep 0.2 curb-mile of street	0.1	0.1	0.2	100	100
	Subtotal	2.2	1.5	1.8	$ 355,200	$ 8,100
- -	Total	48.7	26.3	43.8	$5,340,200	$133,300

[a] *Includes land acquisition and an additional 35 percent of the construction cost to account for engineering, administration, and contingencies. Based on 1991 Engineering News-Record Construction Cost Index of 5,015.*

Source: SEWRPC.

along with increased cleaning of catch basins. Also, intensive weekly sweeping of the industrial parking and storage areas indicated on Map 16 is recommended.

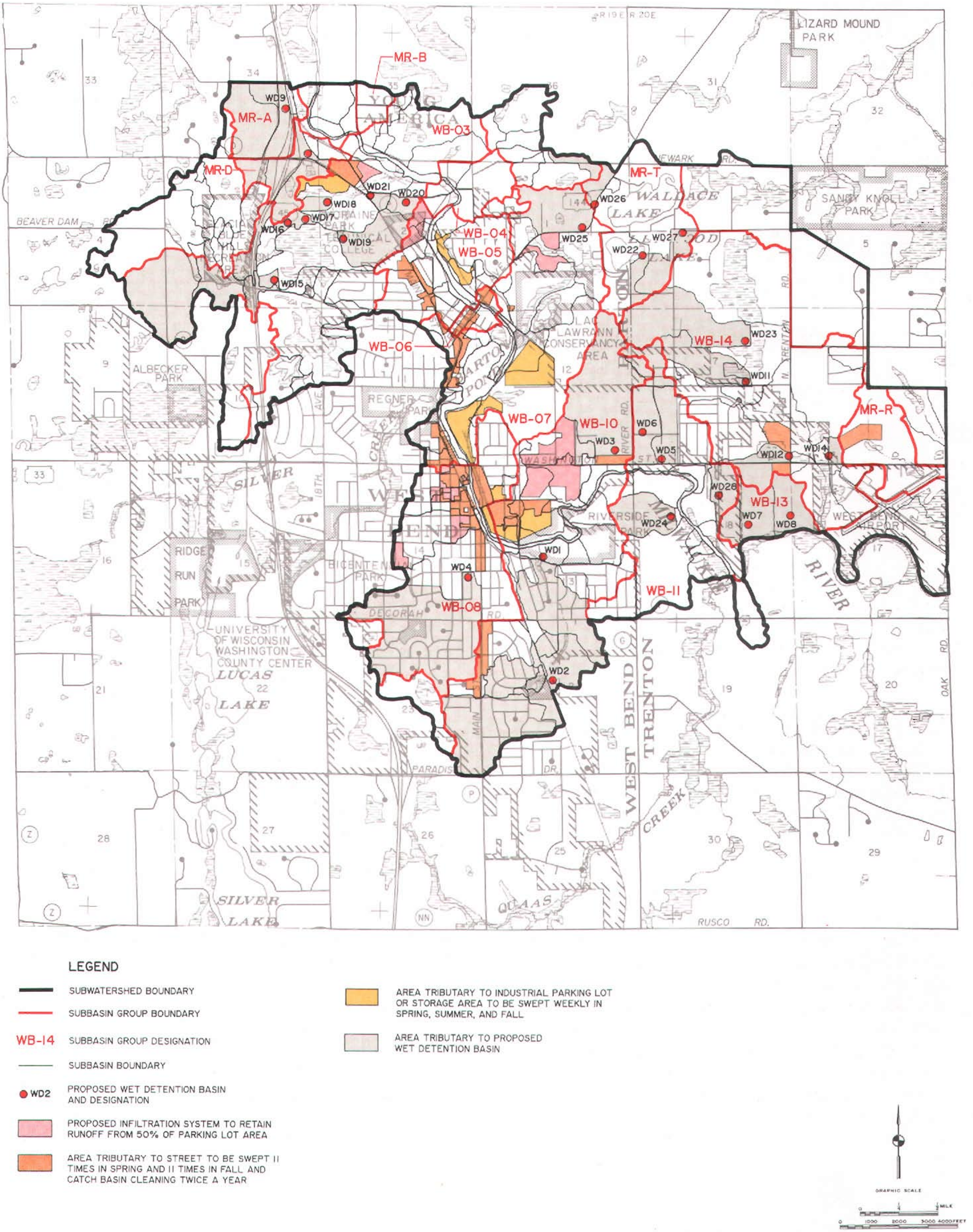
The West Bend Company, which has facilities in subbasin group WB7, has an ongoing program of intensive parking lot sweeping and covering or berming of material storage areas. Such programs are also recommended, where applicable, for the additional industrial areas indicated on Map 16.

Many industries are currently involved in the process of obtaining Wisconsin Pollutant Discharge Elimination System (WPDES) permits for stormwater discharges from industrial facilities other than parking areas. Permit conditions will specify necessary controls for pollutants carried in stormwater runoff. The initiation of sweeping and covering of storage areas are appropriate pollution control measures. The extension of such sweeping operations to parking areas, while not covered under the WPDES permitting program, is a logical adjunct to storage area sweeping to reduce pollutant loadings from areas which cannot be readily treated using other methods. On an annual basis, the increased street, parking lot, and storage area sweeping may be expected to remove 8 percent of the sediment, 4 percent of the phosphorus, and 11 percent of the heavy metals which would be contributed to surface waters in the Milwaukee River study area under uncontrolled planned land use conditions.

The City of West Bend currently has a construction site erosion control ordinance which defines land disturbance activities subject to control, sets forth standards and criteria for erosion control, describes permit application and administrative procedures, and identifies enforcement and appeal procedures. Under the ordinance, land disturbance activities covering an area of 2,000 square feet or more require an erosion control plan to ensure that erosion and sedimentation during and after the land disturbance will not exceed that which would have occurred if the land had been left in its natural state or if the land was properly treated with erosion control measures. Construction erosion control measures

Map 16

PRELIMINARY RECOMMENDED WATER QUALITY MANAGEMENT PLAN ELEMENT FOR THE MILWAUKEE RIVER DRAINAGE AREA



Source: SEWRPC.

may be expected to achieve about a 75 percent reduction in the total uncontrolled pollutant loadings from the construction sites.

Implementation of the recommended nonpoint source pollution control measures would result in sediment loadings to the Milwaukee River under planned land use conditions which are 57 percent lower than those under existing conditions, phosphorus loadings which are 34 percent lower than under existing conditions, and heavy metal loadings which are 3 percent higher than under existing conditions. In comparison to uncontrolled loadings under planned land use conditions, the recommended control measures would reduce sediment loadings by 49 percent, phosphorus loadings by 26 percent, and heavy metal loadings by 44 percent. The sediment and phosphorus loading reductions are a smaller percentage of the planned land use loadings in the absence of nonpoint source pollution abatement measures than of the existing land use loadings because the conversion of rural to urban uses may be expected to produce a modest reduction in the uncontrolled loadings of those pollutants even without controls.

Recommended Public Education Program

In addition to the components of the preliminary recommended plan measures, it is also recommended that a public education program be developed to encourage good urban "housekeeping" practices, to promote the selection of building and construction materials which reduce the runoff contribution of metals and other toxic pollutants, and to promote the acceptance and understanding of the proposed pollution abatement measures and the importance of water quality protection. Urban housekeeping practices and source controls include restricted use of fertilizers and pesticides, improved pet waste and litter control, reduced use of galvanized steel roof materials and gutters, proper disposal of motor vehicle fluids, increased leaf collection and catch basin cleaning, and reduced use of street-deicing salt. Particular attention should be given to reducing pollutant loadings from high pollutant loading areas, such as industrial and commercial sites, parking lots, and material storage areas. To the extent practicable, rooftop and parking lot stormwater runoff should be diverted to pervious soil and vegetated areas, rather than being directly discharged to a storm sewer. Special spill-control or containment facilities, such as earthen berms, may be used to reduce the discharge of spilled substances such as oil and grease, into waterways. Material storage areas may be enclosed or periodically cleaned and diversion of stormwater away from these sites may further reduce pollutant loadings. The continuing effects of the elimination of leaded gasoline and increased air pollution control, which may be implemented on a regional or national level, may also be expected to reduce loadings of certain pollutants, including metals.

Comparison of the Nonpoint Source Pollution Reductions Achieved by the Preliminary Recommended Plan with Those Recommended under the Regional Water Quality Management Plan and under the Priority Watershed Study

The preliminary recommended control measures, if fully implemented, would reduce nonpoint source pollutant loadings to the Milwaukee River under planned land use conditions by from 26 percent to 49 percent, depending on the type of pollutant. The estimated reductions associated with the recommended plan are compared to the levels of control set forth under the adopted regional water quality management plan and under the priority watershed plan in Table 87. The nonpoint source control measures recommended in this stormwater management plan may be expected to provide levels of pollutant removal substantially exceeding those recommended in the adopted regional water quality management plan. As already noted, that plan recommended that a 25 percent reduction in nonpoint source pollutants would be adequate to achieve the water use objectives and standards. If fully implemented, the preliminary recommended plan measures may be expected to reduce phosphorus levels by about 26 percent and other pollutants by almost twice the required level.

Implementation of the preliminary recommended nonpoint source pollution control measures would result in sediment loadings to the Milwaukee River under planned conditions which are 57 percent lower than those under existing conditions, phosphorus loadings which are 34 percent lower than under existing conditions, and heavy metal loadings which are 3 percent higher than under existing conditions. The enhancement reduction goal for sediment as established in the priority watershed study would thus be achieved. However, the enhance-

Table 87

REDUCTION IN NONPOINT SOURCE POLLUTANT LOADINGS

Pollutant	Reductions in Nonpoint Source Pollutant Loadings under Planned Land Use Conditions			
	Regional Water Quality Management Plan (percent)	Priority Watershed Plan Enhancement Goal (percent)[a]	Preliminary Recommended Plan (percent)	Final Recommended Plan (percent)
Sediment	25	40	49	40
Phosphorus	25	44	26	21
Metals	- -[b]	73	44	39

[a] *Under planned land use conditions, the priority watershed study surface water enhancement goal called for nonpoint source pollutant loadings to be reduced to 50 percent of the loadings under existing land use conditions. The percentile reductions listed here are referenced to planned condition loadings in the absence of nonpoint source pollution abatement measures. The reduction percentages for sediment and phosphorus are less than 50 percent because the conversion of land from rural uses under existing conditions to urban uses under planned conditions results in some reduction in loadings of those pollutants even without controls. The reduction percentage for metals is greater than 50 percent because metals loadings are increased with the conversion of land from rural to urban uses.*

[b] *No specific analyses were conducted to establish a level of reduction for metals in the regional water quality management plan.*

Source: SEWRPC.

ment reduction levels for phosphorus and heavy metals would not. The anticipated phosphorus reduction is substantial and an improvement in water quality may be expected to result from the proposed reduction. The phosphorus reduction level substantially exceeds the secondary goal established in the priority watershed study of maintaining current 1988 levels. The limitation on the increase in metals loading, while falling short of the enhancement goal and the secondary goal of maintaining 1988 loadings, is significant, given the inherent difficulty in reducing loadings of heavy metals and other predominantly urban pollutants when an area experiences significant new urban development.

The loading reductions achieved by the preliminary recommended plan are the largest which are practically attainable and may be expected to improve the overall water quality conditions of the Milwaukee River and its intermittent tributaries in the study area. Thus, the nonpoint source pollution control measures called for under the preliminary recommended plan are considered to be not in conflict with the regional water quality management plan and in substantial conformance with the goals of the priority watershed plan.

PRELIMINARY RECOMMENDED PLAN NONPOINT SOURCE POLLUTION CONTROL FACILITY COSTS

As set forth in Table 86, the total capital cost of the preliminary recommended water quality management plan for the Milwaukee River drainage area is approximately $5,340,000, consisting of $4,885,000 for wet detention basins, $423,000 for infiltration facilities, and $32,000 for increased street, parking lot, and storage area sweeping. The annual operation and maintenance cost attendant to this plan is estimated at $133,300, consisting of $78,700 for wet detention basins, $20,200 for infiltration facilities, and $34,400 for increased street, parking lot, and storage area sweeping.

REFINEMENTS TO THE PRELIMINARY RECOMMENDED WATER QUALITY MANAGEMENT PLAN ELEMENT FOLLOWING REVIEW BY CITY STAFF

Some refinements were made in the preliminary recommended water quality management plan for subbasin groups WB08, WB10, and WB11 as a result of review by City staff. Those refinements include: 1) the elimination of single-purpose wet detention basins WD1 and WD2 and dual-purpose detention basin WD5 and 2) the elimination of the basin WD4 permanent pond for water quality control. The wet detention basins which were eliminated were intended to provide control of nonpoint source pollution from a total of 1.2 square miles of the City. The area which was to be controlled is almost entirely developed in urban uses under existing conditions and includes significant areas of commercial and industrial development. In order to partially offset the loss of nonpoint source pollution control from the 1.2-square-mile area due to elimination of the wet detention basins, intensive weekly sweeping of commercial and industrial parking and/or storage lots located in that area is now recommended at the locations shown on Maps 14 and 17. The net effect of eliminating the originally recommended wet detention basins and substituting intensive parking lot and storage area sweeping is a net reduction in the amount of nonpoint source pollutants removed. That occurs because the sweeping program would have lower pollutant removal rates and because less land area would be treated under the sweeping program than with implementation of a detention storage approach.

Reasons for Elimination of Preliminary Recommended Wet Detention Basins

Detention Basin WD1: It was proposed to locate this basin in Riverview Park, along the Milwaukee River. The location was chosen to avoid locating the basin in park areas with existing trails and athletic fields, since City staff indicated that such areas should generally be avoided as locations for detention basins. Upon review of the site by City staff it was found that the proposed basin would encroach on an abandoned landfill site and would, therefore, be unacceptable. Because there is no suitable alternative open space site, the basin was eliminated from the plan.

Detention Basin WD2: It was proposed to construct this basin in Ziegler Park. Because construction of the basin would result in the loss of a baseball diamond and of much of the playground in the park, the proposed site was rejected by City staff. Location of the basin on the east side of the Wisconsin Central Transportation Corporation railway embankment was considered, but rejected because of wetland conflicts and to the location of a concrete waste disposal site in the vicinity. The basin was eliminated from the plan because of the lack of an acceptable alternative site.

Detention Basin WD4: It was proposed to construct this basin on school district property west of Badger Middle School. The basin was intended to be a dual-purpose facility for both water quantity and water quality control. The permanent pond for water quality control was eliminated because of safety concerns related to the location of such a pond near a school and in a relatively densely developed residential area. The plan was, therefore, refined to call for water quantity control through construction of a dry detention basin at the WD4 site.

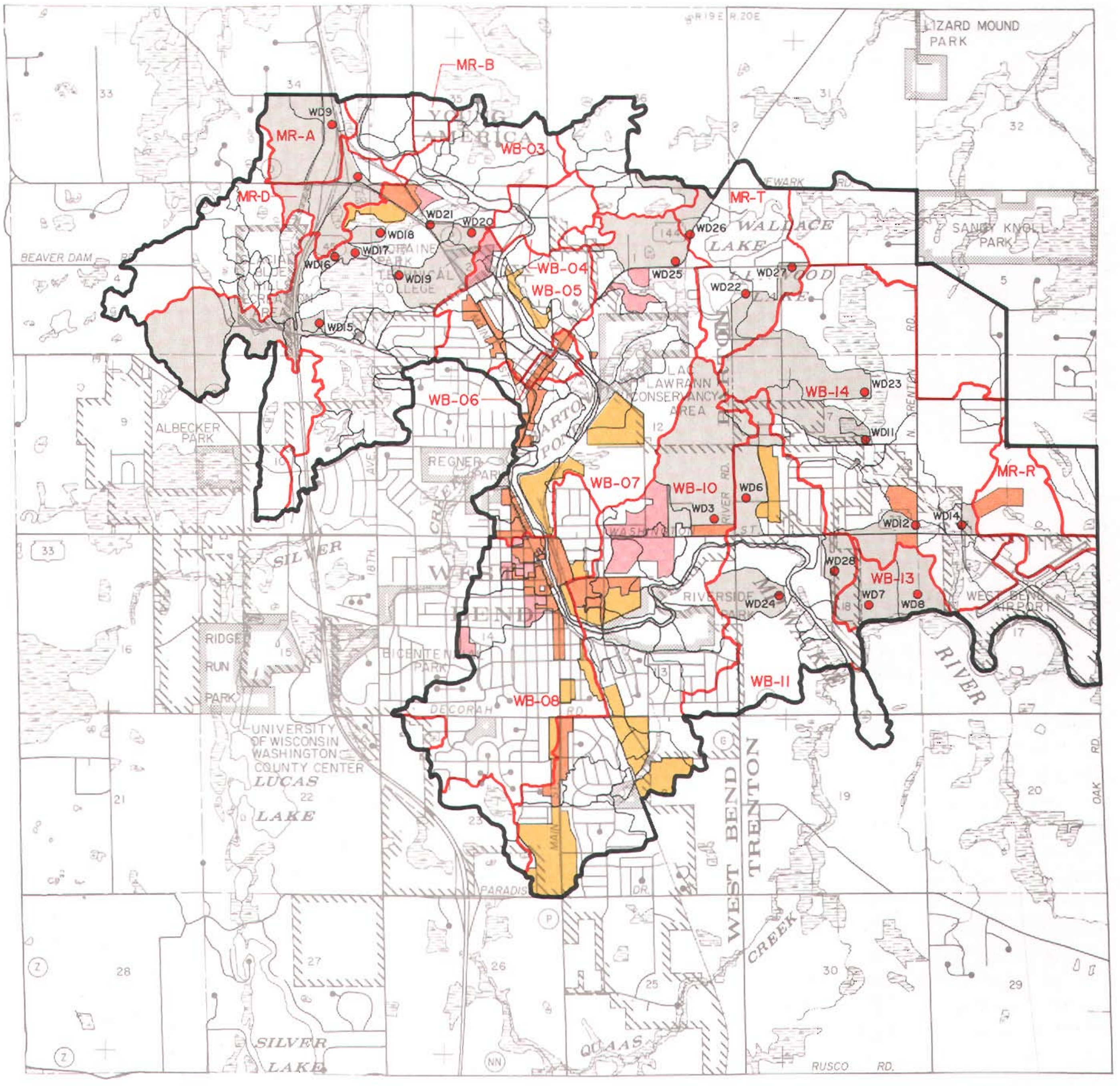
Detention Basin WD5: It was proposed to construct this dual-purpose basin west of Schoenhaar Drive between Lang Street and Washington Street (STH 33). Because of the location of the basin on a prime parcel for future industrial development, the site was rejected by City staff. The dual-purpose detention basin was eliminated from the plan because of the lack of another open-space site.

REVIEW OF SHORELAND ZONING ISSUES RELATED TO RECOMMENDED WET DETENTION BASIN SITES IN UNINCORPORATED AREAS OF WASHINGTON COUNTY

According to Section 59.971(7) of the Wisconsin Statutes, county shoreland and wetland zoning regulations remain in effect in areas which are annexed by a city or village after May 7, 1982. Chapters NR 115 and 117 of the Wisconsin Administrative Code define the shoreland jurisdictional zone associated with a pond, lake, or flowage as including the greater land area defined by either 1) a boundary located 1,000 feet from the ordinary high-water mark of the lake, pond, or flowage, or 2) the 100-year recurrence interval floodplain limit. The staff of the City of West Bend expressed concerns regarding the possibility that the City would be required to enforce the more stringent Washington County shoreland zoning regulations in shoreland jurisdictional zones around wet detention basins constructed on land annexed since May 7, 1982. City staff stated that they would not pursue construction of wet detention basins which would have a shoreland zone requiring enforce-

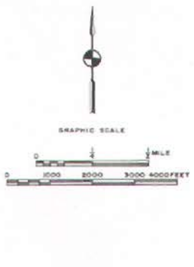
Map 17

RECOMMENDED WATER QUALITY MANAGEMENT PLAN ELEMENT FOR THE MILWAUKEE RIVER DRAINAGE AREA



LEGEND

- ▬ SUBWATERSHED BOUNDARY
- ▬ SUBBASIN GROUP BOUNDARY
- **WB-14** SUBBASIN GROUP DESIGNATION
- — SUBBASIN BOUNDARY
- ● WD2 PROPOSED WET DETENTION BASIN AND DESIGNATION
- 🟥 PROPOSED INFILTRATION SYSTEM TO RETAIN RUNOFF FROM 50% OF PARKING LOT AREA
- 🟧 AREA TRIBUTARY TO STREET TO BE SWEPT 11 TIMES IN SPRING AND 11 TIMES IN FALL AND CATCH BASIN CLEANING TWICE A YEAR
- 🟨 AREA TRIBUTARY TO INDUSTRIAL OR COMMERCIAL PARKING LOT OR STORAGE AREA TO BE SWEPT WEEKLY IN SPRING, SUMMER, AND FALL
- ⬜ AREA TRIBUTARY TO PROPOSED WET DETENTION BASIN



Source: SEWRPC.

Table 88

ANNUAL TOTAL SUSPENDED SOLIDS LOADINGS TO THE MILWAUKEE RIVER DRAINAGE AREA UNDER EXISTING, PLANNED UNCONTROLLED, AND RECOMMENDED PLAN CONDITIONS

	Existing 1985 Land Use				Planned Year 2010 Land Use with No Additional Nonpoint Source Controls							Recommended Plan[a]	
Subbasin Grouping	Urban Loads (pounds)	Urban Area (acres)	Total Urban and Rural Loads (pounds)	Total Urban and Rural Area (acres)	Uncontrolled Urban Loads (pounds)	Percent Change in Urban Loads[b]	Urban Area (acres)	Percent Change in Urban Area[b]	Uncontrolled Total Urban and Rural Loads (pounds)	Percent Change in Total Urban and Rural Loads[b]	Total Urban and Rural Area (acres)	Total Urban and Rural Loads (pounds)	Percent Change in Total Urban and Rural Loads[b]
MR-A	7,750	20.1	57,650	137.1	52,720	580	98.3	389	69,850	21	137.1	11,310	-80
MR-B	1,570	24.4	6,690	35.8	2,130	36	35.4	45	2,160	-68	35.8	2,160	-68
MR-D	5,590	28.4	36,760	113.6	32,750	486	105.1	270	34,350	-7	113.6	13,710	-63
MR-T	8,520	109.0	72,210	317.0	15,770	85	177.5	63	37,040	-49	317.0	28,230	-61
MR-R	3,340	23.7	39,650	161.7	18,120	443	136.4	476	19,270	-51	161.7	16,780	-58
WB03	55,500	296.7	269,570	1,083.0	111,930	102	663.0	123	171,370	-36	1,083.0	102,760	-62
WB04	2,270	25.1	35,600	106.2	11,540	408	93.1	271	13,160	-63	106.2	13,160	-63
WB05	66,030	244.4	80,100	284.8	66,030	0	244.4	0	80,100	0	284.8	68,810	-14
WB06	8,670	29.9	8,950	32.4	15,670	81	29.9	0	15,720	76	32.4	13,580	52
WB07	87,020	275.7	187,600	706.7	152,160	75	453.8	65	157,720	-16	706.7	91,440	-51
WB08	231,620	631.2	244,240	676.0	231,330	0	666.1	6	231,370	-5	676.0	197,620	-19
WB10	235,350	737.4	301,520	1,112.2	410,340	74	1,019.2	38	410,870	36	1,112.2	216,610	-28
WB11[c]	53,520	252.4	160,400	528.9	98,320	84	480.4	90	112,020	-30	528.9	67,760	-58
WB13[d]	15,180	44.4	71,880	173.8	99,520	556	164.5	270	100,130	39	173.8	9,850	-86
WB14[e]	27,220	305.0	350,830	1,030.5	150,040	451	852.3	179	151,270	-57	1,030.5	115,630	-67
Total	809,150	3,047.8	1,923,650	6,499.7	1,468,370	81	5,219.4	71	1,606,400	-16	6,499.7	969,410	-50

[a] *Urban land areas and total urban and rural land areas for this condition are the same as for the planned uncontrolled condition.*

[b] *The percent change refers to the percent change relative to the existing loading.*

[c] *Excludes subbasin MR48, which was included in subbasin grouping WB11 under the priority watershed study.*

[d] *Includes subbasin MR48, which was included in WB11 under the priority watershed study, and 20.5 acres of subbasin W15, which were included in subbasin grouping WB14 under the priority watershed study.*

[e] *Excludes 20.5 acres of subbasin W15 which were included in subbasin grouping WB11 under the priority watershed study.*

Source: SEWRPC.

ment of county shoreland zoning regulations. At the request of the staff of the City of West Bend, the staff of the Wisconsin Department of Natural Resources reviewed the wet detention basins recommended in this plan and concluded that the permanent ponds of the basins would be classified as private waters and, therefore, would not have an associated shoreland zone. Thus, the shoreland zoning issue should not be an impediment to the implementation of the wet detention basins recommended in this plan.

RECOMMENDED WATER QUALITY MANAGEMENT PLAN

Components and Level of Pollution Control of the Recommended Plan

The recommended water quality management plan element for the Milwaukee River drainage area, including the Wingate Creek subwatershed, is shown in graphic summary form on Maps 14 and 17. The control measures selected include the construction of 23 wet detention basins to control runoff from about 1,437 acres, or 22 percent of the Milwaukee River study area; the infiltration of runoff from parking lots serving hospitals, miscellaneous governmental and institutional facilities, and high-density residential development in selected areas; the treatment of runoff from about 592 acres of land, or 9 percent of the study area, through the sweeping of about 14 curb-miles of streets along with selected industrial parking and storage areas; the use of natural vegetation where possible to filter pollutants in the runoff from the proposed West Bend Municipal Airport expansion; and continued enforcement of the City of West Bend construction erosion control ordinance. The estimated pollutant removal effectiveness and costs of the recommended measures are summarized in Tables 88, 89, 90, and 91.

Table 89

ANNUAL PHOSPHORUS LOADINGS TO THE MILWAUKEE RIVER DRAINAGE AREA UNDER EXISTING, PLANNED UNCONTROLLED, AND RECOMMENDED PLAN CONDITIONS

Subbasin Grouping	Existing 1985 Land Use: Urban Loads (pounds)	Urban Area (acres)	Total Urban and Rural Loads (pounds)	Total Urban and Rural Area (acres)	Planned Year 2010 Land Use with No Additional Nonpoint Source Controls: Uncontrolled Urban Loads (pounds)	Percent Change in Urban Loads[b]	Urban Area (acres)	Percent Change in Urban Area[b]	Uncontrolled Total Urban and Rural Loads (pounds)	Percent Change in Total Urban and Rural Loads[b]	Total Urban and Rural Area (acres)	Recommended Plan[a]: Total Urban and Rural Loads (pounds)	Percent Change in Total Urban and Rural Loads[b]
MR-A	14	20.1	109	137.1	83	493	98.3	389	115	6	137.1	59	-46
MR-B	5	24.4	15	35.8	8	60	35.4	45	8	-47	35.8	8	-47
MR-D	11	28.4	72	113.6	57	418	105.1	270	61	-15	113.6	39	-46
MR-T	26	109.0	132	317.0	47	81	177.5	63	73	-45	317.0	59	-55
MR-R	8	23.7	78	161.7	40	400	136.4	476	42	-46	161.7	38	-51
WB03	126	296.7	540	1,083.0	289	129	663.0	123	409	-24	1,083.0	312	-42
WB04	7	25.1	71	106.2	34	386	93.1	271	37	-48	106.2	37	-48
WB05	142	244.4	168	284.8	142	0	244.4	0	168	0	284.8	153	-9
WB06	17	29.9	17	32.4	29	71	29.9	0	29	71	32.4	26	53
WB07	164	275.7	356	706.7	301	84	453.8	65	337	-5	706.7	260	-27
WB08	546	631.2	570	676.0	562	3	666.1	6	563	-1	676.0	518	-9
WB10	509	737.4	707	1,112.2	840	65	1,019.2	38	840	19	1,112.2	624	-12
WB11[c]	113	252.4	318	528.9	255	126	480.4	90	256	-19	528.9	207	-35
WB13[d]	30	44.4	138	173.8	172	473	164.5	270	173	25	173.8	85	-38
WB14[e]	90	305.0	604	1030.5	385	328	852.3	179	394	-35	1,030.5	344	-43
Total	1,808	3,047.8	3,895	6,499.7	3,244	79	5,219.4	71	3,505	-10	6,499.7	2,769	-29

[a] *Urban land areas and total urban and rural land areas for this condition are the same as for the planned uncontrolled condition.*

[b] *The percent change refers to the percent change relative to the existing loading.*

[c] *Excludes subbasin MR48, which was included in subbasin grouping WB11 under the priority watershed study.*

[d] *Includes subbasin MR48, which was included in WB11 under the priority watershed study, and 20.5 acres of subbasin W15, which were included in subbasin grouping WB14 under the priority watershed study.*

[e] *Excludes 20.5 acres of subbasin W15 which were included in subbasin grouping WB11 under the priority watershed study.*

Source: SEWRPC.

The recommended 23 wet detention basins would have permanent ponds ranging in surface area from 0.25 acre to three acres and permanent storage volumes ranging from 1.25 acre-feet to 15 acre-feet. The average depth of the permanent ponds was assumed to be five feet. On an annual basis, under planned land use conditions, the wet basins may be expected to remove 25 percent of the sediment, 13 percent of the phosphorus, and 20 percent of the heavy metals which would be contributed to surface waters in the Milwaukee River study area under planned land use conditions in the absence of nonpoint source pollution abatement measures.

Infiltration systems, which would probably consist of infiltration trenches with a pretreatment facility such as a grass filter strip or a sedimentation-flotation basin for the removal of oil and grease, are recommended to treat the stormwater runoff from about 50 percent of the school, hospital, and miscellaneous governmental and institutional parking areas in those basins shown on Map 17. Infiltration facilities are also recommended for 7.4 acres of high-density residential use area. It is estimated that the infiltration systems would control the runoff from 29 acres of the school, hospital, and miscellaneous governmental and institutional parking lots. On an annual basis, the infiltration facilities may be expected to remove 1 percent of the sediment, 1 percent of the phosphorus, and 1 percent of the heavy metals which would be contributed to surface waters in the Milwaukee River study area under planned land use conditions in the absence of nonpoint source pollution abatement measures.

Table 90

ANNUAL LEAD LOADINGS TO THE MILWAUKEE RIVER DRAINAGE AREA UNDER EXISTING, PLANNED UNCONTROLLED, AND RECOMMENDED PLAN CONDITIONS

	Existing 1985 Land Use				Planned Year 2010 Land Use with No Additional Nonpoint Source Controls							Recommended Plan[a]	
Subbasin Grouping	Urban Loads (pounds)	Urban Area (acres)	Total Urban and Rural Loads (pounds)	Total Urban and Rural Area (acres)	Uncontrolled Urban Loads (pounds)	Percent Change in Urban Loads[b]	Urban Area (acres)	Percent Change in Urban Area[b]	Uncontrolled Total Urban and Rural Loads (pounds)	Percent Change in Total Urban and Rural Loads[b]	Total Urban and Rural Area (acres)	Total Urban and Rural Loads (pounds)	Percent Change in Total Urban and Rural Loads[b]
MR-A	19	20.1	20	137.1	131	589	98.3	389	131	555	137.1	44	120
MR-B	2	24.4	2	35.8	3	50	35.4	45	3	50	35.8	3	50
MR-D	14	28.4	15	113.6	92	557	105.1	270	92	513	113.6	48	220
MR-T	15	109.0	26	317.0	21	40	177.5	63	31	19	317.0	25	-4
MR-R	9	23.7	10	161.7	47	422	136.4	476	47	370	161.7	37	270
WB03	101	296.7	109	1,083.0	222	120	663.0	123	227	108	1,083.0	141	29
WB04	5	25.1	6	106.2	19	280	93.1	271	19	217	106.2	19	217
WB05	136	244.4	137	284.8	136	0	244.4	0	137	0	284.8	106	-23
WB06	20	29.9	20	32.4	40	100	29.9	0	40	100	32.4	32	60
WB07	212	275.7	218	706.7	363	71	453.8	65	370	70	706.7	212	-3
WB08	472	631.2	473	676.0	492	4	666.1	6	492	4	676.0	391	-17
WB10	540	737.4	548	1,112.2	941	74	1,019.2	38	942	72	1,112.2	501	-9
WB11[c]	120	252.4	136	528.9	246	105	480.4	90	247	82	528.9	160	-18
WB13[d]	36	44.4	23	173.8	243	575	164.5	270	243	957	173.8	71	209
WB14[e]	51	305.0	57	1,030.5	282	453	852.3	179	285	400	1,030.5	226	296
Total	1,752	3,047.8	1,800	6,499.7	3,278	87	5,219.4	71	3,306	84	6,499.7	2,016	12

[a] *Urban land areas and total urban and rural land areas for this condition are the same as for the planned uncontrolled condition.*

[b] *The percent change refers to the percent change relative to the existing loading.*

[c] *Excludes subbasin MR48, which was included in subbasin grouping WB11 under the priority watershed study.*

[d] *Includes subbasin MR48, which was included in WB11 under the priority watershed study, and 20.5 acres of subbasin W15, which were included in subbasin grouping WB14 under the priority watershed study.*

[e] *Excludes 20.5 acres of subbasin W15 which were included in subbasin grouping WB11 under the priority watershed study.*

Source: SEWRPC.

An increased street sweeping program with an intensive street sweeping effort in spring, to reduce high street surface loadings prior to the onset of heavy spring rainstorms, and in fall, to reduce high loadings due to leaves and other vegetative debris, is recommended in the commercial and industrial areas shown on Map 17. Under the current street sweeping program within the City of West Bend, all streets are swept approximately four times per year. Leaf collection occurs twice during the fall. The recommended plan calls for the designated streets to be swept an additional nine times early in spring and nine times in fall, along with increased cleaning of catch basins. Also, intensive weekly sweeping of the industrial parking and storage areas indicated on Map 17 and covering or berming of material storage areas as applicable at those sites is recommended. On an annual basis, the increased street, parking lot, and storage area sweeping may be expected to remove 13 percent of the sediment, 7 percent of the phosphorus, and 18 percent of the heavy metals which would be contributed to surface waters in the Milwaukee River study area under uncontrolled planned land use conditions.

The recommended continued enforcement of the City of West Bend construction site erosion control ordinance, as described in the section of this chapter which sets forth the preliminary recommended plan, may be expected to achieve about a 75 percent reduction in the total uncontrolled pollutant loadings from the construction sites.

Implementation of the recommended nonpoint source pollution control measures would result in

Table 91

DESCRIPTION, POLLUTANT REMOVAL EFFECTIVENESS, AND COST OF THE RECOMMENDED WATER QUALITY MANAGEMENT PLAN ELEMENT

Subbasin Grouping	Plan Component Description	Estimated Percent Reduction in Planned (2010) Pollutant Loads			Capital Cost[a]	Annual Operation and Maintenance Cost
		Total Suspended Sediment	Phosphorus	Lead		
MR-A	1. WD9, 2.2-acres, 11.2-acre-foot wet basin	3.6	1.6	2.6	$ 394,000	$ 5,100
	Subtotal	3.6	1.6	2.6	$ 394,000	$ 5,100
MR-B	No nonpoint source pollution control measures	- -	- -	- -	- -	- -
MR-D	1. WD10, 1.6-acres, 8.0-acre-foot wet basin	1.3	0.6	1.3	$ 185,000	$ 4,000
	Subtotal	1.3	0.6	1.3	$ 185,000	$ 4,000
MR-R	1. SW15, sweep 0.8 curb-mile of street	0.2	0.1	0.3	$ 400	$ 400
	Subtotal	0.2	0.1	0.3	$ 400	$ 400
MR-T	1. WD22, 0.31-acre, 1.6-acre-foot wet basin	0.2	0.1	0.1	$ 75,000	$ 1,700
	2. WD26, 0.25-acre, 1.25-acre-foot wet basin	0.3	0.2	0.1	71,000	1,500
	3. WD27, 0.25-acre, 1.25-acre-foot wet basin	0.1	0.1	<0.1	65,000	1,500
	Subtotal	0.6	0.4	0.2	$ 211,000	$ 4,700
WB-3	1. WD15, 2.4-acres, 12.0-acre-foot wet basin	1.8	1.1	0.5	$ 257,000	$ 5,400
	2. WD16, 0.25-acre, 1.25-acre-foot wet basin	0.1	0.1	0.1	71,000	1,500
	3. WD17, 0.25-acre, 1.25-acre-foot wet basin	0.1	0.1	0.1	71,000	1,500
	4. WD18, 0.25-acre, 1.25-acre-foot wet basin	0.2	0.1	0.2	71,000	1,500
	5. WD19, 0.7-acre, 3.5-acre-foot wet basin	0.8	0.5	0.4	109,000	2,300
	6. WD20, 0.25-acre, 1.25-acre-foot wet basin	0.4	0.3	0.2	81,000	1,500
	7. WD21, 0.25-acre, 1.25-acre-foot wet basin	0.2	0.1	0.1	81,000	1,500
	8. IF5, infiltrate runoff from 1.8 acres of parking lots	0.1	0.0	0.1	22,000	1,200
	9. SW11, sweep 3.4 acres of industrial parking and storage area	0.6	0.3	0.7	1,700	1,900
	10. SW12, sweep 1.1 curb-miles of street	0.2	0.1	0.3	500	600
	Subtotal	4.5	2.7	2.8	$ 765,200	$ 18,900
WB-4	No nonpoint source pollution control measures	- -	- -	- -	- -	- -
WB-5	1. IF7, infiltrate runoff from 3.8 acres of parking lots	0.1	0.1	0.1	$ 55,000	$ 2,600
	2. SW5, sweep 2.4 acres of industrial parking and storage area	0.5	0.2	0.5	1,200	1,400
	3. SW6, sweep 1.0 curb-mile of street	0.2	0.1	0.4	500	500
	Subtotal	0.7	0.4	0.9	$ 56,700	$ 4,500
WB-6	1. SW7, sweep 0.5 curb-mile of street	0.1	0.1	0.2	$ 300	$ 300
	Subtotal	0.1	0.1	0.2	$ 300	$ 300
WB-7	1. WD25, 0.68-acre, 3.4-acre-foot wet basin	1.0	0.5	0.8	$ 128,000	$ 2,600
	2. IF8, infiltrate runoff from 7.4 acres of high-density residential area	0.0	0.1	0.1	74,000	3,500
	3. SW1, sweep 2.7 curb-miles of street	0.4	0.3	0.7	1,300	1,400
	4. SW13, sweep 16.6 acres of industrial parking and storage area	2.7	1.4	3.2	8,400	9,300
	Subtotal	4.1	2.3	4.8	$ 211,700	$ 16,800
WB-8	1. IF1, infiltrate runoff from 3.2 acres of parking lots	0.1	0.1	0.2	$ 42,000	$ 2,000
	2. IF2, infiltrate runoff from 3.6 acres of parking lots	0.1	0.1	0.1	44,000	2,400
	3. SW2, sweep 4.2 curb-miles of street	0.7	0.5	1.4	2,000	2,300
	4. SW14, sweep 0.4 curb-mile of street and 5.6 acres of industrial parking and storage area	0.3	0.1	0.4	3,100	2,300
	5. SW16, sweep 4.1 acres of commercial parking lots	0.2	0.1	0.3	2,100	2,300
	6. SW17, sweep 7.5 acres of industrial parking and storage lots	0.6	0.3	0.7	3,800	4,200
	Subtotal	2.0	1.2	3.1	$ 97,000	$ 15,500
WB-10	1. WD3, 3.2-acres, 15.8-acre-foot wet basin	5.9	2.7	5.3	$ 644,000	$ 6,500
	2. IF3, infiltrate runoff from 7.0 acres of parking lots	0.3	0.3	0.3	76,000	3,300
	3. IF4, infiltrate runoff from 4.4 acres of parking lots	0.1	0.1	0.2	59,000	2,800
	4. IF6, infiltrate runoff from 5.6 acres of parking lots	0.2	0.2	0.3	51,000	2,400
	5. SW3, sweep 2.1 curb-miles of street and 44.5 acres of industrial parking and storage area	1.2	0.7	1.6	12,100	13,300
	6. SW4, sweep 0.4 curb-mile of street	0.1	0.1	0.2	200	200
	7. SW8, sweep 0.6 curb-mile of street	0.2	0.1	0.4	300	300
	8. SW18, sweep 38.6 acres of commercial parking lots	2.2	1.1	2.8	19,600	21,600
	9. SW19, sweep 28.7 acres of industrial parking and storage lots	1.9	1.0	2.2	14,600	16,100
	Subtotal	12.1	6.3	13.3	$ 876,800	$ 66,500

Table 91 (continued)

Subbasin Grouping	Plan Component Description	Estimated Percent Reduction in Planned (2010) Pollutant Loads			Capital Cost[a]	Annual Operation and Maintenance Cost
		Total Suspended Sediment	Phosphorus	Lead		
WB-11	1. WD6, 0.64-acre, 3.2-acre-foot wet basin	1.3	0.5	1.2	$ 135,000	$ 2,000
	2. WD24, 0.49-acre, 2.5-acre-foot wet basin	0.5	0.4	0.3	150,000	1,800
	3. WD28, 0.27-acre, 1.4-acre-foot wet basin	0.5	0.3	0.5	85,000	1,800
	4. SW20, sweep 10.1 acres of industrial parking and storage lots	0.9	0.5	1.1	5,100	5,700
	Subtotal	3.2	1.7	3.1	$ 375,100	$ 11,300
WB-13	1. WD7, 1.6-acres, 8.0-acre-foot wet basin	3.5	1.5	3.3	$ 404,000	$ 3,900
	2. WD8, 0.83-acre, 4.1-acre-foot wet basin	1.6	0.7	1.5	219,000	2,600
	Subtotal	5.1	2.2	4.8	$ 623,000	$ 6,500
WB-14	1. WD11, 0.58-acre, 2.9-acre-foot wet basin	0.6	0.4	0.3	$ 94,000	$ 1,900
	2. WD12, 0.25-acre, 1.25-acre-foot wet basin	0.5	0.3	0.5	69,000	1,500
	3. WD14, 0.25-acre, 1.25-acre-foot wet basin	0.2	0.1	0.2	65,000	1,500
	4. WD23, 1.13-acres, 5.6-acre-foot wet basin	0.7	0.5	0.3	127,000	3,000
	5. SW9, sweep 0.1 curb-mile of street	0.1	0.1	0.3	100	100
	6. SW10, sweep 0.2 curb-mile of street	0.1	0.1	0.2	100	100
	Subtotal	2.2	1.5	1.8	$ 355,200	$ 8,100
- -	Total	39.7	21.1	39.2	$4,151,400	$162,600

[a] *Includes land acquisition and an additional 35 percent of the construction cost to account for engineering, administration, and contingencies. Based on 1991 Engineering News-Record Construction Cost Index of 5,015.*

Source: SEWRPC.

sediment loadings to the Milwaukee River under planned land use conditions which are 50 percent lower than those under existing conditions; phosphorus loadings which are 29 percent lower than under existing conditions; and heavy metal loadings which are 12 percent higher than under existing conditions. In comparison to uncontrolled loadings under planned land use conditions, the recommended control measures would reduce sediment loadings by 40 percent, phosphorus loadings by 21 percent, and heavy metal loadings by 39 percent. The sediment and phosphorus loading reductions are a lesser percentage of the planned land use loadings in the absence of nonpoint source pollution abatement measures than of the existing land use loadings because the conversion of rural to urban uses may be expected to produce a modest reduction in the uncontrolled loadings of those pollutants even without controls.

Recommended Public Education Program

In addition to the components of the recommended alternative plan measures, it is also recommended that a public education program be developed as described above in this chapter.

Comparison of the Nonpoint Source Pollution Reductions Achieved by the Recommended Plan with Those Recommended under the Regional Water Quality Management Plan and under the Priority Watershed Study

The recommended control measures, if fully implemented, would reduce nonpoint source pollutant loadings to the Milwaukee River under planned land use conditions by from 21 percent to 40 percent, depending on the type of pollutant. The estimated reductions associated with the recommended plan are compared to the levels of control set forth under the adopted regional water quality management plan, under the priority watershed plan, and under the preliminary recommended plan in Table 87. The nonpoint source control measures recommended in this stormwater management plan may be expected to provide a level of pollutant removal substantially exceeding that recommended for sediment and slightly less than that recommended for phosphorus in the adopted regional water quality management plan. As already noted, that plan recommended that about a 25 percent reduction in nonpoint source pollutants would be adequate to achieve the water use objectives and standards.

Implementation of the nonpoint source pollution control measures recommended herein would result in sediment loadings to the Milwaukee River under planned conditions which are 50 percent lower than those under existing conditions, phosphorus loadings which are 29 percent lower than under existing conditions, and heavy metal loadings which are 12 percent higher than under existing conditions. The water quality "enhancement" reduction goal for sediment as established in the priority watershed study would thus be achieved. However, the enhancement reduction levels for phosphorus and heavy metals would not. The anticipated phosphorus reduction is substantial and an improvement in water quality may be expected to result from the proposed reduction. The phosphorus reduction level substantially exceeds the "secondary" goal established in the priority watershed study of maintaining current 1988 levels. The limitation on the increase in metals loading, while falling short of the "enhancement" goal and the "secondary" goal of maintaining 1988 loadings, is significant, given the inherent difficulty in reducing loadings of heavy metals and other predominantly urban pollutants when an area experiences significant new urban development.

The pollutant loading reductions achieved by the plan are the largest which are practically attainable under the constraints identified during the review of the plan by City of West Bend staff. The anticipated loading reductions following complete implementation of the recommended plan may be expected to improve the overall water quality conditions of the Milwaukee River and its intermittent tributaries in the study area. Thus, the nonpoint source pollution control measures called for under the recommended plan are considered to be not in conflict with the regional water quality management plan and in substantial conformance with the goals of the priority watershed plan.

RECOMMENDED PLAN NONPOINT SOURCE POLLUTION CONTROL FACILITY COSTS

As set forth in Table 91, the total capital cost of the recommended water quality management plan for the Milwaukee River drainage area is approximately $4,151,000, consisting of $3,651,000 for wet detention basins; $423,000 for infiltration facilities; and $77,000 for increased street, parking lot, and storage area sweeping. The annual operation and maintenance cost attendant to this plan is estimated at $162,600, consisting of $58,100 for wet detention basins, $20,200 for infiltration facilities, and $84,300 for increased street, parking lot, and storage area sweeping.

The recommended plan costs are based upon planned development of the study area. The costs reflect only the nonpoint source pollution abatement measures and do not include costs for the stormwater drainage plan element. Costs for the entire stormwater management system plan, including those for both stormwater drainage and nonpoint source pollution abatement measures, are presented in Chapter VII of this volume, which deals with implementation of the plan. That chapter also includes an apportionment of costs to be borne by the City of West Bend, the State of Wisconsin, and by private concerns.[6]

SUMMARY

The recommended water quality management plan element for the Milwaukee River drainage area, including the Wingate Creek subwatershed, calls for the construction of 23 wet detention basins which would control runoff from about 1,437 acres, or 22 percent of the Milwaukee River study area; the infiltration of runoff from parking lots serving hospitals, miscellaneous governmental and institutional facilities, and high-density residential development in selected areas; the abatement of pollutant runoff from about 592 acres of land, or 9 percent of the study area, through the sweeping of about 14 curb-miles of streets, cleaning of catch basins twice a year, and sweeping of selected industrial parking and storage areas; the use of buffer zones of natural vegetation where possible to filter pollutants in the runoff from the proposed West Bend Municipal Airport expansion; and continued enforcement of the City of West Bend construction erosion control ordinance.

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[6] *The final date for implementing nonpoint source pollution control projects in the East and West Branches of the Milwaukee River priority watershed is June 1997. Such projects are eligible for State cost-sharing funds up to that final date.*

Implementation of the recommended nonpoint source pollution control measures would result in sediment loadings to the Milwaukee River under planned land use conditions which are 50 percent lower than those under existing conditions, phosphorus loadings which are 29 percent lower than under existing conditions, and heavy metal loadings which are 12 percent higher than under existing conditions. In comparison to uncontrolled loadings under planned land use conditions, the recommended control measures would reduce sediment loadings by 40 percent, phosphorus loadings by 21 percent, and heavy metal loadings by 39 percent. The recommended plan levels of control of nonpoint source pollutants approximately meet or exceed the recommended reductions set forth in the regional water quality management plan. In addition, the recommended plan achieves the pollutant reduction goals for sediment as established in the priority watershed planning program for water quality enhancement. The water quality enhancement reduction goals for phosphorus and metals loadings set forth in the priority watershed program are not fully achieved. However, the secondary goal for phosphorus of maintaining 1988 loadings is substantially exceeded. The limitation on metals loading falls short of meeting either the enhancement or the secondary goals set forth in the priority watershed plan. However, the metals loading reduction expected is significant given the inherent difficulty in reducing metals loadings below pre-development loadings in areas which experience significant new development. The nonpoint source pollution control measures called for under the recommended plan are considered to be not in conflict with the regional water quality management plan and in substantial conformance with the goals of the priority watershed plan.

The total capital cost of the recommended water quality management plan for the Milwaukee River drainage area is approximately $4,151,000, consisting of $3,651,000 for wet detention basins; $423,000 for infiltration facilities; and $77,000 for increased street, parking lot, and storage area sweeping. The attendant annual operation and maintenance cost is estimated at $162,600, consisting of $58,100 for wet detention basins; $20,200 for infiltration facilities; and $84,300 for increased street, parking lot, and storage area sweeping.

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Chapter V

AUXILIARY PLAN RECOMMENDATIONS

INTRODUCTION

The recommendations set forth in Chapters II, III, and IV of this report address primarily stormwater drainage system facilities and water quality management measures. To provide a comprehensive stormwater management plan, however, these recommendations must be supplemented by plan elements relating to natural resource and open space protection and to the continued proper maintenance of the stormwater management system.

Natural Resource and Open Space Preservation

A land use plan has been prepared and adopted by the City that provides for the preservation of the primary environmental corridor lands within the City and environs, including associated floodlands and wetlands, in essentially natural, open uses.[1] The protection of floodlands and wetlands from the intrusion of urban land uses has important implications for stormwater management, since these lands can provide needed capacity for the storage, infiltration, and transport of stormwater runoff.

Floodplain Map Revisions: Upon adoption of this system plan, the City should amend those portions of its floodplain zoning ordinance pertaining to Wingate Creek to reflect the 100-year recurrence interval water surface profiles set forth in this plan for the existing channel and drainage system under future land use conditions. At that time, the City should also submit its proposed floodplain revisions and additions to the Wisconsin Department of Natural Resources, requesting revision of the Flood Hazard Boundary Maps by the Federal Insurance Administration.

Wetland Protection: Authority for the preservation of wetlands exists at the local, State, and Federal levels as discussed in the regulatory considerations section of Chapter VI of this volume. The proper exercise of that authority will result in the preservation of the stormwater management functions of the wetlands in the study area.

Maintenance of Stormwater Management Facilities

The effectiveness of the stormwater conveyance and detention facilities, once developed, can be sustained only if proper operation, repair, and maintenance procedures are carefully followed. The City has a program of annual catch basin cleaning, outfall cleaning, inspection by television camera, storm sewer pipe cleaning, street sweeping four times a year, and leaf collection twice a year. Important additional maintenance activities include the periodic repair of storm sewers, clearing sewer obstructions, maintenance of open-channel vegetative lining, clearing debris and sediment from open channels, maintenance of detention facility inlets and outlets, maintenance of detention basin vegetative cover, periodic removal of sediment accumulated in detention basins, and sweeping parking lots used as detention facilities. These maintenance activities are recommended to be carried out on a continuing basis to maximize the effectiveness of the stormwater management facilities and measures and to protect the capital investment in the facilities.

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[1] *SEWRPC Community Assistance Planning Report No. 167, A Land Use Plan for the City of West Bend: 2010, July 1992.*

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Chapter VI

PLAN IMPLEMENTATION

INTRODUCTION

The recommended stormwater management plan described in this volume is designed to attain, to the maximum extent practicable, the stormwater management objectives and standards set forth in Chapter IV of Volume One of this report. In a practical sense, however, the plan is not complete until the steps to implement it, that is, to convert the plan into action policies and programs, have been specified. Following formal adoption of this plan by the City of West Bend, realization of the plan will require a long-term commitment to the objectives of the plan and a high degree of coordination and cooperation among city officials and staff, land developers, and concerned citizens in undertaking the substantial investments and series of actions needed to provide urban development in the West Bend area with an efficient and effective stormwater drainage system. The plan should be used as a guide for the development of the stormwater drainage system and related stormwater management measures within the planned urban service area.

The first section of this chapter describes the relationship of land use development and redevelopment to the effectiveness of the planned stormwater management measures. The second section discusses the importance of more detailed engineering to implementation of the plan. The third section sets forth the specific actions required to implement the plan. The fourth section summarizes the overall plan costs and presents an apportionment of costs between the City of West Bend, the State of Wisconsin, and the private sector. A preliminary plan implementation schedule is presented in the fifth section. The sixth section presents regulatory considerations. The seventh section discusses the need for periodic reevaluation and updating of the plan itself.

RELATION TO FUTURE LAND USE DEVELOPMENT

Fundamental to implementation of a sound stormwater management plan is coordination with land use development and redevelopment. Design year 2010 planned land use conditions for the stormwater management area are set forth in SEWRPC Community Assistance Planning Report No. 167, A Land Use Plan for the City of West Bend: 2010, July 1992. The estimated rates and volumes of runoff and nonpoint source pollutant loadings which were used in the development of the alternatives set forth here were determined based on the recommended land use plan set forth in Community Assistance Planning Report No. 167. To a large extent, the effectiveness of the recommended stormwater management measures will depend upon the degree to which future land use development and redevelopment and the stormwater management plan properly complement each other.

Importantly, the stormwater management plan identifies those areas of the subwatershed that should be preserved in open, natural uses. Such preservation will provide major economies in stormwater management, maximizing the use of natural stormwater conveyance and storage, and permitting such conveyance and storage to be incorporated into the stormwater management plan and system. If the preservation of these open areas is greatly compromised, stormwater management problems, such as localized flooding, poor drainage, and water pollution, may be expected to result.

RELATION OF DETAILED ENGINEERING DESIGN TO SYSTEM PLANNING

The systems level stormwater management plan presented in this report is intended to serve as a guide to the design and construction of stormwater management facilities. Engineering design should begin as the systems planning phase is completed. The detailed engineering design should examine in greater depth and detail the variations in the technical, economic, and environmental features of the recommended solutions to problems identified in the system plan in order to determine the best means of carrying out the plan. The resulting facility development plans should be fully consistent with the stormwater collection, conveyance, and detention facility recommendations presented in this report.

Chapter IV of Volume One of this report presented the engineering design criteria and analytic procedures used in the preparation and evaluation of the alternative stormwater management system plans. These criteria and procedures, firmly based in current engineering practice, provided the means for quantitatively sizing and analyzing the performance of both the minor and major stormwater drainage system components. These criteria and procedures should also serve as a basis for the more detailed design of stormwater management system components in the implementation of the recommended plan. It is important that such criteria and procedures be applied uniformly and consistently in all phases of implementation of the plan if the resulting system is to perform as envisioned in the plan.

Table 92 sets forth the design criteria and analytic procedures recommended to be followed in the engineering design of the recommended plan components. Criteria and procedures are presented in the table for estimating stormwater flows; calculating hydraulic capacities of conveyance facilities; designing street cross-sections and related site grading; locating and designing storm sewer inlets; designing storm sewers; designing roadside swales, open channels, and culverts; and designing storage facilities. In this respect, it is recognized that over time new design techniques may be developed and become available for use in the design of stormwater management system components. Any such techniques should, however, be carefully reviewed before adoption for consistency with the criteria and procedures set forth in the plan.

PLAN IMPLEMENTATION

Plan Adoption

An important first step in plan implementation is the formal adoption of the recommended stormwater management plan, as documented herein, by the City of West Bend Plan Commission, the Board of Public Works, and the City Council. In addition, the plan should be endorsed by the Wisconsin Department of Natural Resources.

Upon such adoption, the stormwater management plan becomes the official guide for making stormwater management decisions by City officials. Such formal adoption serves to signify agreement with, and official support of, the recommendations contained in the plan, and enables the City staff to begin integrating the plan recommendations into the ongoing land use control, public works development planning and programming, and subdivision plat review processes of the City.

Implementation Procedures

The plan can be implemented by using the existing City procedures for land subdivision plat approval, capital improvement programming, and public works construction, operation, and maintenance. Funding for capital improvements and operation and maintenance may be obtained through the property tax levy, special assessments, issuance of general obligation bonds, reserve funds, private developer contributions, and grants from the State of Wisconsin.

In reviewing subdivision plats, the City Plan Commission would determine the compatibility of the plats with the land use recommendations set forth in the adopted City land use plan and used in preparation of the stormwater management plan. Any proposed departures from those recommendations should be carefully considered in light of the stormwater management needs of the proposed development and the impacts on upstream and downstream areas. The plat review function can and should, under Wisconsin law, be exercised extraterritorially by the City.

Capital improvements programming would be a particularly important tool for implementing the recommended stormwater management plan. Typically, a capital improvements program is a five-year program for the timing and financing of priority capital improvement projects. Such a program is based upon the projected financial capability of the community and is formulated from a detailed analysis of municipal revenues, debt service obligations, financing procedures, and external funding potentials. Once formulated, the program would be reevaluated, refined, and extended on an annual basis. Under this option, the City's well-developed procedure for capital improvement financing would incorporate the stormwater management plan components in a manner consistent with the construction prioritization set forth below.

Implementation of the plan through the City zoning map and ordinance would be another

Table 92

DESIGN CRITERIA AND PROCEDURES RECOMMENDED TO BE FOLLOWED IN DETAILED ENGINEERING DESIGN OF THE RECOMMENDED STORMWATER MANAGEMENT COMPONENTS

Design Function	Recommended Criteria and Procedures
Storm Runoff Flows	Minor system components should be designed to accommodate flows expected from a 10-year recurrence interval storm event. Major system components should be designed to accommodate flows expected from a 100-year recurrence interval storm event. To determine peak rates of flow for the design of pure conveyance facilities with no significant upstream storage, the Rational Method, as described in SEWRPC Technical Record, Vol. 2, No. 4, April-May 1965, "Determination of Runoff for Urban Stormwater Drainage System Design," or the U. S. Soil Conservation Service Method, as described in SCS Technical Release 55, June 1986, "Urban Hydrology for Small Watersheds," should be used. The rainfall intensity, duration, and frequency curves suitable for use with the Rational Method are provided in Figure 9 in Chapter IV of Volume One of this report. When storage is to be included in the facilities and estimates of runoff volumes as well as peak rates of discharge are required, the TR55 Method for sizing detention basins or a suitable hydrologic-hydraulic simulation model should be used
Conveyance Facilities	The sizes of recommended conveyance facilities are set forth in Tables 6 and 9 and on Maps 6 and 14 of Chapters II and III of this volume. Manning's formula should be used to determine the hydraulic capacities of conveyance facilities where flow conditions approximate uniform conditions. The use of Kutter's formula is also acceptable for uniform pipe flow computations. Storm sewers should be designed to flow full during the design storm event. Flow velocities should not be less than 2.5 feet per second in storm sewers. The chart set forth in Figure 17, Chapter IV of Volume One of this report should be used to determine the hydraulic elements of the storm sewers. Manning's "n" values for roadside swales should be selected using retardance levels C or D, as shown in Figure 14 of Chapter IV of Volume One of this report. Flow velocities should not exceed six feet per second in turf-lined channels. Where pipe flow does not approach uniform conditions, backwater, drawdown, or inlet control conditions should be determined mathematically or by use of appropriate nomographs. Where open-channel flow does not approach uniform conditions, the U. S. Army Corps of Engineers HEC-2 model or another comparable model should be used to compute water surface profiles
Street Cross-Sections and Related Site Grading	Except in areas specifically recommended to have rural cross-sections, streets should be designed with urban cross-sections. Typical street cross-sections are shown in Figure 2 of Chapter III of Volume One of this report. Slopes away from all buildings, as well as the slopes of interior drainage swales, should be at least one-quarter inch per foot to provide positive drainage
Storm Sewer Inlets	Storm sewer inlet location and capacity should be dictated by the allowable stormwater spread and depth of flow in streets. Combination inlets should be used in most instances. Uncontrolled flow across streets should not be allowed when the streets are functioning as a part of the minor stormwater drainage system. At locations where storm sewers function as a part of the major drainage system and are sized to convey design flows resulting from storms with recurrence intervals greater than 10 years, and at locations where a storm sewer is intended to divert a specific design flow to an offline detention basin, sufficient inlet hydraulic capacity should be provided to permit the design capacity of the storm sewer to be developed
Culverts	The length and size of recommended culverts are set forth in Tables 6 and 9 and on Maps 6 and 14 of Chapters II and III of this volume. Culvert capacities should be determined by using appropriate nomographs and charts or by using the HEC-2 model or a comparable substitute where the culvert is a component of an open-channel system. Where appropriate, culverts should be designed to permit fish passage
Storage Facilities	The size and design outflows of recommended storage facilities are set forth in Tables 7 and 10 of Chapters II and III of this volume. The effects of storage facilities on the frequency, duration, and magnitude of downstream flows under future conditions as compared to existing conditions should be carefully examined

NOTE: For a more detailed discussion of these design criteria, see Chapter IV of this report.

Source: SEWRPC.

means of ensuring that land use development takes place in accordance with the assumptions underlying the stormwater management plan. Unlike subdivision control, which operates on a plat-by-plat basis, the zoning ordinance operates over the entire City in advance of development proposals, serving to increase public acceptance of the plan recommendations and improving coordination between upstream development and downstream stormwater management. As in the case of subdivision plat review, any zoning changes should consider the potential impacts on the facilities included in the stormwater management plan.

A common stormwater management problem facing municipalities is a lack of a continuing maintenance program for stormwater facilities, including periodic inspection and routine preventive maintenance. This problem is caused by the absence of an assured, continuous source of funding and incomplete records to justify budgeting for this funding. Stormwater facility maintenance can be easily ignored for a limited period of time; many officials and citizens alike incorrectly perceive that certain components, such as open channels or sewers, are self-maintaining, or that no hazards will result if such facilities become defective. However, a sound, continuing, preventive maintenance program must be given a high priority, particularly for a stormwater management system which includes various types of components such as storm sewers, roadside swales, culverts, open channels, and detention facilities that are interrelated and interconnected. The City does have a maintenance program for drainage facilities. It is recommended that the public works program of the City continue to provide for the maintenance, as well as construction, of the stormwater management facilities, including periodic inspection of conveyance and detention facilities; timely repair of facilities; cleaning of storm sewers, open channels, and detention facility inlets and outlets; maintenance of open channel and detention facility lining materials; and periodic removal of accumulated sediment from conveyance, detention, and sediment control facilities.

Financing

Several means of financing stormwater management components are available to local governmental agencies that are not available to the private sector. Although these means offer flexibility, certain constraints and limitations are imposed on these financing methods by State law; in some cases approval by the electorate required. Therefore, successful public financing of the recommended plan will require a thorough study of costs and available revenues, careful financial planning, public information programs, and a timely approach for securing public support and approvals.

In addition to using such current tax revenue sources as property taxes, the City may make use of such revenue sources as reserve funds, general obligation bonds, private developer contributions, and State grants. Since the City has established the legal limit of two tax incremental financing districts, that means of financing public works projects is not currently available.

Other than Wisconsin Department of Natural Resources nonpoint source pollution abatement program funds, State and Federal grants are generally not available to finance stormwater management measures at this time. The City may be able to obtain financial assistance from the Department of Natural Resources' Wisconsin Fund Nonpoint Source Pollution Abatement Program for the construction of many of the components of the water quality management plan element.[1] It is also possible that the cost of certain components of the recommended stormwater drainage or flood control systems could be shared between the City and the Wisconsin Department of Transportation as a part of highway and airport construction or reconstruction projects.

To provide a dependable source of funds necessary to meet the operation and maintenance costs attendant to implementation of the plan, such costs should be funded from the City general fund as part of the ongoing public works program.

For new urban developments which contain recommended stormwater management components to be financed all or in part by the private

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[1] *The end date for implementing nonpoint source pollution control projects in the East and West Branches of the Milwaukee River priority watershed is June 1997. Such projects can be signed up for State cost sharing funds up to that end date.*

sector, provision of the recommended facilities would ordinarily be a condition of plat approval by the City. Thus, the costs would be ultimately borne at least in part by the land parcel purchasers. Contributions of materials and services to the City may also be made by land developers.

STORMWATER MANAGEMENT SYSTEM COSTS

The capital costs and operation and maintenance costs of the recommended stormwater management system plan are presented in Table 11 of Chapter III of this volume. The capital cost of the recommended plan is estimated to be $29.54 million. The annual operation and maintenance cost increase of the recommended plan is estimated to be $224,600. Of the total capital cost of the recommended plan, about $25.39 million, or 86 percent, is for the stormwater drainage plan element; and about $4.15 million, or 14 percent, is for the water quality management plan element. Of the total annual operation and maintenance cost, about $62,000, or 28 percent, is for the stormwater drainage plan element; and about $162,600, or 72 percent, is for the water quality management plan element.

These costs are based upon full development of the portion of the urban service area within the study area and do not include the cost of small-diameter collector sewers, roadside swale collectors, and road culverts that may be required to drain collector and land access roadways, the alignments of which have not as yet been determined, or the cost of roadway sections in newly developing areas that have been designated to function as a component of the major drainage system. The cost of minimum size collectors would be approximately $7,000 per acre of area served.

Schedule of Public Sector and Private Sector Costs

In general, the capital costs of each stormwater management component were assumed to be borne by the public sector if the components were designed to serve public property, or if the general public, not just owners of new development, would benefit from the component. Capital costs were assumed to be borne by the private sector if the primary benefit of the component would accrue to new development. Public sector and private sector expenditures are listed in Table 93. The following criteria were applied to allocate capital costs to the public sector and private sector:

1. Upgrading existing drainage system components intended to resolve existing stormwater problems for more than an isolated area, and components designed to serve public property, were assumed to be funded by the public sector.
2. Components, or portions of components, designed to served specific, new urban development or to solve an isolated problem related to existing private urban development were assumed to be funded by the private sector. Also, components which would be likely to serve multiple new developments were assigned to the private sector.
3. The capital costs and operation and maintenance costs of the recommended street sweeping were assigned to the public sector.
4. The capital costs and operation and maintenance costs of sweeping of industrial and commercial parking lots and storage areas was assigned to the private sector.
5. The capital costs of infiltration facilities were assigned depending on whether the facilities would serve private or public land.

Funds may be available from the State of Wisconsin for the installation of best management practices which meet the nonpoint source pollution reduction objectives set forth in the East and West Branches of the Milwaukee River Priority Watershed Study. The current policy of the Wisconsin Department of Natural Resources regarding the provision of funding for nonpoint source pollution control measures undertaken by local units of government provides for State funding of up to 70 percent of the capital cost of wet detention basins to serve areas of existing urban development. Department funding may also be available for up to 50 percent of the land acquisition cost, up to 50 percent of the cost of the conveyance components required to divert runoff into treatment facilities, and up to 100 percent of the design and engineering costs for structural best management practices which serve existing urban development.

Table 93

RECOMMENDED APPORTIONMENT OF PUBLIC-SECTOR AND PRIVATE-SECTOR COSTS FOR COMPONENTS OF THE RECOMMENDED MILWAUKEE RIVER DRAINAGE AREA STORMWATER MANAGEMENT PLAN IN THE CITY OF WEST BEND STUDY AREA

Hydrologic Unit Designation or Subbasin Grouping	Component Designation	Public-Sector Costs (dollars)		Private-Sector Costs (dollars)		Total Costs (dollars)	
		Capital[a]	Annual Operation and Maintenance	Capital[a]	Annual Operation and Maintenance	Capital	Annual Operation and Maintenance
Stormwater Drainage Plan Element (refer to Tables 6 and 9)							
Wingate Creek Subwatershed							
Subbasin W1B	1	- -	100	14,000	- -	14,000	100
	2	- -	100	25,000	- -	25,000	100
	3	- -	200	34,000	- -	34,000	200
	4	- -	400	135,000	- -	135,000	400
	5	- -	200	12,000	- -	12,000	200
Subtotal	- -	- -	1,000	220,000	- -	220,000	1,000
Subbasin W1D	1	- -	600	6,000	- -	6,000	600
	2	- -	1,100	27,000	- -	27,000	1,100
	3	- -	2,700	68,000	- -	68,000	2,700
Subtotal	- -	- -	4,400	101,000	- -	101,000	4,400
Subbasin W2A	1	- -	100	9,000	- -	9,000	100
	2	- -	300	58,000	- -	58,000	300
	3	- -	200	120,000	- -	120,000	200
	4	- -	100	106,000	- -	106,000	100
	5	- -	100	169,000	- -	169,000	100
Subtotal	- -	- -	800	462,000	- -	462,000	800
Subbasin W2B	1	- -	100	73,000	- -	73,000	100
	2	- -	100	123,000	- -	123,000	100
	3	- -	400	43,000	- -	43,000	400
	4	- -	800	77,000	- -	77,000	800
Subtotal	- -	- -	1,400	316,000	- -	316,000	1,400
Subbasin W3A	1	1,000	100	- -	- -	1,000	100
	2	5,000	200	- -	- -	5,000	200
	3	72,000	2,800	- -	- -	72,000	2,800
Subtotal	- -	78,000	3,100	- -	- -	78,000	3,100
Subbasin W3B	1	- -	200	53,000	- -	53,000	200
	2	- -	100	65,000	- -	65,000	100
	3	- -	600	36,000	- -	36,000	600
Subtotal	- -	- -	900	154,000	- -	154,000	900
Subbasin W4	1	77,000	300	- -	- -	77,000	300
	2	39,000	0	- -	- -	39,000	0
	3	180,000	-200	- -	- -	180,000	-200
Subtotal	- -	296,000	100	- -	- -	296,000	100
Subbasin W7	1	34,000	100	- -	- -	34,000	100
Subtotal	- -	34,000	100	- -	- -	34,000	100
Subbasin W8A	1	42,000	- -	- -	- -	42,000	0
Subtotal	- -	42,000	- -	- -	- -	42,000	0
Subbasin W8B	1	- -	100	12,000	- -	12,000	100
	2	- -	50	9,000	- -	9,000	50
	3	- -	100	16,000	- -	16,000	100
	4	- -	100	42,000	- -	42,000	100
	5	- -	50	38,000	- -	38,000	50
	6	66,000	2,700	- -	- -	66,000	2,700
Subtotal	- -	66,000	3,100	117,000	- -	183,000	3,100
Subbasin W9A	1	- -	100	14,000	- -	14,000	100
	2	- -	200	23,000	- -	23,000	200
Subtotal	- -	- -	300	37,000	- -	37,000	300

Table 93 (continued)

Hydrologic Unit Designation or Subbasin Grouping	Component Designation	Public-Sector Costs (dollars)		Private-Sector Costs (dollars)		Total Costs (dollars)	
		Capital[a]	Annual Operation and Maintenance	Capital[a]	Annual Operation and Maintenance	Capital	Annual Operation and Maintenance
Subbasin W9B	1	- -	100	3,000	- -	3,000	100
	2	- -	200	39,000	- -	39,000	200
	3	- -	100	36,000	- -	36,000	100
	4	- -	100	30,000	- -	30,000	100
Subtotal	- -	- -	500	108,000	- -	108,000	500
Subbasin W9D	1	9,000	100	- -	- -	9,000	100
	2	38,000	100	- -	- -	38,000	100
	3	81,000	100	- -	- -	81,000	100
	4	74,000	- -	- -	- -	74,000	0
Subtotal	- -	202,000	300	- -	- -	202,000	300
Subbasin W11	1	- -	100	23,000	- -	23,000	100
	2	- -	100	26,000	- -	26,000	100
	3	- -	100	50,000	- -	50,000	100
Subtotal	- -	- -	300	99,000	- -	99,000	300
Subbasin W12	1	- -	300	19,000	- -	19,000	300
Subtotal	- -	- -	300	19,000	- -	19,000	300
Subbasin W14	1	- -	100	41,000	- -	41,000	100
	2	- -	100	58,000	- -	58,000	100
	3	- -	200	132,000	- -	132,000	200
	4	- -	3,800	93,000	- -	93,000	3,800
Subtotal	- -	- -	4,200	324,000	- -	324,000	4,200
Subbasin W15	1	37,000	200	- -	- -	37,000	200
	2	42,000	200	- -	- -	42,000	200
	3	31,000	100	- -	- -	31,000	100
Subtotal	- -	110,000	500	- -	- -	110,000	500
Wingate Creek Subwatershed Subtotal	- -	828,000	21,300	1,957,000	- -	2,785,000	21,300
Milwaukee River Drainage Area outside Wingate Creek							
Hydrologic Unit A	1	- -	170	27,000	- -	27,000	170
	2	- -	300	53,000	- -	53,000	300
	3	- -	130	28,000	- -	28,000	130
	4	- -	150	34,000	- -	34,000	150
	5	- -	90	24,000	- -	24,000	90
	6	- -	70	46,000	- -	46,000	70
	7	- -	70	58,000	- -	58,000	70
Subtotal	- -	- -	980	270,000	- -	270,000	980
Hydrologic Unit B	1	39,000	330	3,000	- -	42,000	330
	2	13,000	80	- -	- -	13,000	80
	3	8,000	40	- -	- -	8,000	40
	4	- -	180	48,000	- -	48,000	180
	5	1,000	30	- -	- -	1,000	30
	6	- -	1,100	16,000	- -	16,000	1,100
	7	- -	30	7,000	- -	7,000	30
	8	- -	20	3,000	- -	3,000	20
Subtotal	- -	61,000	1,810	77,000	- -	138,000	1,810
Hydrologic Unit C	1	- -	310	34,000	- -	34,000	310
	2	- -	40	5,000	- -	5,000	40
	3	- -	60	9,000	- -	9,000	60
	4	9,000	20	- -	- -	9,000	20
	5	- -	100	9,000	- -	9,000	100
	6	1,000	30	- -	- -	1,000	30
Subtotal	- -	10,000	560	57,000	- -	67,000	560

Table 93 (continued)

Hydrologic Unit Designation or Subbasin Grouping	Component Designation	Public-Sector Costs (dollars)		Private-Sector Costs (dollars)		Total Costs (dollars)	
		Capital[a]	Annual Operation and Maintenance	Capital[a]	Annual Operation and Maintenance	Capital	Annual Operation and Maintenance
Hydrologic Unit D	1	148,000	2,800	- -	- -	148,000	2,800
Subtotal	- -	148,000	2,800	- -	- -	148,000	2,800
Hydrologic Unit E	1	11,000	90	- -	- -	11,000	90
	2	16,000	110	- -	- -	16,000	110
	3	22,000	130	- -	- -	22,000	130
	4	9,000	50	- -	- -	9,000	50
	5	25,000	180	16,000	- -	41,000	180
	6	- -	30	6,000	- -	6,000	30
	7	110,000	130	- -	- -	110,000	130
	8	- -	70	57,000	- -	57,000	70
	9	- -	200	198,000	- -	198,000	200
	10	10,000	- -	- -	- -	10,000	- -
	11	37,000	- -	- -	- -	37,000	- -
	12	23,000	- -	- -	- -	23,000	- -
	13	15,000	- -	- -	- -	15,000	- -
	14	78,000	- -	- -	- -	78,000	- -
	15	104,000	- -	- -	- -	104,000	- -
	16	12,000	- -	- -	- -	14,000	- -
	17	13,000	- -	- -	- -	15,000	- -
	18	- -	5,000	97,000	- -	97,000	5,000
	19	- -	100	8,000	- -	8,000	100
	20	59,000	- -	- -	- -	59,000	- -
Subtotal	- -	544,000	6,090	382,000	- -	926,000	6,090
Hydrologic Unit F	1	114,000	- -	- -	- -	114,000	- -
	2	2,000	- -	- -	- -	2,000	- -
	3	36,000	- -	- -	- -	36,000	- -
	4	5,000	- -	- -	- -	5,000	- -
	5	56,000	- -	- -	- -	56,000	- -
	6	38,000	- -	- -	- -	38,000	- -
	7	37,000	- -	- -	- -	37,000	- -
	8	87,000	-70	- -	- -	87,000	-70
	9	13,000	-10	- -	- -	13,000	-10
	10	- -	70	12,000	- -	12,000	70
	11	52,000	-40	- -	- -	52,000	-40
	12	34,000	- -	- -	- -	34,000	- -
	13	31,000	- -	- -	- -	31,000	- -
	14	43,000	- -	- -	- -	43,000	- -
	15	11,000	- -	- -	- -	11,000	- -
	16	5,000	- -	- -	- -	5,000	- -
	17	16,000	- -	- -	- -	16,000	- -
	18	17,000	- -	- -	- -	17,000	- -
Subtotal	- -	597,000	-50	12,000	- -	609,000	-50
Hydrologic Unit G	1	43,000	-40	- -	- -	43,000	-40
	2	22,000	-20	- -	- -	22,000	-20
	3	4,000	- -	- -	- -	4,000	- -
	4	15,000	- -	- -	- -	15,000	- -
	5	34,000	- -	- -	- -	34,000	- -
	6	26,000	- -	- -	- -	26,000	- -
	7	61,000	- -	- -	- -	61,000	- -
	8	3,000	- -	- -	- -	3,000	- -
	9	15,000	- -	- -	- -	15,000	- -
	10	7,000	- -	- -	- -	7,000	- -
	11	34,000	- -	- -	- -	34,000	- -
	12	38,000	- -	- -	- -	38,000	- -
	13	50,000	- -	- -	- -	50,000	- -
	14	64,000	- -	- -	- -	64,000	- -
	15	10,000	- -	- -	- -	10,000	- -
Subtotal	- -	426,000	-60	- -	- -	426,000	-60

Table 93 (continued)

Hydrologic Unit Designation or Subbasin Grouping	Component Designation	Public-Sector Costs (dollars)		Private-Sector Costs (dollars)		Total Costs (dollars)	
		Capital[a]	Annual Operation and Maintenance	Capital[a]	Annual Operation and Maintenance	Capital	Annual Operation and Maintenance
Hydrologic Unit H	1	- -	260	29,000	- -	29,000	260
	2	- -	100	16,000	- -	16,000	100
	3	- -	240	58,000	- -	58,000	240
	4	- -	730	206,000	- -	206,000	730
	5	- -	1,700	102,000	- -	102,000	1,700
	6	- -	300	26,000	- -	26,000	300
Subtotal	- -	- -	3,330	437,000	- -	437,000	3,330
Hydrologic Unit I	1	- -	150	34,000	- -	34,000	150
	2	- -	100	21,000	- -	21,000	100
	3	13,000	440	- -	- -	13,000	440
	4	6,000	40	- -	- -	6,000	40
Subtotal	- -	19,000	730	55,000	- -	74,000	730
Hydrologic Unit J	1	34,000	- -	- -	- -	34,000	- -
	2	39,000	- -	- -	- -	39,000	- -
	3	29,000	- -	- -	- -	29,000	- -
	4	7,000	- -	- -	- -	7,000	- -
	5	82,000	-70	- -	- -	82,000	-70
	6	29,000	- -	- -	- -	29,000	- -
	7	6,000	- -	- -	- -	6,000	- -
	8	30,000	- -	- -	- -	30,000	- -
	9	28,000	- -	- -	- -	28,000	- -
	10	4,000	- -	- -	- -	4,000	- -
	11	79,000	-60	- -	- -	79,000	-60
	12	60,000	60	- -	- -	60,000	60
	13	64,000	60	- -	- -	64,000	60
	14	7,000	-10	- -	- -	7,000	-10
	15	33,000	-20	- -	- -	33,000	-20
	16	9,000	-10	- -	- -	9,000	-10
	17	55,000	-30	- -	- -	55,000	-30
	18	37,000	-20	- -	- -	37,000	-20
	19	110,000	-60	- -	- -	110,000	-60
	20	8,000	- -	- -	- -	8,000	- -
	21	7,000	-10	- -	- -	7,000	-10
	22	27,000	-30	- -	- -	27,000	-30
	23	16,000	-10	- -	- -	16,000	-10
Subtotal	- -	800,000	-210	- -	- -	800,000	-210
Hydrologic Unit K	1	24,000	- -	- -	- -	24,000	- -
	2	17,000	20	- -	- -	17,000	20
	3	11,000	40	- -	- -	11,000	40
	4	83,000	- -	- -	- -	83,000	- -
	5	62,000	- -	- -	- -	62,000	- -
	6	23,000	- -	- -	- -	23,000	- -
	7	50,000	- -	- -	- -	50,000	- -
	8	137,000	-130	- -	- -	137,000	-130
	9	39,000	- -	- -	- -	39,000	- -
	10	23,000	- -	- -	- -	23,000	- -
	11	6,000	40	- -	- -	6,000	40
	12	24,000	- -	- -	- -	24,000	- -
	13	134,000	- -	- -	- -	134,000	- -
	14	61,000	- -	- -	- -	61,000	- -
	15	35,000	- -	- -	- -	35,000	- -
	16	83,000	- -	- -	- -	83,000	- -
	17	38,000	- -	- -	- -	38,000	- -
	18	5,000	-100	- -	- -	5,000	-100
	21	45,000	40	- -	- -	45,000	-40
	22	125,000	- -	- -	- -	125,000	- -

Table 93 (continued)

Hydrologic Unit Designation or Subbasin Grouping	Component Designation	Public-Sector Costs (dollars)		Private-Sector Costs (dollars)		Total Costs (dollars)	
		Capital[a]	Annual Operation and Maintenance	Capital[a]	Annual Operation and Maintenance	Capital	Annual Operation and Maintenance
Hydrologic Unit K (continued)	19	77,000	- -	- -	- -	77,000	- -
	20	39,000	- -	- -	- -	39,000	- -
	23	59,000	- -	- -	- -	59,000	- -
	24	152,000	-110	- -	- -	152,000	-110
	25	198,000	-170	- -	- -	198,000	-170
	26	34,000	- -	- -	- -	34,000	- -
	27	69,000	-40	- -	- -	69,000	-40
	28	457,000	- -	- -	- -	457,000	- -
	29	104,000	- -	- -	- -	104,000	- -
	30	110,000	-80	- -	- -	110,000	-80
	31	29,000	-20	- -	- -	29,000	-20
	32	60,000	- -	- -	- -	60,000	- -
	33	171,000	- -	- -	- -	171,000	- -
	34	41,000	- -	- -	- -	41,000	- -
	35	255,000	-90	- -	- -	255,000	-90
	36	63,000	- -	- -	- -	63,000	- -
	37	60,000	- -	- -	- -	60,000	- -
	38	35,000	- -	- -	- -	35,000	- -
	39	27,000	-30	- -	- -	27,000	-30
	40	218,000	- -	- -	- -	218,000	- -
	41	16,000	-10	- -	- -	16,000	-10
	42	17,000	- -	- -	- -	17,000	- -
	43	29,000	- -	- -	- -	29,000	- -
	44	112,000	1,400	- -	- -	112,000	1,400
	45	277,000	1,700	- -	- -	277,000	1,700
	46	279,000	1,900	- -	- -	279,000	1,900
Subtotal	- -	4,013,000	4,280	- -	- -	4,013,000	4,280
Hydrologic Unit L	1	48,000	0	- -	- -	48,000	0
	2	148,000	-130	- -	- -	148,000	-130
	3	98,000	0	- -	- -	98,000	0
	4	205,000	0	- -	- -	205,000	0
	5	126,000	0	- -	- -	126,000	0
	6	202,000	0	- -	- -	202,000	0
	7	247,000	0	- -	- -	247,000	0
	8	139,000	0	- -	- -	139,000	0
	9	14,000	0	- -	- -	14,000	0
	10	102,000	0	- -	- -	102,000	0
	11	98,000	0	- -	- -	98,000	0
	12	78,000	0	- -	- -	78,000	0
	13	59,000	0	- -	- -	59,000	0
	14	206,000	-200	- -	- -	206,000	-200
	15	56,000	-50	- -	- -	56,000	-50
	16	93,000	-70	- -	- -	93,000	-70
	17	16,000	-10	- -	- -	16,000	-10
	18	655,000	360	- -	- -	655,000	360
	19	8,000	- -	- -	- -	8,000	- -
	20	67,000	-60	- -	- -	67,000	-60
	21	139,000	-100	- -	- -	139,000	-100
	22	99,000	- -	- -	- -	99,000	- -
	23	39,000	- -	- -	- -	39,000	- -
	24	51,000	- -	- -	- -	51,000	- -
	25	319,000	- -	- -	- -	319,000	- -
	26	94,000	- -	- -	- -	94,000	- -
	27	191,000	- -	- -	- -	191,000	- -
	28	1,102,000	470	- -	- -	1,102,000	470
	29	301,000	110	- -	- -	301,000	110
Subtotal	- -	5,000,000	320	- -	- -	5,000,000	320

Table 93 (continued)

Hydrologic Unit Designation or Subbasin Grouping	Component Designation	Public-Sector Costs (dollars)		Private-Sector Costs (dollars)		Total Costs (dollars)	
		Capital[a]	Annual Operation and Maintenance	Capital[a]	Annual Operation and Maintenance	Capital	Annual Operation and Maintenance
Hydrologic Unit M	1	20,000	- -	- -	- -	20,000	- -
	2	45,000	- -	- -	- -	45,000	- -
	3	65,000	- -	- -	- -	65,000	- -
	4	102,000	- -	- -	- -	102,000	- -
	5	68,000	- -	- -	- -	68,000	- -
	6	87,000	- -	- -	- -	87,000	- -
	7	91,000	-70	- -	- -	91,000	-70
	8	82,000	- -	- -	- -	82,000	- -
	9	224,000	- -	- -	- -	224,000	- -
	10	78,000	- -	- -	- -	78,000	- -
	11	219,000	2,000	- -	- -	219,000	2,000
Subtotal	- -	1,081,000	1,930	- -	- -	1,081,000	1,930
Hydrologic Unit N	1	- -	190	30,000	- -	30,000	190
	2	- -	230	47,000	- -	47,000	230
	3	- -	690	180,000	- -	180,000	690
	4	- -	320	267,000	- -	267,000	320
	5	65,000	60	- -	- -	65,000	60
	6	- -	250	294,000	- -	294,000	250
	7	- -	150	207,000	- -	207,000	150
	8	202,000	150	- -	- -	202,000	150
	9	263,000	100	- -	- -	263,000	100
	10	102,000	0	- -	- -	102,000	0
	11	35,000	100	- -	- -	35,000	100
	12	22,000	170	- -	- -	22,000	170
	13	32,000	150	- -	- -	32,000	150
	14	41,000	180	- -	- -	41,000	180
	15	89,000	130	- -	- -	89,000	130
	16	15,000	10	- -	- -	15,000	10
	17	20,000	100	- -	- -	20,000	100
Subtotal	- -	886,000	2,980	1,025,000	- -	1,911,000	2,980
Hydrologic Unit O	1	75,000	500	- -	- -	75,000	500
	2	23,000	370	- -	- -	23,000	370
	3	63,000	900	- -	- -	63,000	900
Subtotal	- -	161,000	1,770	- -	- -	161,000	1,770
Hydrologic Unit P	1	8,000	- -	- -	- -	8,000	- -
	2	110,000	- -	- -	- -	110,000	- -
	3	85,000	- -	- -	- -	85,000	- -
Subtotal	- -	203,000	- -	- -	- -	203,000	- -
Hydrologic Unit Q	1	125,000	- -	- -	- -	125,000	- -
	2	91,000	0	- -	- -	91,000	- -
	3	60,000	0	- -	- -	60,000	- -
	4	60,000	0	- -	- -	60,000	- -
	5	45,000	0	- -	- -	45,000	- -
	6	- -	1,400	75,000	- -	75,000	1,400
Subtotal	- -	381,000	1,400	75,000	- -	456,000	1,400
Hydrologic Unit R	1	- -	20	29,000	- -	29,000	220
	2	- -	50	23,000	- -	23,000	150
	3	- -	20	56,000	- -	56,000	320
	4	- -	80	208,000	- -	208,000	280
	5	- -	70	108,000	- -	108,000	470
	6	- -	90	61,000	- -	61,000	90
	7	- -	150	119,000	- -	119,000	150
	8	70,000	380	- -	- -	70,000	380
	9	4,000	20	- -	- -	4,000	20
	10	9,000	40	- -	- -	9,000	40
	11	3,000	20	- -	- -	3,000	20
Subtotal	- -	86,000	2,140	604,000	- -	690,000	2,140

Table 93 (continued)

Hydrologic Unit Designation or Subbasin Grouping	Component Designation	Public-Sector Costs (dollars)		Private-Sector Costs (dollars)		Total Costs (dollars)	
		Capital[a]	Annual Operation and Maintenance	Capital[a]	Annual Operation and Maintenance	Capital	Annual Operation and Maintenance
Hydrologic Unit S	1	97,000	-100	- -	- -	97,000	-100
	2	70,000	-70	- -	- -	70,000	-70
	3	73,000	- -	- -	- -	73,000	- -
	4	26,000	- -	- -	- -	26,000	- -
	5	13,000	- -	- -	- -	13,000	- -
	6	60,000	-50	- -	- -	60,000	-50
	7	21,000	-20	- -	- -	21,000	-20
Subtotal	- -	360,000	-240	- -	- -	360,000	-240
Hydrologic Unit T	1	12,000	210	11,000	- -	23,000	210
	2	191,000	560	40,000	- -	231,000	560
	3	6,000	150	42,000	- -	48,000	150
	4	29,000	160	- -	- -	29,000	160
	5	19,000	660	129,000	- -	148,000	660
	6	35,000	520	85,000	- -	120,000	520
	7	38,000	230	24,000	- -	62,000	230
	8	11,000	20	- -	- -	11,000	20
	9	45,000	70	- -	- -	45,000	70
	10	31,000	430	- -	- -	31,000	430
	11	4,000	- -	- -	- -	4,000	- -
	12	- -	250	19,000	- -	19,000	250
Subtotal	- -	421,000	3,260	350,000	- -	771,000	3,260
Hydrologic Unit Z	1	18,000	100	- -	- -	18,000	100
	2	9,000	60	- -	- -	9,000	60
	3	6,000	20	- -	- -	6,000	20
Subtotal	- -	33,000	180	- -	- -	33,000	180
Hydrologic Unit AB	1	13,000	- -	- -	- -	13,000	- -
	2	7,000	- -	- -	- -	7,000	- -
	3	39,000	- -	- -	- -	39,000	- -
	4	3,000	- -	- -	- -	3,000	- -
Subtotal	- -	62,000	- -	- -	- -	62,000	0
Hydrologic Unit AE	1	41,000	- -	- -	- -	41,000	0
	2	49,000	- -	- -	- -	49,000	0
	3	35,000	- -	- -	- -	35,000	0
	4	88,000	- -	- -	- -	88,000	0
	5	1,000	100	- -	- -	1,000	100
Subtotal	- -	214,000	100	- -	- -	214,000	100
Hydrologic Unit AF	1	9,000	- -	- -	- -	9,000	- -
	2	47,000	- -	- -	- -	47,000	-20
	3	18,000	-20	- -	- -	18,000	30
	4	5,000	20	- -	- -	5,000	20
	5	32,000	10	- -	- -	32,000	10
	6	13,000	30	- -	- -	13,000	- -
	7	17,000	- -	- -	- -	17,000	- -
	8	34,000	- -	- -	- -	34,000	- -
	9	3,000	20	- -	- -	3,000	20
	10	5,000	40	- -	- -	5,000	40
	11	10,000	50	- -	- -	10,000	50
	12	4,000	30	- -	- -	4,000	30
	13	4,000	20	- -	- -	4,000	20
	14	60,000	- -	- -	- -	60,000	- -
Subtotal	- -	261,000	200	- -	- -	261,000	200

Table 93 (continued)

Hydrologic Unit Designation or Subbasin Grouping	Component Designation	Public-Sector Costs (dollars)		Private-Sector Costs (dollars)		Total Costs (dollars)	
		Capital[a]	Annual Operation and Maintenance	Capital[a]	Annual Operation and Maintenance	Capital	Annual Operation and Maintenance
Hydrologic Unit AH	1	13,000	- -	- -	- -	13,000	- -
	2	41,000	- -	- -	- -	41,000	- -
	3	13,000	- -	- -	- -	13,000	- -
	4	38,000	- -	- -	- -	38,000	- -
	5	71,000	-60	- -	- -	71,000	-60
Subtotal	- -	176,000	-60	- -	- -	176,000	-60
Hydrologic Unit AI	1	31,000	- -	- -	- -	31,000	- -
	2	16,000	- -	- -	- -	16,000	- -
	3	25,000	- -	- -	- -	25,000	- -
	4	37,000	- -	- -	- -	37,000	- -
	5	7,000	- -	- -	- -	7,000	- -
	6	5,000	- -	- -	- -	5,000	- -
	7	4,000	- -	- -	- -	4,000	- -
	8	43,000	- -	- -	- -	43,000	- -
	9	43,000	- -	- -	- -	43,000	- -
Subtotal	- -	211,000	- -	- -	- -	211,000	- -
Hydrologic Unit AJ	1	42,000	- -	- -	- -	42,000	- -
	2	46,000	- -	- -	- -	46,000	- -
	3	47,000	- -	- -	- -	47,000	- -
	4	14,000	- -	- -	- -	14,000	- -
Subtotal	- -	149,000	- -	- -	- -	149,000	- -
Hydrologic Unit AK	1	53,000	- -	- -	- -	53,000	- -
Subtotal	- -	53,000	- -	- -	- -	53,000	- -
Hydrologic Unit AL	1	25,000	- -	- -	- -	25,000	- -
	2	50,000	- -	- -	- -	50,000	- -
	3	34,000	- -	- -	- -	34,000	- -
	4	4,000	- -	- -	- -	4,000	- -
	5	74,000	- -	- -	- -	74,000	- -
	6	24,000	- -	- -	- -	24,000	- -
	7	26,000	- -	- -	- -	26,000	- -
Subtotal	- -	237,000	- -	- -	- -	237,000	- -
Hydrologic Unit AM	1	2,000	- -	- -	- -	2,000	- -
	2	7,000	- -	- -	- -	7,000	- -
	3	42,000	- -	- -	- -	42,000	- -
	4	68,000	- -	- -	- -	68,000	- -
	5	125,000	- -	- -	- -	125,000	- -
	6	50,000	- -	- -	- -	50,000	- -
	7	33,000	-30	- -	- -	33,000	-30
Subtotal	- -	327,000	-30	- -	- -	327,000	-30
Hydrologic Unit AP	1	62,000	- -	- -	- -	62,000	- -
	2	34,000	- -	- -	- -	34,000	- -
	3	16,000	- -	- -	- -	16,000	- -
Subtotal	- -	112,000	- -	- -	- -	112,000	- -
Hydrologic Unit AQ	1	176,000	- -	- -	- -	176,000	- -
	2	36,000	150	- -	- -	36,000	150
Subtotal	- -	212,000	150	- -	- -	212,000	150
Hydrologic Unit AS	1	23,000	350	- -	- -	23,000	350
	2	10,000	- -	- -	- -	10,000	- -
	3	7,000	- -	- -	- -	7,000	- -
Subtotal	- -	40,000	350	- -	- -	40,000	350

Table 93 (continued)

Hydrologic Unit Designation or Subbasin Grouping	Component Designation	Public-Sector Costs (dollars)		Private-Sector Costs (dollars)		Total Costs (dollars)	
		Capital[a]	Annual Operation and Maintenance	Capital[a]	Annual Operation and Maintenance	Capital	Annual Operation and Maintenance
Hydrologic Unit AU	1	1,000	- -	- -	- -	1,000	- -
	2	27,000	- -	- -	- -	27,000	- -
	3	4,000	- -	- -	- -	4,000	- -
	4	27,000	- -	- -	- -	27,000	- -
	5	39,000	- -	- -	- -	39,000	- -
	6	2,000	- -	- -	- -	2,000	- -
	7	4,000	- -	- -	- -	4,000	- -
	8	1,000	- -	- -	- -	1,000	- -
	9	51,000	- -	- -	- -	51,000	- -
	10	16,000	- -	- -	- -	16,000	- -
	11	45,000	- -	- -	- -	45,000	- -
	12	50,000	- -	- -	- -	50,000	- -
	13	35,000	-30	- -	- -	35,000	-30
	14	13,000	-10	- -	- -	13,000	-10
	15	64,000	- -	- -	- -	64,000	- -
	16	3,000	- -	- -	- -	3,000	- -
	17	21,000	- -	- -	- -	21,000	- -
	18	86,000	- -	- -	- -	86,000	- -
Subtotal	- -	489,000	-40	- -	- -	489,000	-40
Hydrologic Unit AY	1	25,000	270	8,000	- -	33,000	270
	2	56,000	490	20,000	- -	76,000	490
	3	19,000	450	57,000	- -	76,000	450
	4	- -	170	29,000	- -	29,000	170
	5	- -	10	3,000	- -	3,000	10
	6	- -	100	34,000	- -	34,000	100
	7	37,000	230	34,000	- -	71,000	230
	8	63,000	60	- -	- -	63,000	60
	9	500	30	- -	- -	500	30
	10	400	50	- -	- -	400	50
Subtotal	- -	200,900	1,860	185,000	- -	385,900	1,860
Hydrologic Unit AZ	1	- -	100	3,000	- -	3,000	100
Subtotal	- -	- -	100	3,000	- -	3,000	100
Hydrologic Unit BC	1	- -	80	9,000	- -	9,000	80
	2	- -	150	23,000	- -	23,000	150
	3	- -	140	30,000	- -	30,000	140
	4	- -	350	88,000	- -	88,000	350
	5	- -	110	75,000	- -	75,000	110
	6	- -	100	84,000	- -	84,000	100
	7	- -	30	4,000	- -	4,000	30
	8	- -	50	6,000	- -	6,000	50
Subtotal	- -	- -	1,010	319,000	- -	319,000	1,010
Hydrologic Unit BE	1	- -	280	60,000	- -	60,000	280
	2	- -	90	21,000	- -	21,000	90
	3	- -	320	86,000	- -	86,000	320
	4	- -	60	39,000	- -	39,000	60
	5	- -	80	84,000	- -	84,000	80
	6	- -	70	67,000	- -	67,000	70
	7	- -	80	81,000	- -	81,000	80
	8	- -	230	266,000	- -	266,000	230
	9	- -	1,800	73,000	- -	73,000	1,800
Subtotal	- -	- -	3,010	777,000	- -	777,000	3,010
Milwaukee River Drainage Area outside Wingate Creek Subtotal	- -	17,973,900	40,650	4,628,000	- -	22,601,900	40,650
Stormwater Drainage Subtotal	- -	18,801,900	61,950	6,585,000	- -	25,386,900	61,950

Table 93 (continued)

Hydrologic Unit Designation or Subbasin Grouping	Component Designation	Public-Sector Costs (dollars)		Private-Sector Costs (dollars)		Total Costs (dollars)	
		Capital[a]	Annual Operation and Maintenance	Capital[a]	Annual Operation and Maintenance	Capital	Annual Operation and Maintenance
Water Quality Management Plan Element (refer to Table 87)							
Hydrologic Unit A	1	- -	5,100	394,000	- -	394,000	5,100
Subtotal	- -	- -	5,100	394,000	- -	394,000	5,100
Hydrologic Unit D	1	- -	4,000	185,000	- -	185,000	4,000
Subtotal	- -	- -	4,000	185,000	- -	185,000	4,000
Hydrologic Unit R	1	400	400	- -	- -	400	400
Subtotal	- -	400	400	- -	- -	400	400
Hydrologic Unit T	1	- -	1,700	75,000	- -	75,000	1,700
	2	- -	1,500	71,000	- -	71,000	1,500
	3	- -	1,500	65,000	- -	65,000	1,500
Subtotal	- -	- -	4,700	211,000	- -	211,000	4,700
Subbasin WB3	1	103,000	5,400	154,000	- -	257,000	5,400
	2	- -	1,500	71,000	- -	71,000	1,500
	3	- -	1,500	71,000	- -	71,000	1,500
	4	- -	1,500	71,000	- -	71,000	1,500
	5	17,000	2,300	92,000	- -	109,000	2,300
	6	- -	1,500	81,000	- -	81,000	1,500
	7	- -	1,500	81,000	- -	81,000	1,500
	8	- -	1,200	22,000	- -	22,000	1,200
	9	- -	- -	1,700	1,900	1,700	1,900
	10	500	600	- -	- -	500	600
Subtotal	- -	120,500	17,000	644,700	1,900	765,200	18,900
Subbasin WB5	1	19,000	2,600	36,000	- -	55,000	2,600
	2	- -	- -	1,200	1,400	1,200	1,400
	3	500	500	- -	- -	500	500
Subtotal	- -	19,500	3,100	37,200	1,400	56,700	4,500
Subbasin WB6	1	300	300	- -	- -	300	300
Subtotal	- -	300	300	- -	- -	300	300
Subbasin WB7	1	- -	2,600	128,000	- -	128,000	2,600
	2	- -	3,500	74,000	- -	74,000	3,500
	3	1,300	1,400	- -	- -	1,300	1,400
	4	- -	- -	8,400	9,300	8,400	9,300
Subtotal	- -	1,300	7,500	210,400	9,300	211,700	16,800
Subbasin WB8	1	29,400	2,000	12,600	- -	42,000	2,000
	2	30,800	2,400	13,200	- -	44,000	2,400
	3	2,000	2,300	- -	- -	2,000	2,300
	4	300	200	2,800	2,100	3,100	2,300
	5	- -	- -	2,100	2,300	2,100	2,300
	6	- -	- -	3,800	4,200	3,800	4,200
Subtotal	- -	62,500	6,900	34,500	8,600	97,000	15,500
Subbasin WB10	1	- -	6,500	644,000	- -	644,000	6,500
	2	53,200	3,300	22,800	- -	76,000	3,300
	3	31,000	2,800	28,000	- -	59,000	2,800
	4	19,600	2,400	31,400	- -	51,000	2,400
	5	1,600	1,700	10,500	11,600	12,100	13,300
	6	200	200	- -	- -	200	200
	7	300	300	- -	- -	300	300
	8	- -	- -	19,600	21,600	19,600	21,600
	9	- -	- -	14,600	16,100	14,600	16,100
Subtotal	- -	105,900	17,200	770,900	49,300	876,800	66,500

Table 93 (continued)

Hydrologic Unit Designation or Subbasin Grouping	Component Designation	Public-Sector Costs (dollars)		Private-Sector Costs (dollars)		Total Costs (dollars)	
		Capital[a]	Annual Operation and Maintenance	Capital[a]	Annual Operation and Maintenance	Capital	Annual Operation and Maintenance
Subbasin WB11	1	135,000	2,000	- -	- -	135,000	2,000
	2	- -	1,800	150,000	- -	150,000	1,800
	3	85,000	1,800	- -	- -	85,000	1,800
	4	- -	- -	5,100	5,700	5,100	5,700
Subtotal	- -	220,000	5,600	155,100	5,700	375,100	11,300
Subbasin WB13	1	121,000	3,900	283,000	- -	404,000	3,900
	2	- -	2,600	219,000	- -	219,000	2,600
Subtotal	- -	121,000	6,500	502,000	- -	623,000	6,500
Subbasin WB14	1	- -	1,900	94,000	- -	94,000	1,900
	2	- -	1,500	69,000	- -	69,000	1,500
	3	- -	1,500	65,000	- -	65,000	1,500
	4	- -	3,000	127,000	- -	127,000	3,000
	5	100	100	- -	- -	100	100
	6	100	100	- -	- -	100	100
Subtotal	- -	200	8,100	355,000	- -	355,200	8,100
Water Quality Subtotal	- -	651,600	86,400	3,499,800	76,200	4,151,400	162,600
Total	- -	19,453,500	148,350	10,084,800	76,200	29,538,300	224,550

[a] Includes 35 percent for engineering, administration, and contingencies. Costs are for year 1991 with Engineering News-Record Construction Cost Index = 5,015.

Source: SEWRPC.

Chapter NR 120 of the Wisconsin Administrative Code, which details the administrative procedures of the State nonpoint source water pollution abatement program, forbids provision of State funds for stormwater management practices to serve new urban development and for construction site erosion control measures. However, State funds may be available to pay the entire cost of local staff to enforce a construction erosion control ordinance over a maximum period of five years. State funds may also be provided for accelerated street sweeping above the current levels practiced by the City. The funds would cover the costs of accelerated sweeping, for a five-year period, after which the City would be required to maintain the accelerated sweeping schedule for 10 years. Tables 94 and 95 provide possible allocations of costs between the City, the State, and the private sector on the basis of current State cost-sharing policy.

The East and West Branches of the Milwaukee River Priority Watershed Study was completed by the Wisconsin Department of Natural Resources in 1989. In order for urban best management practice to be eligible for State funds provided under the Wisconsin Fund Nonpoint Source Pollution Abatement Program, funds must be applied for by June 1997. In addition to funds provided by the Wisconsin Department of Natural Resources, it is also possible that the cost of certain recommended components of the stormwater drainage system may be shared between the City and the Wisconsin Department of Transportation as a part of future highway construction or reconstruction projects. Because the division of costs for such measures is presently unknown, this plan assigns all such costs to the City.

All operation and maintenance costs, except those for sweeping of industrial and commercial parking lot and storage areas, were assumed to be financed by the public sector regardless of whether public sector or private sector funds were used to construct the facilities. It may be desirable for the operation and maintenance costs of some stormwater drainage and some additional nonpoint source pollution control measures to be borne by the private sector, depending on the specific nature of individual projects. If operation and maintenance costs for a specific project are financed by the private sector, it would be necessary for the City and the party responsible for operation and maintenance to execute a legal agreement which details both the responsibility of the private party for providing operation and maintenance and the degree of maintenance to be provided. Those stormwater management facilities which are constructed with private funds, but maintained by the City, would be dedicated to the City following construction.

PRELIMINARY PLAN SCHEDULE FOR IMPLEMENTATION

Prioritization of Capital Improvements

A preliminary prioritization of the recommended capital improvements is given in Table 96. This prioritization is provided to identify those projects that should be implemented to alleviate the most pressing stormwater management problems and to identify a necessary sequence for implementation of certain interdependent components of the total system. For this prioritization, a project is defined as a set of stormwater management components that should be constructed in concert in order for the set to function properly by itself and within the context of the larger total system of which it is a part. In some instances, several relatively small sewer replacement projects in the same localized area were grouped together as one larger project for the purposes of prioritization. An economy-of-scale may be possible by constructing several small projects in the same area at the same time.

The projects are classified as high-, intermediate-, or low-priority projects. The high-priority projects are those that address significant existing problems or those that are required to serve new development that is actually occurring. The intermediate-priority projects are those required to serve new development anticipated in the near future on the basis of development proposals which have been submitted to the City and on plans for the extension of sanitary sewer service. The low-priority projects are those required to serve and promote development in the more distant future. The storm frequency for which certain projects are to be designed and the consequences of exceeding the capacity of the existing stormwater management system were also considered in the prioritization.

The sequence in which projects are actually implemented and the time at which they are implemented will ultimately depend on a number of factors not related solely to stormwater management considerations. Such factors include budgetary constraints, the need to implement other projects in the City's capital improvements program, and variations in future development patterns as determined by the urban land market. As a result, some intermediate-priority projects may actually be constructed before some high-priority projects. However, where a specific implementation sequence for a series of components comprising a unified stormwater management project is required, that sequence should be followed to ensure the proper functioning of the system.

Identification of Critical Implementation Sequences

This section identifies projects for which the implementation sequence of the project components is critical. The project numbers are those assigned in Table 96.

In general, projects which call for upgrading the existing stormwater conveyance system should proceed from downstream to upstream to insure that the downstream portions of the system are not overloaded when the hydraulic capacities of the upstream portions are increased. When a detention facility for water quantity control is to be constructed downstream of new or improved conveyance facilities, it is desirable to construct the detention facility first. It is recommended that a detention facility which is intended to provide nonpoint source pollution control for areas of new development be constructed prior to the commencement of site disturbance so that the basin can act as a sediment basin during construction. Accumulated sediment would have to be removed following stabilization of the site in order to restore the storage capacity of the detention basin.

Projects No. 1 and 2, Storm Sewer Replacement in Hydrologic Unit MR-L and Storm Sewer Replacement and Detention Storage Construction in Hydrologic Unit MR-K: As indicated by the prioritization set forth in Table 96, the recommended storm sewer replacements in Hydrologic Unit MR-L should be implemented

Table 94

ASSIGNMENT OF CITY, STATE, AND PRIVATE-SECTOR COSTS OF THE RECOMMENDED MILWAUKEE RIVER DRAINAGE AREA WATER QUALITY MANAGEMENT PLAN

Hydrologic Unit Designation or Subbasin Grouping	Component Designation	Capital Cost[a] (dollars)			
		City of West Bend	State of Wisconsin	Private Sector	Total
Water Quality Management Plan Element (Refer to Table 91)					
Hydrologic Unit A	1	- -	- -	394,000	394,000
Subtotal	- -	0	0	394,000	394,000
Hydrologic Unit D	1	- -	- -	185,000	185,000
Subtotal	- -	0	0	185,000	185,000
Hydrologic Unit R	1	400	- -	- -	400
Subtotal	- -	400	- -	- -	400
Hydrologic Unit T	1	- -	- -	75,000	75,000
	2	- -	- -	71,000	71,000
	3	- -	- -	65,000	65,000
Subtotal	- -	- -	- -	211,000	211,000
Subbasin WB3	1	35,000	68,000	154,000	257,000
	2	- -	- -	71,000	71,000
	3	- -	- -	71,000	71,000
	4	- -	- -	71,000	71,000
	5	6,000	11,000	92,000	109,000
	6	- -	- -	81,000	81,000
	7	- -	- -	81,000	81,000
	8	- -	- -	22,000	22,000
	9	- -	- -	1,700	1,700
	10	500	- -	- -	500
Subtotal	- -	41,500	79,000	644,700	765,200
Subbasin WB5	1	- -	19,000	36,000	55,000
	2	- -	- -	1,200	1,200
	3	500	- -	- -	500
Subtotal	- -	500	19,000	37,200	56,700
Subbasin WB6	1	300	- -	- -	300
Subtotal	- -	300	- -	- -	300
Subbasin WB7	1	- -	- -	128,000	128,000
	2	- -	- -	74,000	74,000
	3	1,300	- -	- -	1,300
	4	- -	- -	8,400	8,400
Subtotal	- -	1,300	- -	210,400	211,700
Subbasin WB8	1	- -	29,400	12,600	42,000
	2	- -	30,800	13,200	44,000
	3	2,000	- -	- -	2,000
	4	300	- -	2,800	3,100
	5	- -	- -	2,100	2,100
	6	- -	- -	3,800	3,800
Subtotal	- -	2,300	60,200	34,500	97,000
Subbasin WB10	1	- -	- -	644,000	644,000
	2	- -	53,200	22,800	76,000
	3	- -	31,000	28,000	59,000
	4	- -	19,600	31,400	51,000
	5	1,600	- -	10,500	12,100
	6	200	- -	- -	200

Table 94 (continued)

Hydrologic Unit Designation or Subbasin Grouping	Component Designation	Capital Cost[a] (dollars)			
		City of West Bend	State of Wisconsin	Private Sector	Total
Subbasin WB10 (continued)	7	300	- -	- -	300
	8	- -	- -	19,600	19,600
	9	- -	- -	14,600	14,600
Subtotal	- -	2,100	103,800	770,900	876,800
Subbasin WB11	1	49,000	86,000	- -	135,000
	2	- -	- -	150,000	150,000
	3	25,000	60,000	- -	85,000
	4	- -	- -	5,100	5,100
Subtotal	- -	74,000	146,000	155,100	375,100
Subbasin WB13	1	39,000	82,000	283,000	404,000
	2	- -	- -	219,000	219,000
Subtotal	- -	39,000	82,000	502,000	623,000
Subbasin WB14	1	- -	- -	94,000	94,000
	2	- -	- -	69,000	69,000
	3	- -	- -	65,000	65,000
	4	- -	- -	127,000	127,000
	5	100	- -	- -	100
	6	100	- -	- -	100
Subtotal	- -	200	- -	355,000	355,200
Total	- -	161,600	490,000	3,499,800	4,151,400

[a] *Includes 35 percent for engineering, administration, and contingencies. Costs are for year 1991 with Engineering News-Record Construction Cost Index = 5,015.*

Source: SEWRPC.

Table 95

POSSIBLE APPORTIONMENT OF TOTAL CITY OF WEST BEND, STATE OF WISCONSIN, AND PRIVATE-SECTOR COSTS FOR THE RECOMMENDED MILWAUKEE RIVER DRAINAGE AREA STORMWATER MANAGEMENT PLAN BASED ON CURRENT STATE COST-SHARING POLICY

Plan Element	City of West Bend		State of Wisconsin		Private Sector		Total	
	Capital Cost[a]	Annual Operation and Maintenance	Capital Cost[a]	Annual Operation and Maintenance	Capital Cost[a]	Annual Operation and Maintenance	Capital Cost[a]	Annual Operation and Maintenance
Stormwater Drainage System	$18,801,900	$ 61,950	- -	- -	$ 6,585,000	$ 0	$25,386,900	$ 61,950
Water Quality Management Measures	161,600	86,400	$490,000	$0	3,499,800	76,200	4,151,400	162,600
Total	$18,963,500	$148,350	$490,000	$0	$10,084,800	$76,200	$29,538,300	$224,550

[a] *Includes 35 percent for engineering, administration, and contingencies. Costs are for year 1991 with Engineering News-Record Construction Cost Index = 5,015.*

Source: SEWRPC.

Table 96

PRIORITIZATION OF STORMWATER MANAGEMENT PLAN PROJECTS FOR THE MILWAUKEE RIVER DRAINAGE AREA

Project Number and Description	Hydrologic Unit or Subbasin Grouping	Project Components as Listed in Chapters III and IV	Capital Cost[a] (dollars)			
			City of West Bend	State of Wisconsin	Private Sector	Total
High-Priority Projects						
1. Storm Sewer Conveyance Improvements	L	Table 9, entire Hydrologic Unit L	5,000,000	- -	- -	5,000,000
2. Storm Sewer Conveyance Improvements and Detention Storage	K	Table 9, entire Hydrologic Unit K	4,013,000	- -	- -	4,013,000
3. Storm Sewer Conveyance Improvements and Detention Storage	AU	Table 9, entire Hydrologic Unit AU	489,000	- -	- -	489,000
4. Storm Sewer Conveyance Improvements	J	Table 9, entire Hydrologic Unit J	800,000	- -	- -	800,000
5. Storm Sewer Conveyance Improvements	G	Table 9, entire Hydrologic Unit G	426,000	- -	- -	426,000
6. Storm Sewer Conveyance Improvements	E	Table 9, Hydrologic Unit E, items 10 through 17	296,000	- -	- -	296,000
7. Storm Sewer Conveyance Improvements	AE	Table 9, entire Hydrologic Unit AE	214,000	- -	- -	214,000
8. Storm Sewer Conveyance Improvements	AF	Table 9, entire Hydrologic Unit AF	261,000	- -	- -	261,000
9. Storm Sewer Conveyance Improvements and Detention Storage	N	Table 9, Hydrologic Unit N, items 5, and 8 through 17; and Table 84, subbasin grouping WB10, item 1	886,000	- -	644,000	1,530,000
10. Open Channel Conveyance Improvements and Detention Storage	O	Table 9, entire Hydrologic Unit O; and Table 84, WB11, item 1	210,000	86,000	- -	296,000
11. Storm Sewer Conveyance Improvements	P	Table 9, entire Hydrologic Unit P	203,000	- -	- -	203,000
12. Storm Sewer Conveyance Improvements	F	Table 9, entire Hydrologic Unit F, except item 10	597,000	- -	- -	597,000
13. Open Channel Conveyance Improvements	I	Table 9, Hydrologic Unit I, items 3 and 4	19,000	- -	- -	19,000
14. Storm Sewer Conveyance Improvements and Detention Storage	M and S	Table 9, entire Hydrologic Units M and S	1,441,000	- -	- -	1,441,000
15. Storm Sewer Conveyance Improvements	Z	Table 9, entire Hydrologic Unit Z	33,000	- -	- -	33,000
16. Storm Sewer Conveyance Improvements	AB	Table 9, entire Hydrologic Unit AB	62,000	- -	- -	62,000
17. Storm Sewer Conveyance Improvements	AH	Table 9, entire Hydrologic Unit AH	176,000	- -	- -	176,000

Table 96 (continued)

Project Number and Description	Hydrologic Unit or Subbasin Grouping	Project Components as Listed in Chapters II, III and IV	Capital Cost[a] (dollars)			
			City of West Bend	State of Wisconsin	Private Sector	Total
High-Priority Projects (continued)						
18. Storm Sewer Conveyance Improvements	AI	Table 9, entire Hydrologic Unit AI	211,000	- -	- -	211,000
19. Storm Sewer Conveyance Improvements	AJ	Table 9, entire Hydrologic Unit AJ	149,000	- -	- -	149,000
20. Storm Sewer Conveyance Improvements	AK	Table 9, entire Hydrologic Unit AK	53,000	- -	- -	53,000
21. Storm Sewer Conveyance Improvements	AL	Table 9, entire Hydrologic Unit AL	237,000	- -	- -	237,000
22. Storm Sewer Conveyance Improvements	AM	Table 9, entire Hydrologic Unit AM	327,000	- -	- -	327,000
23. Storm Sewer Conveyance Improvements	AP	Table 9, entire Hydrologic Unit AP	112,000	- -	- -	112,000
24. Storm Sewer Conveyance Improvements	AQ	Table 9, entire Hydrologic Unit AQ	212,000	- -	- -	212,000
25. Detention Basin WD28	AS	Table 9, entire Hydrologic Unit AS; and Table 84, subbasin WB11, item 3	65,000	60,000	- -	125,000
26. Storm Sewer Conveyance Improvements	Wingate Creek W8A	Table 6, subbasin W8A, items 1 and 2	42,000	- -	- -	42,000
27. Storm Sewer Conveyance Improvements	Wingate Creek W7	Table 6, subbasin W7, items 1 and 2	34,000	- -	- -	34,000
28. Storm Sewer Conveyance Improvements	Wingate Creek W4	Table 6, subbasin W4, items 1 through 4	296,000	- -	- -	296,000
29. Trenton Road Culvert Replacement	Wingate Creek W9D	Table 6, subbasin W9D, items 4 and 5 (partial)	74,000	- -	- -	74,000
30. Storm Sewer and Open Channel Conveyance Project	Q	Table 9, entire Hydrologic Unit Q	381,000	- -	75,000	456,000
31. Runoff Infiltration Practices[b]	- -	Table 86	- -	183,200	239,800	423,000
32. Street, parking, and storage area sweeping[b]	- -	Table 86	7,600	- -	69,800	77,400
Subtotal	- -	- -	17,322,600	329,200	1,028,600	18,680,400
Intermediate-Priority Projects						
33. Storm Sewer and Open Channel Conveyance	R	Table 9, entire Hydrologic Unit R	86,000	- -	604,000	690,000
34. New Storm Sewers and Detention Storage	BC	Table 9, entire Hydrologic Unit BC; and Table 84, subbasin WB11, item 2	- -	- -	469,000	469,000
35. Wingate Creek Subwatershed Facilities Associated with Future Development	Wingate Creek	Table 6, minus items 26 through 29 above; and Table 84, subbasin WB14, items 1 through 4	382,000	- -	2,312,000	2,694,000

Table 96 (continued)

Project Number and Description	Hydrologic Unit or Subbasin Grouping	Project Components as Listed in Chapters III and IV	Capital Cost[a] (dollars)			
			City of West Bend	State of Wisconsin	Private Sector	Total
Intermediate-Priority Projects (continued)						
36. New Storm Sewers	I	Table 9, Hydrologic Unit I, items 1 and 2	- -	- -	55,000	55,000
37. Storm Sewer and Open Channel Conveyance	N	Table 9, Hydrologic Unit N, items 1, through 4, 6, and 7	- -	- -	1,025,000	1,025,000
38. Storm Sewer Conveyance and Detention Storage	BE	Table 9, entire Hydrologic Unit BE; and Table 84, subbasin WB13, items 1 and 2	39,000	82,000	1,279,000	1,400,000
39. Storm Sewer Conveyance and Detention Storage	H	Table 9, entire Hydrologic Unit H; and Table 84, subbasin WB7, item 1	- -	- -	565,000	565,000
40. Detention Basin WD10	D	Table 9, Hydrologic Unit D; and Table 84, subbasin MR-D, item 1	148,000	- -	185,000	333,000
Subtotal	- -	- -	655,000	82,000	6,494,000	7,231,000
Low-Priority Projects						
41. New Storm Sewers and Wet Detention Basin WD9	A	Table 9, entire Hydrologic Unit A; and Table 84, subbasin MR-A, item 1	- -	- -	664,000	664,000
42. Storm Sewer Conveyance and Detention Storage	B	Table 9, entire Hydrologic Unit B	61,000	- -	77,000	138,000
43. Storm Sewer and Open Channel Conveyance with Detention Storage	C	Table 9, entire Hydrologic Unit C	10,000	- -	57,000	67,000
44. Storm Sewer and Open Channel Conveyance with Detention Storage	E	Table 9, Hydrologic Unit E, items 1 through 9 and 18 through 20; and Table 84, subbasin WB-3, items 1 through 7	293,000	79,000	1,003,000	1,375,000
45. New Storm Sewer	F	Table 9, Hydrologic Unit F, item 10	- -	- -	12,000	12,000
46. Storm Sewer and Open Channel Conveyance with Detention Storage	T	Table 9, entire Hydrologic Unit T; and Table 84, subbasin MR-T, items 1 through 3	421,000	- -	561,000	982,000
47. New Storm Sewers	AY	Table 9, entire Hydrologic Unit AY	200,900	- -	185,000	385,900
48. New Open Channel Conveyance	AZ	Table 9, entire Hydrologic Unit AZ	- -	- -	3,000	3,000
Subtotal	- -	- -	985,900	79,000	2,562,000	3,626,900
Total	- -	- -	18,963,500	490,200	10,084,600	29,538,300

[a] *Includes 35 percent for engineering, administration, and contingencies. Costs are for year 1991 with* Engineering News-Record *Construction Cost Index = 5,015.*

[b] *These nonpoint source measures are assigned a high priority because State of Wisconsin cost-sharing funds available under the Wisconsin Nonpoint Source Pollution Abatement Program must be applied for by June 1997.*

Source: SEWRPC.

prior to the recommendations for Hydrologic Unit MR-K. This implementation sequence is necessary to eliminate overflow from Hydrologic Unit MR-L into Hydrologic Unit MR-K as a contributor to potential flooding along 5th Avenue between Hawthorn Drive and Decorah Road. As discussed in Chapter III of this volume, under existing conditions, flow in excess of the storm sewer capacities at the intersection of Main and Vine Streets and in Hawthorn Drive west of Sunset Drive would overflow from Hydrologic Unit MR-L into Hydrologic Unit MR-K, worsening the potential for flooding along 5th Avenue between Hawthorn Drive and

Decorah Road. Once that overflow is removed as a potential flooding source, the improvements recommended for Hydrologic Unit MR-K could proceed. Those facilities would eliminate the potential for flooding in Hydrologic Unit MR-K during storms with recurrence intervals up to, and including, 100 years.

When a project involves the provision of both a series of detention storage facilities and improved conveyance facilities in a hydrologic unit which is completely developed in urban land uses, as is essentially the case with Hydrologic Unit MR-K, the optimum approach from a hydrologic and hydraulic standpoint is to construct the detention facilities and their outlets in sequence from upstream to downstream followed by the installation of the improved conveyance facilities from downstream to upstream. Construction of detention facilities in sequence from upstream to downstream avoids a situation whereby peak flows in the downstream portion of a hydrologic unit would be temporarily increased during the time period over which detention basins were constructed. The increase in downstream flows could occur because: the time of occurrence of peak outflows from downstream detention facilities would be delayed in comparison to existing conditions, 2) that delay could cause those peak outflows to be coincident, or more closely coincident, with peak flows from upstream areas, 3) the resultant higher peak flows would exceed those for which the downstream detention basin was designed, and 4) the release rate from the basin would be higher than intended.

In Hydrologic Unit MR-K it is recommended that the three detention basins and their associated outlets be constructed in sequence from upstream to downstream, and that the recommended replacement storm sewers be constructed from downstream to upstream, following completion of the detention basins. Construction of the basin outlets at the same time as the basins should be feasible prior to upgrading the storm sewer system because the basin outlets are to be connected to existing storm sewers which are not recommended for replacement.

Project No. 9, New and Replacement Storm Sewers and Detention Storage in Hydrologic Unit MR-N: This project calls for the construction of dual-purpose detention basin WD3 to store runoff from areas of both existing and planned urban development. Appurtenances to the detention basin include an open channel inlet, a 790-foot-long, 48-inch-diameter reinforced concrete pipe outlet, and a 200-foot-long outlet channel downstream from the 48-inch-diameter pipe. It is recommended that the facilities be constructed in the following order: 1) detention basin and inlet channel, 2) 48-inch-diameter pipe outlet and outlet channel, and 3) replacement storm sewer in Lang Drive and new storm sewers in River Road.

Project No. 10, Open Channel Construction and Modification and Detention Storage Construction in Hydrologic Unit MR-O: This project calls for the construction or modification of 2,080 feet of open channel in the area northeast of the intersection of Washington Street (STH 33) and River Road and the construction of dual-purpose detention basin WD6 to store runoff from the existing West Bend Industrial Park-North. It is recommended that the detention basin be constructed prior to the open channels and that the 880-foot-long section of open channel to be located between Lang Street and Washington Street (STH 33) be constructed prior to modification of the existing upstream 1,200-foot-long section of open channel located north of Lang Street.

Project No. 14, New and Replacement Storm Sewers in Hydrologic Units MR-M and MR-S: The recommended facilities for each of these hydrologic units are grouped as a single project because, as described in Chapter III of this volume, implementation of the recommendations for Hydrologic Unit MR-S are required in order to fully abate potential stormwater drainage problems in Hydrologic Unit MR-M. It is recommended that the facilities be implemented in the following order: 1) detention basin M1, 2) replacement of the designated existing storm sewer tributary to basin M1, and 3) replacement of the designated existing storm sewers and installation of one new storm sewer which will connect Units MR-M and MR-S, proceeding from downstream to upstream.

Project No. 39, New Storm Sewers and Detention Storage in Hydrologic Unit MR-H: This project calls for the construction of dual-purpose detention basins WD25 and WD26 to store runoff from areas of planned urban development. It is recommended that the facilities be constructed in the following order: 1) detention basin WD26 and its outlet storm sewer, 2) detention basin WD25 and its outlet, and 3) new storm sewers. Construction of basin WD26 first will insure that runoff from the area tributary to WD26 is diverted from basin WD25, which is not sized to handle that runoff.

REGULATORY CONSIDERATIONS

Implementation of some of the drainage improvements recommended in this system plan may require the prior approval of certain regulatory agencies other than the City, including the Wisconsin Department of Natural Resources and the U. S. Army Corps of Engineers. Because the regulatory process involved is complex, the City should seek legal counsel before proceeding with stormwater management and flood control improvements which involve the construction or improvement of artificial waterways connecting to navigable waters, the alteration or enclosure of navigable watercourses, the removal of material from the beds of navigable watercourses, or the disturbance of wetlands.

Federal regulatory authority relates to the filing of wetlands and is granted under Section 404 of the Federal Water Pollution Control Act of 1972 as amended. The administering agency is the U. S. Army Corps of Engineers.

State regulatory authority relates to the construction or improvement of artificial waterways, canals, or ponds connecting to, or located within 500 feet of, a navigable waterway, the alteration of navigable waterways, the placement of deposits or structures in the bed of navigable waterways or the enclosure of navigable waterways, the removal of material from navigable waterways, and also to activities affecting the water quality of wetlands. This authority is contained in Sections 30.12, 30.19, 30.195, 30.20, 30.206, and 144.025 of the Wisconsin Statutes. The administering agency is the Wisconsin Department of Natural Resources.

Chapters of the Wisconsin Administrative Code which are pertinent to activities called for under the recommended plan include Chapter NR 103, "Water Quality Standards for Wetlands," Chapter NR 116, "Wisconsin's Floodplain Management Program," Chapter NR 115, "Wisconsin's Shoreland Management Program," and Chapter NR 117, "Wisconsin's City and Village Shoreland-Wetland Protection Program." Because of the importance of the relatively new Chapter NR 103 regulations, special analyses have been conducted under this planning effort to address the requirements of this Chapter of the Code. Those analyses are set forth in Chapters II and III of this volume and in Appendix A of this volume.

Implementation of the plan will allow the Federal Emergency Management Agency, upon the request of the City, to revise the floodplain boundary maps following submittal of substantiating information. Such revisions should be requested immediately upon adoption of this plan.

PLAN REEVALUATION AND UPDATING

The recommended stormwater management and flood control components, as well as the forecasts and assumptions used as a basis for plan development, should be reevaluated at 10-year intervals in light of changes in actual development in the identified area. The plan components, including the need for certain facilities and the location, size and capacity of facilities, should be revised as necessary to reflect changing development patterns and stormwater management needs. In addition, in the initial plan development, it was necessary to limit the analysis and recommendations to major conveyance and detention facilities, since the layout of some future collector and land access streets had not been determined. A major effort in plan updating should be directed toward developing recommendations and updating inventories for smaller conveyance elements as development plans are prepared and incorporating this information into the master stormwater management plan.

Chapter VII

SUMMARY

The recommended stormwater management system plan for that portion of the Milwaukee River drainage area within the City of West Bend study area consists of a stormwater drainage plan element and a related water quality management plan element. The recommended plan was selected following careful evaluation of numerous alternatives considered for each of the 58 hydrologic units defined within the study area.

A recommended stormwater drainage plan element, based on the best alternative identified for each hydrologic unit in the study area, was developed with minor system components and major system components. The minor system components were designed for a 10-year recurrence interval peak flow, while the major system components were designed for a 100-year recurrence interval peak flow. The recommended components consist of about 12.4 miles of new storm sewers, 11.4 miles of replacement storm sewers, 2.4 miles of open channels or roadside swales, 1,900 lineal feet of new or replacement culverts, nine dry detention basins for water quantity control, and eight dual-purpose detention basins for both water quantity and water quality control.

The water quality management plan element calls for 15 wet detention basins for water quality control alone; the infiltration of runoff from about 77 acres of parking lots associated with government and institutional or commercial land uses; the treatment of runoff from about 592 acres of land through increased sweeping of about 14 curb-miles of streets and 138 acres of industrial and commercial parking and/or storage areas during spring and fall, along with increased catch basin cleaning and improved collection of leaves and other vegetative debris; continued enforcement of the City construction erosion control ordinance; and public education programs.

In comparison to uncontrolled loadings under planned land use conditions, the recommended measures may be expected to reduce uncontrolled pollutant loadings from the study area by 40 percent for sediment; 21 percent for phosphorus; and 39 percent for lead, used as an indicator for metals. The estimated reductions associated with the recommended plan are compared to the levels of control set forth under the adopted regional water quality management plan and under the priority watershed plan in Table 87 of Chapter IV of this volume. The nonpoint source control measures recommended in this stormwater management plan may be expected to provide levels of pollutant removal substantially exceeding those recommended for sediment and slightly less than that recommended for phosphorus in the adopted regional water quality management plan. That plan recommended that a 25 percent reduction in nonpoint source pollutants would be adequate to achieve the water use objectives and standards.

The enhancement reduction goal for sediment as established in the priority watershed study would be achieved. However, the enhancement reduction levels for phosphorus and heavy metals would not. The anticipated phosphorus reduction is substantial and an improvement in water quality may be expected to result from the proposed reduction. The phosphorus reduction level substantially exceeds the secondary goal established in the priority watershed study of maintaining current 1988 levels. The limitation on the increase in metals loading, while falling short of the enhancement goal and the secondary goal of maintaining 1988 loadings, is significant, given the inherent difficulty in reducing loadings of heavy metals and other predominantly urban pollutants when an area experiences significant new urban development.

The loading reductions achieved by the plan are the largest which are practically attainable, given the constraints identified during the review of the plan by City of West Bend staff; they may be expected to improve the overall water quality conditions of the Milwaukee River and its intermittent tributaries in the study area. Thus, the nonpoint source pollution control measures called for under the recommended plan are considered to be not in conflict with the regional water quality management plan and in substantial conformance with the goals of the priority watershed plan.

The total capital cost of the recommended plan is about $29.54 million. Of that cost, about $25.39 million, or 86 percent, is for the stormwater drainage plan element and about $4.15 million, or 14 percent, is for the water quality management plan element. Of the total capital cost of the plan, about $18.96 million, or 64 percent, is recommended to be borne by the City of West Bend; about $0.49 million, or 2 percent, is recommended to be borne by the State of Wisconsin; and about $10.08 million, or 34 percent, is recommended to be financed by the private sector, primarily land developers. Of the total annual operation and maintenance cost of $224,550, about $61,950, or 28 percent, is for the stormwater drainage plan element; about $162,600, or 72 percent, is for the water quality management plan element. About $148,350, or 66 percent of the total annual operation and maintenance cost, is recommended to be borne by the City of West Bend and the remaining $76,200, or 34 percent, is recommended to be borne by the private sector. The private sector operation and maintenance costs are for intensive sweeping of industrial and commercial parking and/or storage areas.

The initial step in plan implementation is formal adoption of the plan by the City Plan Commission, Board of Public Works, and City Council. The plan can be implemented and financed through the existing City structure for review, administration, and financing of stormwater management projects. The recommended plan should be integrated into the City's public works program to ensure construction of the recommended facilities and to ensure reliable and stable operation and maintenance of both the existing and new facilities. In order to help implement the plan, the City should carefully review subdivision plats to determine conformance to the recommended plan, incorporating public expenditures for stormwater management into a sound overall capital improvements program for the City.

The plan recommends the most cost-effective means of resolving existing and probable future stormwater management problems in the portion of the Milwaukee River drainage area within the City of West Bend study area, thereby reducing the public costs attributable to improperly functioning facilities. Implementation of the recommended plan would provide protection against substantial inconvenience to residents during minor storm events and also against major property damage. It would significantly abate the hazard to human health and safety attendant to major storm events. The plan would improve water quality and aquatic habitat conditions in the study area, thereby enhancing the potential use of the surface waters for recreational purposes. Implementation of the plan will also support the continued sound development and redevelopment of the City in accordance with the comprehensive City plan adopted in 1992.

APPENDIX

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Appendix A

WETLAND ALTERNATIVES ANALYSIS FOR COMPLIANCE WITH CHAPTER NR 103 OF THE WISCONSIN ADMINISTRATIVE CODE

INTRODUCTION

This appendix documents the analysis of practicable alternatives performed for those stormwater management and flood control features which were called for under the recommended plan and which involved significant disturbance of wetlands. Where a practicable alternative to location of a given facility in a wetland was identified, the final recommended plan as presented in Chapters II and III of this volume was revised to include that alternative. The final recommended stormwater management plan is shown on Maps 6 and 14. Wetlands in the study area are shown on Map 4 in Volume One of this report. The alternatives analysis was performed in the context of the system plan presented in this report and is intended to be adequate to obtain conceptual approval of the stormwater management plan from the Wisconsin Department of Natural Resources and to expedite the permitting process at such time as specific features of the recommended plan are implemented. It may be necessary that the applicant for a State permit, required to implement a facility recommended under this plan, provide additional data in support of the proposed project.

WETLAND CONSIDERATIONS IN THE WINGATE CREEK SUBWATERSHED

Channel Deepening at Outlet of Detention Basin WD23

Under the recommended stormwater drainage plan, deepening of about 265 feet of an existing drainage channel is recommended within a portion of a 100-acre wetland which extends along Wingate Creek in the northeast one-quarter of U. S. Public Land Survey Section 7, Township 11 North, Range 20 East. This channel deepening is required to provide a free outlet for proposed dual-purpose detention basin WD23. That detention basin would be located outside the wetland.

The area draining to the portion of the wetland in which channel deepening would occur totals about 148 acres. The existing land uses tributary to that portion of the wetland are almost entirely rural, while under planned conditions the land uses would be almost entirely urban, with medium-density residential uses being predominant.

The wetland affected by the channel deepening is classified as a combination of forested and shrub wetland characterized by broad-leaved vegetation on wet soils (T3K and S3K).

The soils in the portion of the wetland where the channel deepening is to occur are classified as Mussey loam and Adrian mucky peat. Mussey loam is poorly drained and has a high water table. Adrian mucky peat is very poorly drained and also is associated with a high water table.

The wetland is not in, nor adjacent to, an area of special natural resource interest. Wildlife habitat at the site is classified as Class II, or of medium quality.

The wetland is located partially in the floodplain of Wingate Creek and has significant floodwater and sediment storage capacity and may provide some shoreline erosion protection.

As already noted, the recommended channel deepening is required to provide an outlet for recommended detention basin WD23, and for recommended storm sewers located within subbasin W2B. The design of those storm sewers dictates that the outlet from the detention basin be located about 2.5 feet below the existing channel bottom. Because of a lack of topographic relief, and the fact that the recommended storm sewers would be provided with the minimal allowable cover, it is not possible to raise the sewer inverts sufficiently to eliminate the need for the channel deepening. Also, no alternative location for the storm sewer and detention basin outlet is available which would not encroach on the subject wetland. It would be possible to eliminate the need for the channel deepening if future development within subbasins W2A and W2B were provided with roadside swales, rather than curb and gutter and storm sewers. The use of roadside swales in areas of medium-density residential development would be uneconomical and unacceptable to the City. It was, therefore, concluded that there is no practicable alternative to the recommended channel deepening which would provide the required outlet. Thus, the recommended plan includes the channel deepening which would be carried out in conjunction with the construction of the storm sewers and detention basin in subbasin W2B. Since the deepening of the drainage channel would occur only along a 265-foot-long reach within the outer boundary of the wetland, it is not expected to significantly lower water levels within the wetland. Those water levels would continue to be governed by that portion of the existing drainage channel which would not be deepened, as well as by Wingate Creek.

Detention Basin WD13

Under the initial recommended stormwater drainage plan, dual-purpose detention basin WD13 was recommended to be constructed in a portion of a 26-acre wetland which extends along Wingate Creek and an unnamed tributary to Wingate Creek in the southwest one-quarter of U. S. Public Land Survey Section 8, Township 11 North, Range 20 East. That wetland lies within a much larger area of primary environmental corridor. Basin WD13 is intended to control more frequent floods which contribute to streambank erosion and streambed scour and also to provide reductions in loadings of nonpoint source pollutants delivered to Wingate Creek under planned land use conditions.

The total area draining to the portion of the wetland in which basin WD13 is to be located is about 147 acres. The existing land uses tributary to that portion of the wetland are almost entirely rural, while under planned conditions the land uses would be mostly urban, with medium- and high-density residential uses predominant.

The wetland affected by basin WD13 is classified as an emergent marsh wetland with unknown vegetation type on wet soils (E1K).

The soils in the portion of the wetland where WD13 is to be located are classified as Granby fine sandy loam and Houghton mucky peat. Granby fine sandy loam is generally poorly drained and is associated with a seasonal high water table. Houghton mucky peat is very poorly drained and is subject to flooding.

The wetland is not in, nor adjacent to, an area of special natural resource interest. Wildlife habitat for most of the wetland is classified as Class I, or of high quality, with a small portion in the northern tip of the wetland classified as Class II, or of medium quality.

The wetland is located primarily in the floodplain of Wingate Creek and the unnamed tributary to Wingate Creek and has significant floodwater and sediment storage capacity and may provide some minor shoreline erosion protection.

Construction of the detention basin as initially recommended would involve excavating a 2.5-acre area of the wetland. No deepening of the unnamed tributary to Wingate Creek is envisioned either upstream or downstream of the pond. Because of possible high groundwater levels at this site, there is the potential for the water in the permanent pool to be directly interchanged with the groundwater, leading to possible pollution of groundwater.

Direct disturbance of the wetland and of the primary environmental corridor could be avoided by relocating the detention basin about 1,200 feet upstream along the unnamed tributary. Such a relocation, however, would reduce the effectiveness of the basin, both in controlling discharge rates and in reducing pollutant loadings. Relocation of the basin would reduce the tributary area served from 147 acres to 90 acres, or by about 39 percent. Also, the area tributary to the relocated basin would be comprised entirely of single-family residential development under the land use plan, as opposed to a combination of single-family and higher-density, multi-family residential development under the recommended location. Therefore, pollutant loadings at the relocated basin site would be low, eliminating the need for a wet pond at this location. In addition, the relocated basin would not be capable of restricting the two-year recurrence interval storm discharge from subbasin W14 under proposed land use conditions to the discharge under existing land use conditions. The anticipated two-year recurrence interval discharge from subbasin W14 would be about 20 cubic feet per second (cfs). This is compared to six cfs under existing land use conditions, and about 60 cfs under planned land use conditions assuming no provision of detention storage.

The cost of the relocated detention basin is estimated at $127,000. This includes the $34,000 cost of extending the storm sewer proposed for subbasin W14 an additional 177 feet so as to discharge directly to the relocated basin. The recommended plan was revised to incorporate relocation of this detention basin as the most practicable alternative. This basin would still serve to significantly reduce the anticipated two-year storm discharge from subbasin W14. Also, since anticipated pollutant loadings from subbasin W14 are low, the loss of water quality benefits from this basin would be minimal.

WETLAND CONSIDERATIONS IN THE MILWAUKEE RIVER DRAINAGE AREA OUTSIDE THE WINGATE CREEK SUBWATERSHED

Detention Basin M-1

Detention basin M-1 is recommended to be constructed in Hydrologic Unit M in a portion of an isolated 0.75-acre wetland which extends along an unnamed tributary to the Milwaukee River on the east side of Eastern and Indiana Avenues in the northeast one-quarter of U. S. Public Land Survey Section 24, Township 11 North, Range 19 East in the City of West Bend. The wetland and unnamed tributary are located upstream of a very long channel enclosure within storm sewers. The detention basin is intended to control runoff from planned land uses from storms with recurrence intervals up to, and including, 100 years. Only approximately the western one-third of the basin would encroach on the existing wetland. Construction of the basin as proposed could be accomplished without the discharge of fill to the wetland. The basin could be constructed as an expansion of the existing wetland through planting of wetland vegetation. The outlet from the wetland would continue to be the existing 58-inch-wide by 36-inch-high corrugated metal pipe arch storm sewer. Thus, water levels in the wetland would be unaffected by construction of the proposed detention basin.

If the unnamed tributary were determined to be navigable by the Wisconsin Department of Natural Resources, construction of the basin would require a permit from the State under Chapter 30 of the Wisconsin Statutes. Because the project would involve activities in a wetland, a permit for the project would be required from the U. S. Army Corps of Engineers under Section 404 of the Federal Clean Water Act; Wisconsin Department of Natural Resources water quality certification applying the standards of Chapter NR 103 would also be required. Thus, a systems-level wetland evaluation and practicable alternatives analysis is presented here.

The total area draining to the wetland is about 25 acres. The existing and planned land uses tributary to that portion of the wetland are predominantly industrial with some government and institutional uses and some upstream wetlands.

The wetland affected by basin M-1 is classified as an isolated wetland of less than two acres in size. No wetland or vegetation type has been assigned to the wetland in the Regional Planning Commission wildlife habitat inventory. The soils in the wetland are classified as Mussey loam. Mussey loam is poorly drained and has a high water table.

The wetland is not in, nor adjacent to, an area of special natural resource interest and it has no significant recreational, cultural, educational, scientific, or natural aesthetic values due to its small size and isolated location. The wetland is located to the east of an isolated natural area which is designated for preservation through public land use regulation as set forth in SEWRPC Community Assistance Planning Report No. 104, A Park and Open Space Plan for the City of West Bend, June 1985, and SEWRPC Community Assistance Planning Report No. 167, A Land Use Plan for the City of West Bend: 2010, July 1992. However, no special preservation status is assigned in those reports to the wetland in question.

Wildlife habitat in the wetland is classified as Class III, or of good quality. The wetland is located upstream of a long channel enclosure which would not permit fish passage to the wetland from the Milwaukee River. It is, therefore, highly unlikely that the wetland would provide spawning habitat for fish.

The wetland is located in the floodplain of the unnamed tributary, and it has relatively significant floodwater and sediment storage capacity, may provide some filtration or storage of nutrients or toxic substances, and may provide some minor shoreline erosion protection. All those characteristics could be enhanced through the proposed construction of detention basin M-1, which would expand the available storage volume and could be landscaped to actually expand the wetland area.

The larger wetland on the west side of Indiana Avenue is an unacceptable alternative site for the construction of the detention basin. There are no upland sites on which the basin could be constructed practically. The only feasible alternative to the construction of the detention basin as proposed would be to implement Alternative M-1, which calls for replacement of storm sewers at an additional capital cost of $169,000. Because of the prohibitively high capital cost increase of the alternative to construction of the proposed basin in the wetland and the lack of practical upland sites, it was concluded that there is no practicable, cost-effective alternative to construction of the basin which would meet the stormwater drainage objectives of the plan. Thus, it is recommended that detention basin M-1 be constructed as proposed.