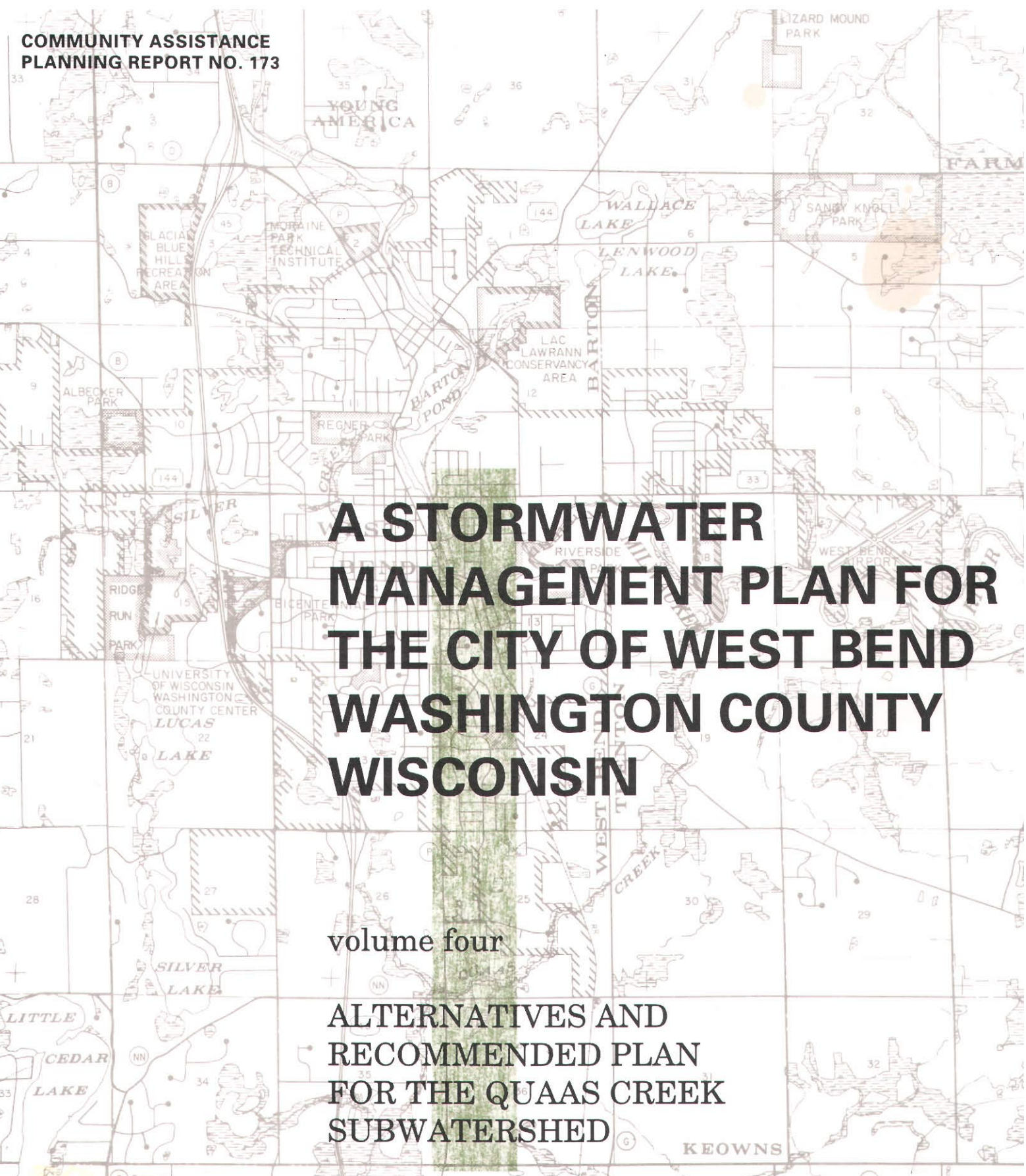
COMMUNITY ASSISTANCE
PLANNING REPORT NO. 173



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

volume four

ALTERNATIVES AND RECOMMENDED PLAN FOR THE QUAAS CREEK SUBWATERSHED

SOUTHEASTERN WISCONSIN REGIONAL PLANNING COMMISSION

SOUTHEASTERN WISCONSIN REGIONAL PLANNING COMMISSION

KENOSHA COUNTY
Leon T. Dreger
Thomas J. Gorlinski
Sheila M. Siegler

RACINE COUNTY
David B. Falstad, Chairman
Martin J. Itzin
Jean M. Jacobson, Secretary

MILWAUKEE COUNTY
Daniel J. Diliberti
William Ryan Drew
Tyrone P. Dumas

WALWORTH COUNTY
John D. Ames
Anthony F. Balestrieri
Allen L. Morrison, Treasurer

OZAUKEE COUNTY
Leroy A. Bley
Thomas H. Buestrin, Vice-Chairman
Elroy J. Schreiner

WASHINGTON COUNTY
Lawrence W. Hillman
Daniel S. Schmidt
Patricia A. Strachota

WAUKESHA COUNTY
Duane H. Bluemke
Robert F. Hamilton
Paul G. Vrakas

CITY OF WEST BEND OFFICIALS

MAYOR

Michael R. Miller

CITY COUNCIL

Joseph F. Gates
Robert M. Motl
Hope H. Nelson
Thomas F. O'Meara, III
Stephen M. Sexton
Tony R. Spaeth
Albert W. Tennies
Terrence W. Vrana

CITY PLAN COMMISSION

Michael R. Miller, Chairman
Jed M. Dolnick
Allen E. Fritschel
Allen E. Hron
Kenneth M. Pesch
Albert W. Tennies
A. James White

DIRECTOR OF CITY DEVELOPMENT

John B. Capelle, AICP

CITY ENGINEER

Kenneth M. Pesch, P.E.

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

SOUTHEASTERN WISCONSIN REGIONAL PLANNING COMMISSION STAFF

Kurt W. Bauer, PE, AICP, RLS ..... Executive Director
Philip C. Evenson, AICP ..... Assistant Director
Kenneth R. Yunker, PE ..... Assistant Director
Robert P. Biebel, PE ..... Chief Environmental Engineer
Monica C. Drewniany, AICP ..... Chief Special Projects Planner
Leland H. Kreblin, RLS ..... Chief Planning Illustrator
Elizabeth A. Larsen ..... Administrative Officer
Donald R. Martinson, PE ..... Chief Transportation Engineer
John R. Meland ..... Chief Economic Development Planner
Thomas D. Patterson ..... Geographic Information Systems Manager
Bruce P. Rubin ..... Chief Land Use Planner
Roland O. Tonn, AICP ..... Chief Community Assistance Planner

Special acknowledgement is due Ms. Najoua Ksontini, SEWRPC Engineer, and Mr. Michael G. Hahn, SEWRPC Principal 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 Four

ALTERNATIVES AND RECOMMENDED PLAN FOR THE QUAAS CREEK SUBWATERSHED

Prepared by the

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

July 1996

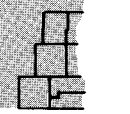
Inside Region $ 5.00
Outside Region $10.00

(This page intentionally left blank)

SOUTHEASTERN WISCONSIN REGIONAL PLANNING COMMISSION

916 N. EAST AVENUE • P.O. BOX 1607 • WAUKESHA, WISCONSIN 53187-1607 • TELEPHONE (414) 547-6721
TELECOPIER (414) 547-1103

Serving the Counties of: KENOSHA
MILWAUKEE
OZAUKEE
RACINE
WALWORTH
WASHINGTON
WAUKESHA



July 3, 1996

Mayor, City Council, and
City Plan Commission
c/o City Clerk
City of West Bend
1115 S. Main Street
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 fourth 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 evaluation.

The second and third volumes 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 and the Milwaukee River drainage areas, respectively, described and evaluated alternative stormwater management plans designed to serve those subwatersheds through the design year 2010, and recommended a stormwater management system plan for those subwatersheds.

This volume pertains to that portion of the planned urban service area of the City lying within the Quaas Creek subwatershed and presents a recommended stormwater management system plan for that 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

(This page intentionally left blank)

TABLE OF CONTENTS

LIST OF TABLES

LIST OF MAPS

(This page intentionally left blank)

Chapter I

INTRODUCTION

This volume is the fourth and final volume 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.

The third volume presents a recommended stormwater management plan for that portion of the planned urban service area of the City lying within designated areas draining to the Milwaukee River.

This, the fourth volume, presents a recommended stormwater management plan for that portion of the planned urban service area of the City which lies within the Quaas Creek subwatershed and provides information similar to that provided for the other subwatersheds in the second and third volumes of this report.

STUDY AREA

The study area is shown on Map 1. The Quaas Creek subwatershed stormwater management study area includes nine hydrologic units designated A through I. The total subwatershed area is 8.74 square miles, including about 0.32 square mile which is internally drained. The hydrologic units were further subdivided into 92 subbasins.

Quaas Creek originates just southeast of the intersection of USH 45 and Paradise Drive in the northeast one-quarter of U. S. Public Land Survey Section 26, Township 11 North, Range 19 East, Town of West Bend. From its origin, it flows in a generally southerly direction about 1.44 miles to CTH P. In that reach the stream is crossed by private drives at River Miles 4.78, 5.88, and 5.98, measured from the mouth of the stream. From CTH P, the Creek flows 4.53 miles in a generally northeasterly direction to the Milwaukee River. In that reach the stream is crossed by CTH P at River Mile 4.53, by a private drive at River Mile 3.89, by Progress Drive at River Mile 3.31, by the Wisconsin Central Railroad (formerly Chicago & North Western Railway) embankment at River Mile 2.85, by CTH G (River Road) at River Mile 2.50, by Paradise Drive at River Mile 2.10, by Sand Drive at River Mile 1.51, by a private drive at River Mile 1.14, and by Decorah Road at River Mile 0.54.

The confluence of Quaas Creek and the South Branch of Quaas Creek lies just upstream of CTH P. The South Branch flows 2.25 miles in a generally northeasterly direction from its origin at Quaas Lake in the southwest one-quarter of Section 34, Township 11 North, Range 19 East, to the confluence with the main stem of Quaas Creek. The South Branch is crossed by Mile View Road and by CTH NN.

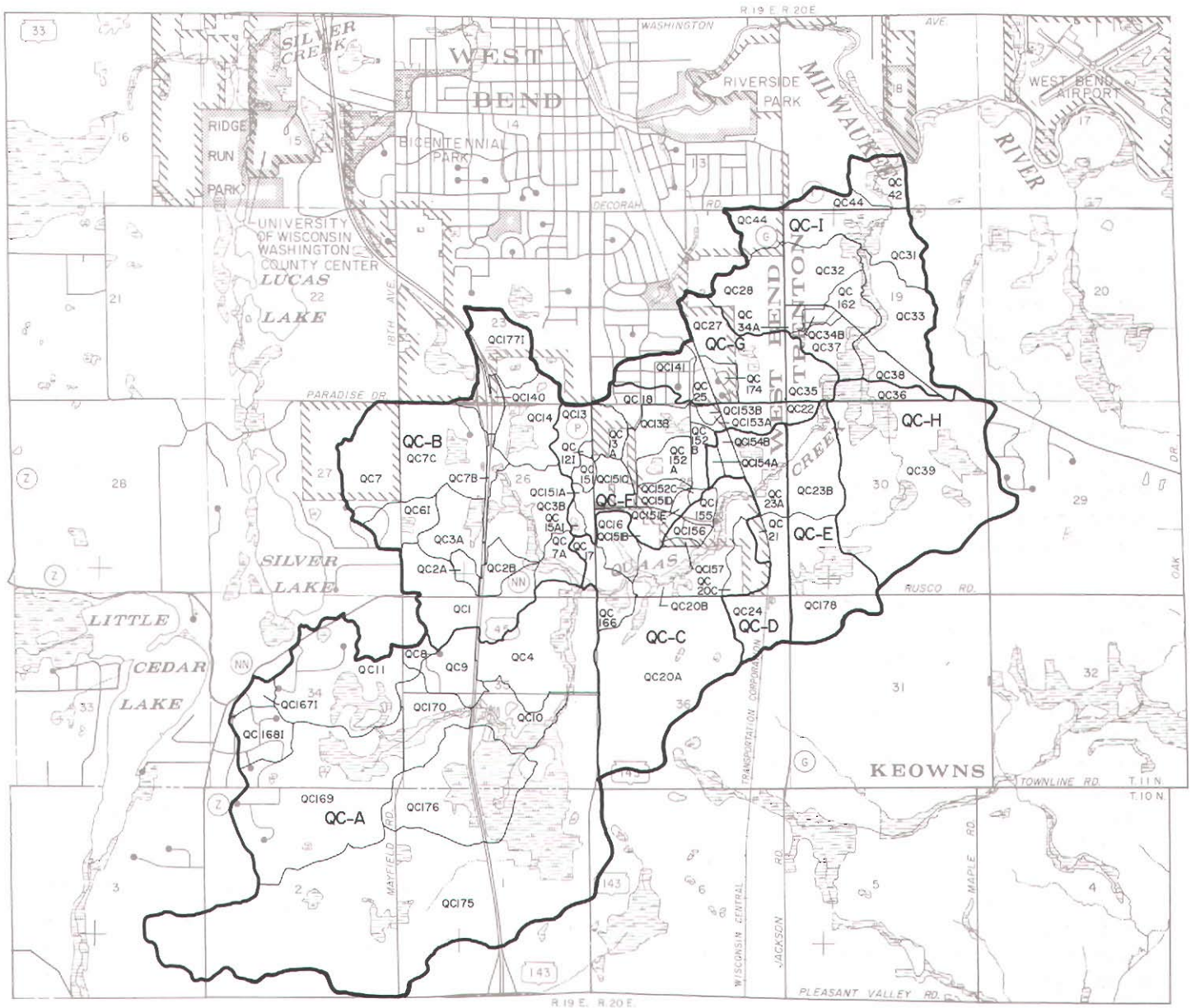
The stormwater management alternatives are designed to serve the Quaas Creek drainage area through the design year 2010. Planned year 2010 land use conditions are based on the recommended land use plan prepared by the Regional Planning Commission for the City of West Bend.[1] Under 1985 land use conditions, about 13 percent of the subwatershed was developed in urban land uses. Under planned year 2010 conditions, about 45 per-

---

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

Map 1

THE QUAAS CREEK SUBWATERSHED



LEGEND

- SUBWATERSHED BOUNDARY
- HYDROLOGIC UNIT BOUNDARY
- SUBBASIN BOUNDARY
- QC-H HYDROLOGIC UNIT DESIGNATION
- QC174 SUBBASIN DESIGNATION
- QC168I INTERNALLY DRAINED SUBBASIN DESIGNATION

GRAPHIC SCALE
0 1/2 1 MILE
0 1000 2000 3000 4000 FEET

Source: SEWRPC.

cent of the subwatershed is anticipated to be developed in urban land uses.

ORGANIZATION OF VOLUME FOUR

Following this introductory chapter, the second chapter of this volume presents the water quality management plan element, dealing specifically with the control of nonpoint source pollution from the areas of planned urban land use for which stormwater management system plans were prepared. The third chapter presents alternative stormwater drainage plans. It includes the evaluation of the existing stormwater drainage system; the preparation, test, and evaluation of alternative stormwater drainage system plans; and selection of a preliminary recommended stormwater drainage system plan. The fourth chapter integrates the stormwater drainage and water quality management elements of the plan into an overall recommended stormwater management plan; evaluates the effect of the recommended plan on flood stages in Quaas Creek; 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; and provides estimates of the cost of the recommended plan. Chapter V deals with implementation of the plan, including an apportionment of the costs between the City, the State of Wisconsin, and the private sector and also a prioritization of projects. The sixth 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.

(This page intentionally left blank)

Chapter II

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 Quaas 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 by the Wisconsin Department of Natural Resources (DNR).[2]

The recommended water quality control facilities and measures for the Quaas Creek subwatershed were integrated with the recommended stormwater drainage measures to form the recommended stormwater management plan. The recommended stormwater management plan, as presented on Map 10 in Chapter IV of this volume, thus includes both drainage and water quality management measures.

WATER USE OBJECTIVES AND WATER QUALITY STANDARDS

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. Those objectives were established at the inception of the stormwater management planning process for the City of West Bend and were based upon the recommendations set forth in the regional water quality management plan. The levels of control of nonpoint source pollutants determined in the regional water quality management plan to be needed to meet the recommended water use objectives and their supporting water quality standards provide the basis for the design of the recommended water quality management plan. The levels of control developed to meet the water use objectives set forth in Volume One of this report are also compared to the levels of control recommended in the DNR nonpoint source priority watershed plan for the East and West Branches of the Milwaukee River.

The reach of Quaas Creek downstream of CTH G was found to be potentially capable of meeting the warm-water forage fish and full recreational water use objectives. The reach currently supports a diverse population of forage fish and aquatic life intolerant to very tolerant of degraded water quality and habitat. No water quality sampling data are available to indicate whether the water quality standards are indeed being achieved. Water use objective summaries prepared by the Wisconsin Department of Natural Resources under the priority watershed plan for the East and West Branches of the Milwaukee River watershed indicate that the factors which are currently limiting achievement of the recommended water use objectives in this reach include sedimentation, loss of habitat, and bacterial contamination.

Upstream of CTH G, Quaas Creek, the South Branch of Quaas Creek, and two short tributaries to the South Branch currently support a Class II brook trout fishery, consistent with the recommended water use objective of recreational use and maintenance of cold-water fish and aquatic life. No current water quality sampling data are available to indi-

---

[1] *See SEWRPC Planning Report No. 30, A Regional Water Quality Management Plan for Southeastern Wisconsin: 2000, 1979.*

[2] *See 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.*

cate whether the water quality standards are being achieved. Water use objective summaries prepared by the Wisconsin Department of Natural Resources under the priority watershed study indicate that under existing conditions sedimentation and limited habitat are preventing this reach from attaining a potential use as a Class I trout stream.

Quaas Lake, at the headwaters of the South Branch of Quaas Creek, is classified as being capable of meeting the warm-water sport fish and full recreation water use objectives. The habitat of the lake has been rated from fair to good for sport fish spawning, but no sport fish are reported to be present in the Lake. Sedimentation and winterkills limit achievement of the recommended water use objectives.

Other significant water-related natural resource features in the study area which merit protection are 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 Quaas Creek subwatershed, annual pollutant loadings to surface waters under existing and planned future land use conditions were estimated for each of seven subbasin groups within the subwatershed. Those subbasin groups, which are delineated on Map 2, are formed from the same subbasin areas used for analysis of the stormwater drainage system in the subwatershed as described in Chapter III. The subbasins were combined 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 1 through 6. 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 Wisconsin Department of Natural Resources under the priority watershed planning program,[3] with the exception that planned condition lead loading rates have been reduced appropriately to reflect the substantial reduction in lead loading rates observed and documented in recent years. That reduction in lead loading rates is primarily attributable to discontinuation of the use of leaded gasoline. However, loadings of other metals from urban sources, such as copper, zinc, and cadmium, are not significantly affected by this change in motor fuel. Because of the major reduction in lead loadings, the use of this parameter in comparisons of past and future conditions is of limited value. However, lead was the only metal for which reduction goals and analyses were prepared in the priority watershed plan. Thus, the analyses relating to lead were made only for comparative purposes.

On the basis of the adopted land use plan for the City and environs, urban land use in the study area may be expected to increase by about 256 percent over the 25-year planning period. The conversion of land from rural to urban uses may be expected to result in a 14 percent reduction in the annual sediment loading and a 12 percent reduction in the annual phosphorus loading. However, the loading of metals and other pollutants which are contributed almost exclusively by urban sources, and represented in the analysis by copper, zinc, and cadmium, may be expected to increase by over 100 percent by the year 2010 if controls are not provided.

BASIS FOR THE SELECTION OF THE TARGETED LEVELS OF NONPOINT SOURCE POLLUTION CONTROL

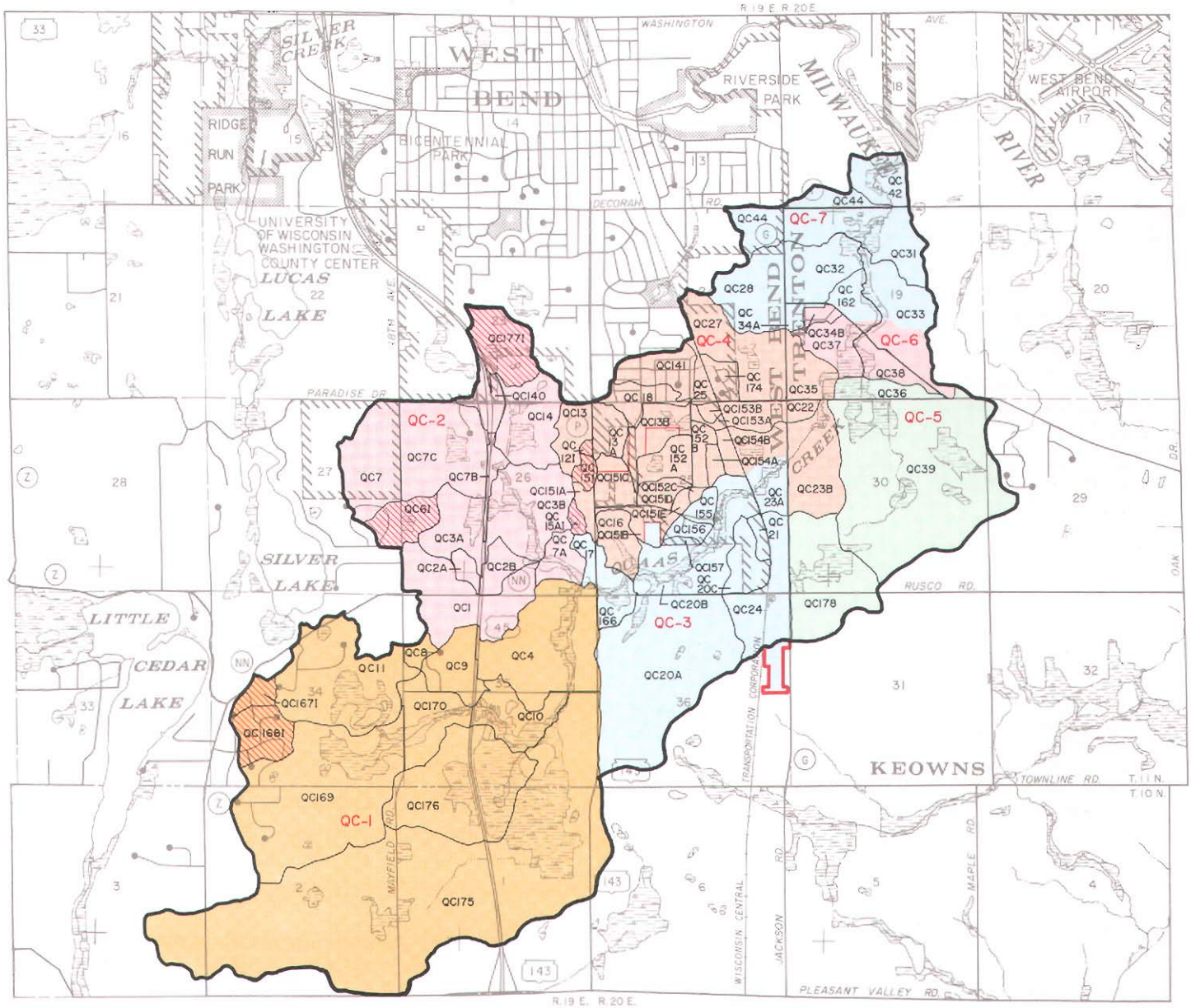
With regard to the targeted nonpoint source pollutant loading reductions, the measures considered were directed toward reducing the pollutant loadings based upon two separate planning efforts. The primary objective was to provide reductions in nonpoint source pollutant loadings to the levels set forth in the regional water quality management plan. That level of control would achieve the water quality standards associated with the water use objectives described earlier. These recommendations

---

[3]*The "Source Loading and Management Model" applied under the priority watershed planning program is discussed on page 74 in Chapter IV of Volume One of this report.*

Map 2

SUBBASIN GROUPS FOR NONPOINT SOURCE POLLUTION CONTROL ANALYSIS



LEGEND

- SUBWATERSHED BOUNDARY
- SUBWATERSHED BOUNDARY UNDER PLANNED DRAINAGE CONDITIONS
- SUBBASIN BOUNDARY
- SUBBASIN BOUNDARY UNDER PLANNED DRAINAGE CONDITIONS
- QC-7 SUBBASIN GROUP DESIGNATION
- QC174 SUBBASIN DESIGNATION
- QC1681 INTERNALLY DRAINED SUBBASIN DESIGNATION
- INTERNALLY DRAINED SUBBASIN

GRAPHIC SCALE

0 1/2 1 MILE

0 1000 2000 3000 4000 FEET

Source: SEWRPC.

Table 1

ANNUAL TOTAL SUSPENDED SOLIDS LOADINGS FROM THE QUAAS CREEK SUBWATERSHED UNDER EXISTING, PLANNED UNCONTROLLED, AND RECOMMENDED PLAN CONDITIONS

	Existing				Planned Uncontrolled							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	Urban Area (acres)	Percent Change in Urban Area	Uncontrolled Total Urban and Rural Loads (pounds)	Percent Change in Total Urban and Rural Loads	Total Urban and Rural Area[b] (acres)	Total Urban and Rural Loads (pounds)	Percent Change in Total Urban and Rural Loads Relative to Existing Loads
QC-1	8,540	271	588,240	2,032	15,540	82	271	0	594,110	1	2,032	594,110	1
QC-2	1,180	94	222,600	732	104,580	8,763	458	387	161,490	-27	732	140,550	-37
QC-3	4,310	27	231,110	639	205,010	4,657	455	1,585	240,040	-4	654	78,580	-66
QC-4	38,380	176	269,880	798	232,800	507	732	316	233,050	-14	798	102,960	-62
QC-5	650	34	182,250	595	12,870	1,880	196	476	121,290	-33	595	121,290	-33
QC-6	200	11	18,960	75	3,200	1,500	44	300	5,760	-70	75	5,760	-70
QC-7	25,270	80	182,845	522	57,890	129	310	288	111,190	-39	528	83,970	-54
Total	78,530	693	1,695,885	5,393	631,890	705	2,466	256	1,466,930	-14	5,414	1,127,220	-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 total urban and rural area in the subwatershed increases by 21 acres, or 0.4 percent because of proposed changes in the subwatershed boundary in subbasin groupings QC-3 and QC-7. The area changes were determined on the basis of site-grading plans for proposed developments as provided by the City.*

Source: SEWRPC.

Table 2

ANNUAL TOTAL PHOSPHORUS LOADINGS FROM THE QUAAS CREEK SUBWATERSHED UNDER EXISTING, PLANNED UNCONTROLLED, AND RECOMMENDED PLAN CONDITIONS

	Existing				Planned Uncontrolled							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	Urban Area (acres)	Percent Change in Urban Area	Uncontrolled Total Urban and Rural Loads (pounds)	Percent Change in Total Urban and Rural Loads	Total Urban and Rural Area[b] (acres)	Total Urban and Rural Loads (pounds)	Percent Change in Total Urban and Rural Loads Relative to Existing Loads
QC-1	47.5	271	1,164.2	2,032	55.4	17	271	0	1,173.1	1	2,032	1,173	1
QC-2	12.4	94	439.0	732	247.1	1,893	458	387	360.7	-18	732	331	-25
QC-3	10.2	27	447.1	639	346.3	3,295	455	1,585	417.2	-7	654	260	-42
QC-4	91.1	176	537.1	798	468.5	414	732	316	471.2	-12	798	323	-40
QC-5	6.7	34	357.6	595	43.9	555	196	476	256.2	-28	595	256	-28
QC-6	2.1	11	38.2	75	10.6	405	44	300	16.2	-58	75	16	-58
QC-7	71.5	80	374.9	522	152.0	113	310	288	258.0	-31	528	219	-42
Total	242.0	693	3,358.1	5,393	1,323.8	448	2,466	256	2,952.6	-12	5,414	2,579	-23

[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 total urban and rural area in the subwatershed increases by 21 acres, or 0.4 percent because of proposed changes in the subwatershed boundary in subbasin groupings QC-3 and QC-7. The area changes were determined on the basis of site-grading plans for proposed developments as provided by the City.*

Source: SEWRPC.

Table 3

ANNUAL LEAD LOADINGS FROM THE QUAAS CREEK SUBWATERSHED UNDER EXISTING, PLANNED UNCONTROLLED, AND RECOMMENDED PLAN CONDITIONS

	Existing				Planned Uncontrolled							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	Urban Area (acres)	Percent Change in Urban Area	Uncontrolled Total Urban and Rural Loads (pounds)	Percent Change in Total Urban and Rural Loads	Total Urban and Rural Area[b] (acres)	Total Urban and Rural Loads (pounds)	Percent Change in Total Urban and Rural Loads Relative to Existing Loads
QC-1	20.6	271	37.2	2,032	9.1	-56	271	0	22.4	-40	2,032	22.4	-40
QC-2	2.9	94	8.5	732	60.5	1,986	458	387	61.7	626	732	52.3	515
QC-3	10.4	27	16.1	639	141.4	1,260	455	1,585	142.1	783	654	43.3	169
QC-4	86.6	176	92.4	798	175.6	103	732	316	175.6	90	798	97.8	6
QC-5	1.4	34	6.0	595	5.5	293	196	476	7.9	32	595	7.9	32
QC-6	0.4	11	1.0	75	1.3	225	44	300	1.4	40	75	1.4	40
QC-7	37.4	80	41.2	522	33.3	-11	310	288	34.5	-16	528	18.6	-55
Total	160.0	693	202.4	5,393	426.7	167	2,466	256	445.6	120	5,414	243.7	20

[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 total urban and rural area in the subwatershed increases by 21 acres, or 0.4 percent because of proposed changes in the subwatershed boundary in subbasin groupings QC-3 and QC-7. The area changes were determined on the basis of site-grading plans for proposed developments as provided by the City.*

Source: SEWRPC.

Table 4

ANNUAL COPPER LOADINGS FROM THE QUAAS CREEK SUBWATERSHED UNDER EXISTING, PLANNED UNCONTROLLED, AND RECOMMENDED PLAN CONDITIONS

	Existing				Planned Uncontrolled							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	Urban Area (acres)	Percent Change in Urban Area	Uncontrolled Total Urban and Rural Loads (pounds)	Percent Change in Total Urban and Rural Loads	Total Urban and Rural Area[b] (acres)	Total Urban and Rural Loads (pounds)	Percent Change in Total Urban and Rural Loads Relative to Existing Loads
QC-1	1.24	271	1.24	2,032	14.60	1,077	271	0	14.60	1,077	2,032	14.60	1,077
QC-2	0.02	94	0.02	732	37.54	187,600	458	387	37.54	187,600	732	34.94	174,600
QC-3	1.13	27	1.13	639	57.94	5,027	455	1,585	57.94	5,027	654	20.74	1,735
QC-4	11.27	176	11.27	798	68.72	510	732	316	68.72	510	798	43.12	283
QC-5	0.00	34	0.00	595	2.40	--	196	476	2.40	--	595	2.40	--
QC-6	0.00	11	0.00	75	0.60	--	44	300	0.60	--	75	0.60	--
QC-7	3.57	80	3.57	522	12.20	242	310	288	12.20	242	528	7.50	110
Total	17.23	693	17.23	5,393	194.00	1,026	2,466	256	194.00	1,026	5,414	123.90	619[c]

[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 total urban and rural area in the subwatershed increases by 21 acres, or 0.4 percent because of proposed changes in the subwatershed boundary in subbasin groupings QC-3 and QC-7. The area changes were determined on the basis of site-grading plans for proposed developments as provided by the City.*

[c] *The projected increases in copper loadings would be reduced through both the recommended implementation of source controls and the recommended public education program. The degree of reduction achieved through those means is not readily quantifiable because it is dependent on the degree of implementation of voluntary measures.*

Source: SEWRPC.

Table 5

ANNUAL ZINC LOADINGS FROM THE QUAAS CREEK SUBWATERSHED UNDER EXISTING, PLANNED UNCONTROLLED, AND RECOMMENDED PLAN CONDITIONS

	Existing				Planned Uncontrolled							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	Urban Area (acres)	Percent Change in Urban Area	Uncontrolled Total Urban and Rural Loads (pounds)	Percent Change in Total Urban and Rural Loads	Total Urban and Rural Area[b] (acres)	Total Urban and Rural Loads (pounds)	Percent Change in Total Urban and Rural Loads Relative to Existing Loads
QC-1	10.1	271	10.1	2,032	59.4	488	271	0	59.4	488	2,032	59.4	488
QC-2	0.4	94	0.4	732	226.5	62,817	458	387	226.5	62,817	732	203.5	56,428
QC-3	7.8	27	7.8	639	394.8	4,942	455	1,585	394.8	4,942	654	154.8	1,877
QC-4	78.8	176	78.8	798	471.2	498	732	316	471.2	498	798	309.2	292
QC-5	0.3	34	0.3	595	16.8	4,991	196	476	16.8	4,991	595	16.8	4,991
QC-6	0.1	11	0.1	75	4.2	4,567	44	300	4.2	4,567	75	4.2	4,567
QC-7	39.9	80	39.9	522	98.1	146	310	288	98.1	146	528	60.1	51
Total	137.4	693	137.4	5,393	1,271.0	825	2,466	256	1,271.0	825	5,414	808.0	488[c]

[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 total urban and rural area in the subwatershed increases by 21 acres, or 0.4 percent because of proposed changes in the subwatershed boundary in subbasin groupings QC-3 and QC-7. The area changes were determined on the basis of site-grading plans for proposed developments as provided by the City.*

[c] *The projected increases in zinc loadings would be reduced through both the recommended implementation of source controls and the recommended public education program. The degree of reduction achieved through those means is not readily quantifiable because it is dependent on the degree of implementation of voluntary measures.*

Source: SEWRPC.

Table 6

ANNUAL CADMIUM LOADINGS FROM THE QUAAS CREEK SUBWATERSHED UNDER EXISTING, PLANNED UNCONTROLLED, AND RECOMMENDED PLAN CONDITIONS

	Existing				Planned Uncontrolled							Recommended Plan[a]	
Subbasin Grouping	Urban Loads (pounds)	Urban Area (acres)	Total Urban and Rural Loads (pounds)	Tota Urban and Rural Area (acres)	Uncontrolled Urban Loads (pounds)	Percent Change in Urban Loads	Urban Area (acres)	Percent Change in Urban Area	Uncontrolled Total Urban and Rural Loads (pounds)	Percent Change in Total Urban and Rural Loads	Total Urban and Rural Area[b] (acres)	Total Urban and Rural Loads (pounds)	Percent Change in Total Urban and Rural Loads Relative to Existing Loads
QC-1	0.05	271	0.05	2,032	0.61	1,120	271	0	0.61	1,120	2,032	0.61	1,120
QC-2	0.00	94	0.00	732	1.30	--	458	387	1.30	--	732	1.26	--
QC-3	0.05	27	0.05	639	2.47	4,840	455	1,585	2.47	4,840	654	0.88	1,660
QC-4	0.57	176	0.57	798	3.29	477	732	316	3.29	477	798	2.16	279
QC-5	0.00	34	0.00	595	0.00	--	196	476	0.00	--	595	0.00	--
QC-6	0.00	11	0.00	75	0.00	--	44	300	0.00	--	75	0.00	--
QC-7	0.02	80	0.02	522	0.31	1,450	310	288	0.31	1,450	528	0.12	500
Total	0.69	693	0.69	5,393	7.98	1,057	2,466	256	7.98	1,057	5,414	5.03	629[c]

[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 total urban and rural area in the subwatershed increases by 21 acres, or 0.4 percent because of proposed changes in the subwatershed boundary in subbasin groupings QC-3 and QC-7. The area changes were determined on the basis of site-grading plans for proposed developments as provided by the City.*

[c] *The projected increases in cadmium loadings would be reduced through both the recommended implementation of source controls and the recommended public education program. The degree of reduction achieved through those means is not readily quantifiable because it is dependent on the degree of implementation of voluntary measures.*

Source: SEWRPC.

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 Quaas Creek subwatershed, 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 plus construction erosion control, streambank stabilization, and onsite septic system management. The water quality modeling conducted to develop these recommendations included simulation of in-stream temperature, biochemical oxygen demand, dissolved oxygen, fecal coliform, ammonia nitrogen, and phosphorus conditions. 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 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. Thus, the levels of control expected under the plan recommended here are compared to the reduction goals established under that plan. Those nonpoint source pollutant reduction goals were established by the Wisconsin Department of Natural Resources staff, which considered primarily sediment, phosphorus, and lead, the latter as an indicator of metal loadings. The pollutant reduction goals were established based upon DNR staff judgement, considering field observations, stormwater quality sampling, and estimates of the degree of improvement needed for achievement of desired recreational and aquatic-life uses of the surface waters in the study area.

The priority watershed planning program recommended that: 1) the total sediment loadings be reduced under planned conditions to about 50 percent of the existing condition loads, 2) the total phosphorus loadings be reduced under planned conditions to about 25 percent of the existing condition loads, and 3) the total lead loads be maintained at their existing low level under planned conditions. The water resource objectives established for the Quaas Creek subwatershed under the priority watershed program are to enhance the existing recreational and aquatic-life uses for Quaas Creek and to protect sensitive and valuable wetlands from sedimentation.

Under the current planning process, consideration was given to the degree to which nonpoint source pollution controls of the recommended plan developed under the current planning process would meet the reduction goals established under the priority watershed planning program. However, experience, including that gained during preparation of the Silver Creek and Milwaukee River drainage area stormwater management plans as presented in Volumes Two and Three, respectively, of this report, indicates that the levels of metals reduction recommended under the priority watershed planning program are not likely to be achievable practically.

The Quaas Creek subwatershed is expected to undergo significant urbanization, transforming it from an area which was about 13 percent urban in 1985 to an area which may be expected to be about 45 percent urban under planned year 2010 conditions. As shown in Tables 3 through 6, that land use transformation is expected to result in very large relative increases in the loadings of metals found in urban runoff. The extremely large reduction in metals loadings called for by the priority watershed study under planned land use conditions cannot be practically and cost-effectively achieved through the provision of structural best management practices alone. Even with supplemental controls, which eliminate the sources of some metals in the subwatershed, the no-increase goal is not likely to be practically achievable.

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 seven subbasin groups in the planning area. Table 7 presents a ranking of the subbasin groups according to the estimated planned uncontrolled nonpoint source pollutant loadings of sediment, phosphorus, copper, zinc, and cadmium. This ranking was useful in targeting subbasin groups which should be provided with non-

---

[4]*See SEWRPC Planning Report No. 37, A Water Resources Management Plan for the Milwaukee Harbor Estuary, December 1987.*

Table 7

PLANNED UNIT-AREA LOADINGS FROM SUBBASIN GROUPS WITHIN THE QUAAS CREEK SUBWATERSHED: PLANNED YEAR 2010 URBAN AND RURAL LAND USE WITHOUT NONPOINT SOURCE POLLUTION CONTROLS

Ranking	Total Suspended Solids		Phosphorus	
	Subbasin Group	Unit Area Loading (pounds per acre per year)	Subbasin Group	Unit Area Loading (pounds per acre per year)
1	QC-3	375	QC-3	0.65
2	QC-1 and QC-4	292	QC-4	0.59
3	QC-2	221	QC-1	0.58
4	QC-7	213	QC-2 and QC-7	0.49
5	QC-5	204	QC-5	0.43
6	QC-6	77	QC-6	0.22

Ranking	Copper		Zinc		Cadmium	
	Subbasin Group	Unit Area Loading (pounds per acre per year)	Subbasin Group	Unit Area Loading (pounds per acre per year)	Subbasin Group	Unit Area Loading (pounds per acre per year)
1	QC-4	0.086	QC-3	0.617	QC-4	0.0041
2	QC-3	0.073	QC-4	0.590	QC-3	0.0039
3	QC-2	0.051	QC-2	0.310	QC-2	0.0018
4	QC-7	0.023	QC-7	0.188	QC-7	0.0006
5	QC-6	0.008	QC-6	0.056	QC-1	0.0003
6	QC-1	0.007	QC-1	0.029	QC-5 and 6	0.0000
7	QC-5	0.004	QC-5	0.028	--	--

Source: SEWRPC.

point 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, the need to maintain cool water temperatures in the stream reaches assigned a cold-water fishery water use objective, the need to maintain adequate base flows to meet the established water use objectives, cost-effectiveness of the measures, availability of suitable sites, consistency with City policies regarding the provision of curb and gutter and storm sewer drainage facilities, 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 commercial parking lot runoff, 3) intensive sweeping of industrial areas and materials handling and storage measures, and 4) construction erosion control. The estimated nonpoint source pollutant removal effectiveness of the various measures is set forth in Table 8.

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

Table 8

NONPOINT SOURCE POLLUTANT REMOVAL EFFECTIVENESS OF VARIOUS CONTROL MEASURES

Control Measures	Percent Reductions in Pollutant Loadings					
	Total Suspended Solids	Total Phosphorus	Lead	Copper	Zinc	Cadmium
Wet Detention Basins	90	50	70	60	55	55
Construction Site Erosion Control	75	75	--	--	--	--
Weekly Sweeping of Industrial Parking and Storage Areas and Adjacent Streets	70	50	70	70	70	70
Infiltration of Runoff from Government Institutional Parking Lots and Commercial Parking Lots	40	30	50	40	40	40

Source: Wisconsin Department of Natural Resources and SEWRPC.

by the availability of suitable open space sites. The cost of providing a wet detention 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] Fortunately, suitable open-space sites are generally still available in the Quaas Creek subwatershed. However, consideration of the provision of wet detention basins was limited to those areas which discharge to that reach of Quaas Creek assigned a warm-water forage fishery water use objective. That restriction was imposed to limit the possible increase in water temperatures in the cold-water fish reach upstream of CTH G due to the warming of water temporarily stored in the permanent ponds of wet detention basins. Thus, wet detention was recommended to be provided only in those subbasin groups which discharge at, and downstream of, CTH G. Those subbasin groups include QC-4 through QC-7. One exception to this rule occurs in group QC-3, where three wet detention basins were constructed in the West Bend Industrial Park-South as part of a nonpoint source control demonstration project jointly funded by the Wisconsin Department of Natural Resources and the City of West Bend. Those basins were constructed in the mid-1980s. Another exception is the West Bend Mutual Insurance property, where a wet detention basin was constructed in the early 1990s.

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. Infiltration of stormwater runoff is especially important in the Quaas Creek subwatershed because it typically is expected to enhance the cool-temperature stream base flows essential to the maintenance of the coldwater fishery.

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, or is constrained by the need to avoid wet detention basin discharges to cold-water fishery reaches.

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 source pollution 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 area for the excavation of a basin, were located on a well-defined drainage system, drained an appropriately sized area which may be expected to

[5]*See SEWRPC Technical Report No. 31, Costs of Urban Nonpoint Source Water Pollution Control Measures, June 1991.*

generate significant pollutant loadings, and discharged at, or downstream of, CTH G. 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, wet detention basins were located outside wetlands identified on the Regional Planning Commission land use inventory and the State of Wisconsin wetland inventory maps. The use of infiltration systems should be limited to areas with adequate open land covered by relatively permeable soils, where the depth to bedrock and to the seasonally high water table may be expected to be 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 lowest cost. The cost-effectiveness of providing wet detention basins, infiltration systems, street and parking lot sweeping, and construction erosion control measures was compared in Table 14 on page 117 in Volume Two of this report. That table indicates 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 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 because of the minimal contributions of heavy metals from construction sites. Infiltration of stormwater runoff from rooftops was not recommended solely for control of nonpoint source pollution because control of the low levels of pollutants in rooftop runoff makes such control cost-ineffective.

RECOMMENDED WATER QUALITY MANAGEMENT PLAN

Components and Level of Pollution Control of the Recommended Plan

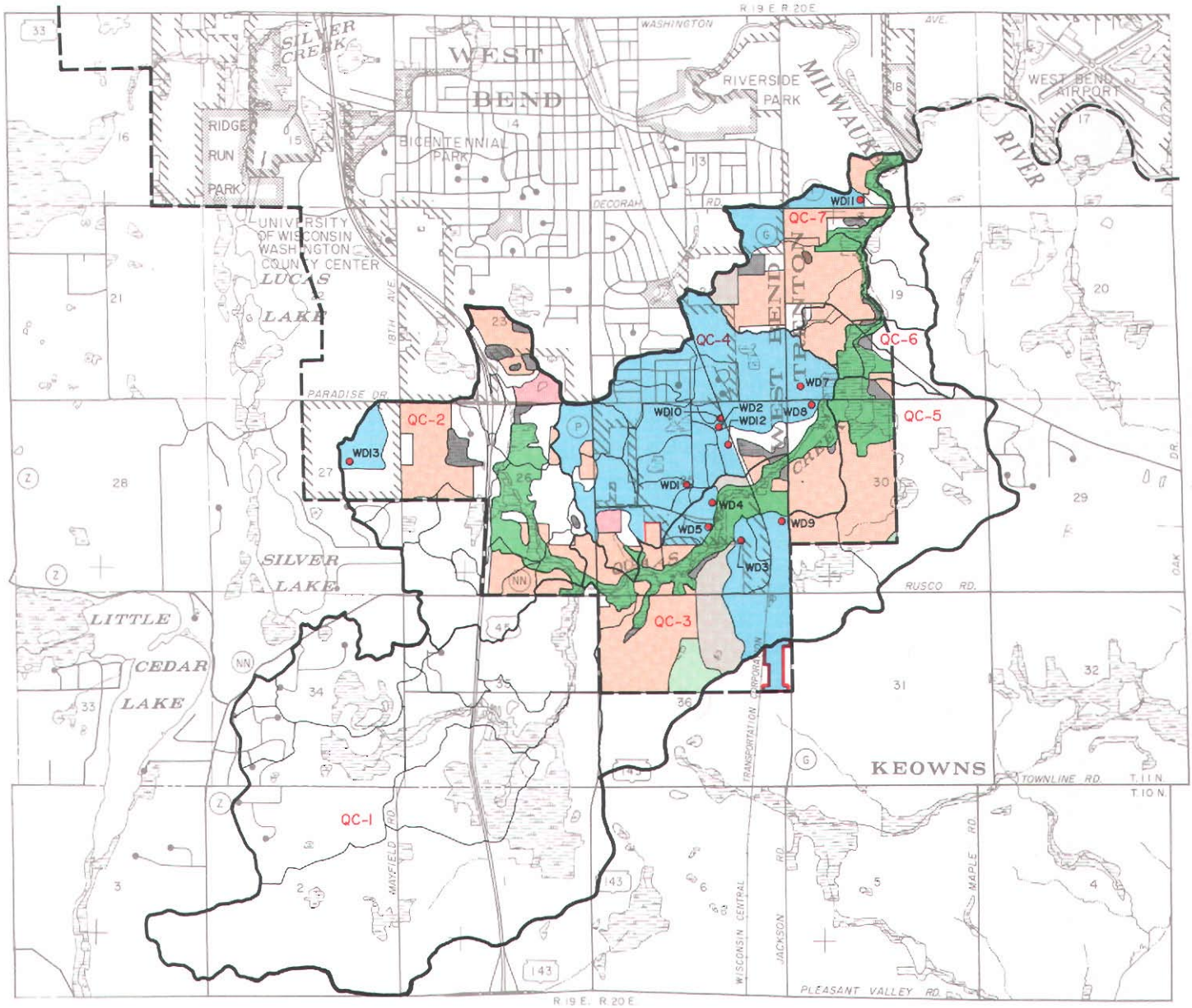
The recommended water quality management plan element for the Quaas Creek subwatershed is shown in graphic summary form on Map 3. The control measures selected include four new wet detention basins, six existing wet detention basins, and two wet detention basins to be constructed in existing dry basins to control runoff from a total of about 881 acres, or 36 percent of the planned urban area; the infiltration of runoff from parking lots serving commercial facilities with a total area of about 28 acres, or 1 percent of the planned urban area; the treatment of runoff from about 114 acres of land, or 5 percent of the planned urban area, through the sweeping of selected industrial parking and storage areas and adjacent streets; 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 1 through 6 and 9.

The recommended 12 wet detention basins would have permanent ponds ranging in surface area from 0.3 acre to 3.4 acres and permanent storage volumes ranging from 1.5 acre-feet to 9.5 acre-feet. The average depth of the permanent ponds for basins which are recommended to be constructed was assumed to be five feet. Six of the 12 recommended basins were constructed subsequent to the establishment of the 1985 baseline "existing" conditions used in the priority watershed study. Thus the nonpoint source pollution control benefits realized from those detention basins are included in the recommended stormwater management plan set forth here. Five of those basins are located in the West Bend Industrial Park-South, part of the joint Wisconsin Department of Natural Resources-City of West Bend nonpoint source control demonstration project, and one is located on the West Bend Mutual Insurance Company property. It is also recommended that dry detention basins "C" and "E" in the West Bend Industrial Park-South be converted to wet basins to improve the pollutant removal effectiveness of the control system in the industrial park under planned land use conditions. The remaining four wet detention basins would be constructed on current open-space sites as urban development proceeds.

On an annual basis, the recommended 12 wet detention basins may be expected to remove about 18 percent of the sediment, 10 percent of the phosphorus, 34 percent of the lead, 26 percent of the copper, 25 percent of the zinc, and 25 percent of the cadmium that may be expected to be contributed to the surface waters of the subwatershed under planned land use conditions in the absence of nonpoint source pollution abatement measures.

Map 3

RECOMMENDED WATER QUALITY MANAGEMENT PLAN ELEMENT FOR THE QUAAS CREEK SUBWATERSHED



LEGEND

- PLANNED URBAN SERVICE AREA BOUNDARY
- SUBWATERSHED BOUNDARY
- SUBWATERSHED BOUNDARY UNDER PLANNED DRAINAGE CONDITIONS
- SUBBASIN GROUP BOUNDARY
- SUBBASIN GROUP BOUNDARY UNDER PLANNED DRAINAGE CONDITIONS
- QC-7 SUBBASIN GROUP DESIGNATION
- SUBBASIN BOUNDARY
- WD12 PROPOSED WET DETENTION BASIN AND DESIGNATION
- AREA TRIBUTARY TO PROPOSED WET DETENTION BASIN
- PROPOSED INFILTRATION SYSTEMS TO RETAIN RUNOFF FROM 50 PERCENT OF COMMERCIAL PARKING LOTS
- AREA TRIBUTARY TO INDUSTRIAL PARKING LOT OR STORAGE AREA TO BE SWEPT WEEKLY IN SPRING, SUMMER, AND FALL
- AREA OF PLANNED MEDIUM DENSITY AND TWO-FAMILY RESIDENTIAL DEVELOPMENT TO BE SERVED BY STORM SEWERS AND WHERE LOW-COST RUNOFF INFILTRATION PRACTICES ARE TO BE ENCOURAGED
- PRIMARY ENVIRONMENTAL CORRIDOR
- SECONDARY ENVIRONMENTAL CORRIDOR
- ISOLATED NATURAL AREA AND OTHER OPEN LANDS TO BE PRESERVED

GRAPHIC SCALE

Source: SEWRPC.

Table 9

DESCRIPTION, POLLUTANT REMOVAL EFFECTIVENESS, AND COST OF THE WATER QUALITY MANAGEMENT PLAN ELEMENTS

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	Copper	Zinc	Cadmium		
QC-2	1. QCWD13, 3.37-acre, 2.3-acre-foot wet basin	1.2	0.9	1.5	0.8	1.3	<0.1	--	$ 1,800
	2. QCIF3, infiltrate runoff from 3.8 acres of commercial parking lots	0.2	0.1	0.6	0.4	0.5	0.5	$ 75,000	3,000
	Subtotal	1.4	1.0	2.1	1.2	1.8	0.5	$ 75,000	$ 4,800
QC-3	1. QCWD3, 1.46-acre, 3.5-acre-foot wet basin	1.6	0.7	2.9	2.3	2.2	2.4	--[b]	$ 2,100
	2. QCWD4, 0.30-acre, 0.6-acre-foot wet basin	0.6	0.3	1.2	1.0	0.9	1.0	--[b]	1,400
	3. QCWD5, 0.34-acre, 1.0-acre-foot wet basin	0.8	0.3	1.5	1.2	1.1	1.1	--[b]	1,500
	4. QCWD9, 1.90-acre, 9.5-acre-foot wet basin	4.0	1.8	7.2	5.8	5.5	5.6	$ 275,000	4,600
	5. SW1, sweep about 35 acres of industrial parking lots and storage areas	3.6	2.0	8.5	7.9	8.2	8.8	21,000	23,100
	Subtotal	10.6	5.1	21.3	18.2	17.9	18.9	$ 296,000	$32,700
QC-4	1. QCWD1, 0.73-acre, 2.0-acre-foot wet basin	2.1	0.9	3.8	3.0	2.9	3.1	--[b]	$ 1,700
	2. QCWD2 0.33-acre, 1.2-acre-foot wet basin	0.4	0.2	0.9	0.7	0.6	0.9	--[b]	1,500
	3. QCWD7, 1.93-acre, 9.6-acre-foot wet basin	2.0	1.4	3.5	2.7	2.6	2.4	$ 298,000	4,600
	4. QCWD8, 0.74-acre, 3.7-acre-foot wet basin	0.9	0.7	1.6	1.1	1.2	1.0	146,000	2,200
	5. QCWD10, 1.00-acre, 5.0-acre-foot wet basin[c]	2.5	1.4	5.7	4.1	3.8	5.1	161,000	2,900
	6. QCWD12, 0.47-acre, 2.4-acre-foot wet basin[c]	1.1	0.5	2.0	1.6	1.5	1.6	89,000	1,900
	7. QCIF1, infiltrate runoff from 1.9 acres of commercial parking lots	0.1	0.1	0.3	0.2	0.2	0.2	90,000	4,000
	Subtotal	9.1	5.2	17.8	13.4	12.8	14.3	$ 784,000	$18,800
QC-7	1. QCWD11, 0.76-acre, 3.8-acre-foot wet basin	1.3	1.0	2.3	1.4	1.8	1.1	$ 154,000	$ 2,200
	2. SW2, sweep about five acres of industrial parking lots and storage areas	0.5	0.3	1.2	1.1	1.2	1.3	3,000	3,400
	Subtotal	1.8	1.3	3.5	2.5	3.0	2.4	$ 157,000	$ 5,600
--	Total	22.9	12.6	44.7	35.3	35.5	36.1	$1,312,000	$61,900

[a] *Includes land acquisition and an additional 35 percent of the construction cost to account for engineering, administration, and contingencies. Based on 1995 Engineering News-Record Construction Cost Index of 5,970.*

[b] *Wet basins constructed in Industrial Park-South since the 1985 baseline date for which existing condition nonpoint source pollutant loadings were estimated. No capital cost assigned.*

[c] *Expansions of Industrial Park-South dry detention basins C and E, respectively, to include permanent ponds.*

Source: SEWRPC.

Infiltration systems, consisting 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 commercial parking areas in those areas shown on Map 3. It is estimated that the infiltration systems would control the runoff from about 5.7 acres of commercial parking lots. Runoff from some commercial areas was not recommended to be treated through infiltration because of the probable existence of relatively high groundwater tables in those areas.

On an annual basis, the recommended infiltration facilities may be expected to remove 0.3 percent of the sediment, 0.2 percent of the phosphorus, 0.9 percent of the lead, 0.6 percent of the copper, 0.7 percent of the zinc, and 0.7 percent of the cadmium which may be expected to be contributed to the surface waters of the subwatershed under planned land use conditions in the absence of nonpoint source pollution abatement measures.

A program of covering or berming of industrial material storage areas; intensive weekly street, parking lot, and storage area sweeping in industrial

areas; and catch basin cleaning in industrial areas is recommended in the locations shown on Map 3. The sweeping program should include a concerted effort in spring to reduce high surface loadings prior to the onset of heavy spring rainstorms.

Chapter NR 216 of the Wisconsin Administrative Code sets forth rules governing the stormwater discharge permitting program administered by the Wisconsin Department of Natural Resources. The permits are issued under the Wisconsin Pollutant Discharge Elimination System (WPDES) program. Stormwater discharge permits must be obtained by certain municipalities and industries and by owners of construction sites where five or more acres of land are disturbed. The City of West Bend is not currently required to obtain a citywide stormwater discharge permit.

Many industries are currently involved in the process of obtaining 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 which will 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, along with improved materials handling and storage practices, may be expected to remove 4 percent of the sediment, 2 percent of the phosphorus, 10 percent of the lead, 9 percent of the copper, 9 percent of the zinc, and 10 percent of the cadmium which may be expected to be contributed to the surface waters of the subwatershed under planned land use conditions in the absence of nonpoint source pollution abatement measures.

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 may be expected to achieve about a 75 percent reduction in the total uncontrolled pollutant loadings from the construction sites.

Implementation of the recommended urban nonpoint source pollution control measures may be expected to result in sediment loadings to Quaas Creek under planned land use conditions which are 34 percent lower than those under existing conditions, phosphorus loadings which are 23 percent lower than under existing conditions, lead loadings which are 20 percent higher than under existing conditions, copper loadings which are about 620 percent higher than under existing conditions, zinc loadings which are about 490 percent higher than under existing conditions, and cadmium loadings which are about 630 percent higher than under existing conditions.[6] In comparison to uncontrolled loadings under planned land use conditions, the recommended control measures would reduce sediment loadings by 23 percent, phosphorus loadings by 13 percent, lead loadings by 45 percent, copper loadings by 35 percent, zinc loadings by 36 percent, and cadmium loadings by 36 percent. The sediment and phosphorus loading reductions constitute a lower percentage reduction in the loadings under planned land use conditions in the absence of nonpoint source pollution abatement measures than of such loadings under existing land use conditions 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.

Role of Primary Environmental Corridors in Preserving Water Quality

As shown on Map 5 in Volume One of this report, all of Quaas Creek, the South Branch of Quaas Creek, and two small tributaries to the South Branch lie within a primary environmental corridor. Such corridors typically contain high-value woodlands, wetlands, wildlife habitat areas, floodlands, and groundwater recharge and discharge areas. The Commission recommends that primary environmental corridors be preserved and protected in their natural state. Thus, these corridors will provide

---

[6]*The projected increases in metals loadings would be reduced through both the recommended implementation of source controls and the recommended public education program. The degree of reduction achieved through those means is not readily quantifiable because it is dependent on the degree of implementation of voluntary measures.*

valuable riparian buffer areas along the entire stream network in the Quaas Creek subwatershed. In general, the preservation of the corridors will improve water quality and in-stream and riparian habitat by: helping to maintain stream base flows and cool water temperatures through infiltration of stormwater runoff and the preservation of areas of groundwater discharge; shading the streams with natural riparian vegetation, thus promoting cooler water temperatures and providing cover for fish; and providing floodwater storage capacity to reduce peak rates of runoff and limit the potential for streambank erosion.

Practices Which Promote Infiltration of Runoff in Areas of Medium-Density Residential Development

Under the recommended plan, most of the runoff which is not to be treated through the implementation of specific best management practices would come from areas of planned medium-density residential development. City policy calls for the use of curbs and gutters and storm sewers in such areas, eliminating the possibility of infiltrating stormwater runoff through the use of roadside swales. Infiltration of stormwater runoff should be promoted to the extent practicable in those areas through the use of appropriate relatively low-cost measures to infiltrate runoff prior to its conveyance to the storm sewer systems. As an example, roof drains should be directed away from building foundations to grassed areas to promote infiltration. Infiltration can also be promoted through the use of site development practices which limit disturbance of the existing topography and which minimize compaction of soil in areas where such compaction is not required for structural purposes. Also, if the storm sewer systems are designed to discharge along the perimeter of the primary environmental corridors, rather than directly to stream reaches, the ability of the corridors to promote infiltration of runoff may be enhanced. Therefore, the recommended stormwater drainage system, as set forth in Chapter IV of this volume, calls for storm sewers to terminate along the outer edges of the primary environmental corridor lands and for the discharge points to be designed to minimize erosion and to spread the flow to produce a diffuse sheet flow in the corridors.

Control of Streambank Erosion

An inventory of streambank erosion sites along the 4.5-mile-long reach of Quaas Creek downstream of CTH P was conducted in 1984 by the Wisconsin Department of Natural Resources under the priority watershed study. That inventory identified a total of 31 degraded streambank reaches with a total length of about 8,100 lineal feet. It was estimated by DNR staff that the total annual sediment production from those sites was about 96 tons per year. Approximately 10 percent of the total sediment yield was attributed to bank disturbance by cattle with access to the stream. The stream reach inventoried by the Department lies completely within the planned urban service area for the City. Thus, under planned land use conditions, it is anticipated that the existing agricultural uses in the primary environmental corridor along that reach of the stream will be discontinued, livestock access to the stream will be eliminated, and the vegetation in those portions of the corridor where there is an inadequate riparian buffer will revert to a more natural state.

The development of a more extensive streamside buffer consisting of natural vegetation and the discontinuation of livestock access to the stream are factors which, in the absence of additional destabilizing actions in the subwatershed, would act to reduce streambank erosion. However, the anticipated increase in urban land use under planned year 2010 conditions in the area tributary to the lower reach of Quaas Creek is a potentially destabilizing factor which could offset the stabilizing factors resulting from the discontinuation of agricultural land uses and could create the potential for additional streambank erosion and streambed scour. The potential impacts of increased urbanization could be mitigated through the provision of water quantity controls which reduce the peak rates of flow and also the durations of the peak, or near-peak, flows. Detention facilities would be effective in reducing peak rates of flow, while infiltration practices would be required to reduce durations of peak flows.

Control of the more-frequently occurring floods with recurrence intervals of two years or less is critical to reducing the potential for streambank erosion as urban development proceeds. Thus, the priority watershed study recommended that the peak mean annual flood flow under planned development conditions be maintained at, or below, the peak rate under existing conditions. A comparison of peak two-year recurrence interval flood flows under existing land use and drainage conditions and under planned land use and recommended drainage conditions is presented in Chapter IV of this volume. That comparison shows that the recommended objective may be expected to be essentially met for the downstream 4.5 miles, or 80 percent of the total length, of Quaas Creek.

Special Considerations Related to the Stream Reaches with a Cold-Water Fishery Water Use Objective

As noted above, the recommended water use objective for the stream reaches upstream of CTH G is for recreational use and maintenance of a cold-water fishery and aquatic life. The infiltration of runoff is important to meeting those objectives through the preservation of both stream base flow and cool water temperatures. The water quality management plan recommends measures, or encourages the utilization of practices, which promote infiltration of runoff in areas of residential and commercial land uses. Infiltration is generally not encouraged in industrial areas, where groundwater contamination could result. Such infiltration should be considered only in areas where it is absolutely essential to achieving surface water quality objectives and where site-specific information demonstrates that groundwater pollution will not result.

The amount of runoff which is infiltrated as urban development proceeds is related to the amount of pervious area remaining in the subwatershed under planned year 2010 land use conditions. An indicator of the relative amounts of pervious and impervious land is the relationship between rural and urban land uses, with rural land uses being generally less than 10 percent impervious, and urban land uses being from 20 to 85 percent impervious, depending on the type of land use. Under existing conditions, about 13 percent of the subwatershed was devoted to urban land uses. Under planned year 2010 conditions, about 45 percent of the subwatershed would be developed in urban uses. Under 1985 conditions, about 12 percent of the area of those subbasins tributary to the cold-water fishery reaches of the stream system was devoted to urban land uses. Under planned year 2010 conditions about 34 percent of the area of those subbasins would be devoted to urban land uses. The total amount of impervious land in the subbasins tributary to the downstream end of the cold-water fishery reach of Quaas Creek would be expected to increase from about 3 percent under 1985 land use conditions to about 15 percent under planned conditions. Because urbanization is proposed to occur in only the downstream portion of the cold-water stream reach, the percentage of impervious area would approximate 15 percent at the outlet of the cold-water reach and would be less for the two-mile-long reach extending upstream of the outlet to the confluence of Quaas Creek and the South Branch of Quaas Creek east of CTH P.

Under planned land use conditions, the imperviousness of the area tributary to the downstream portion of the cold-water stream reach would be limited and thus consistent with the need to preserve the cold-water temperature characteristics of the stream. Therefore, the City's local land use plan should be carefully followed to avoid additional development in the upper reaches of the watershed, which could adversely impact stream temperatures in that reach.

The area tributary to the upper 1.0-mile-long reach of Quaas Creek, extending from the confluence with the South Branch upstream to Paradise Drive, would have an overall imperviousness of about 24 percent under planned land use conditions. Therefore, it is especially important to implement the recommendation calling for the provision of low-cost measures to promote the infiltration of precipitation in areas of planned medium-density residential development tributary to the cold-water fishery reaches of Quaas Creek. Such infiltration would assist in the maintenance of a cool base flow in the stream and could at least partially offset the adverse thermal affects due to the amount of impervious surface in the tributary area. For the cold-water stream reach as a whole, the impact of impervious surfaces on base flow and stream water temperature is further mitigated through the recommendations to provide infiltration of commercial parking lot runoff in those areas shown on Map 3 and to preserve primary environmental corridors.

Recommended Public Education Program

In addition to 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. Because of the anticipated increases in metals loadings to the streams, it is essential that controls on the sources of those metals be stressed. Table 10 lists potential sources of metals as well as other toxic substances found in urban runoff.

Urban housekeeping practices and source controls include restricted use of fertilizers and pesticides, improved pet-waste and litter control, the reduced use of galvanized metal 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

Table 10

POTENTIAL SOURCES OF SELECTED TOXIC SUBSTANCE FOUND IN URBAN RUNOFF

Toxic Substances	Automotive Use	Pesticide Use	Industrial Use
Melogenated Aliphatics			
Methylene chloride	--	Fumigant	Plastics, paint remover, solvents
Methyl chloride	--	Fumigant	Refrigerant, solvent
Phthalate Esters			
Bis(2-ethyhexyl) phthalate	--	--	Plasticizer
Butylbenzyl phthalate	--	--	Plasticizer, printing inks, paper, stain, adhesive
Di-N-butyl phthalate	--	Insecticide	--
Polycyclic Aromatic Hydrocarbons			
Chrysene	Gasoline, oil/grease	--	Solvent
Phenanthrene	Gasoline	--	Wood and coal combustion
Pyrene	Gasoline, soil, asphalt	Wood preservative	Wood and coal combustion
Other Volatile Compounds			
Benzene	Gasoline	--	Solvent
Chloroform	Formed from salt, gasoline, asphalt	Insecticide	Solvent, chlorination
Toluene	Gasoline, asphalt	--	Solvent
Metals			
Chromium	Metal corrosion, road salt	--	Paint, metal corrosion, electroplating
Copper	Metal corrosion, brakes	Algicide	Paint, metal corrosion, electroplating
Lead	Batteries	--	Paint
Zinc	Metal corrosion, road salt, rubber	Wood preservative	Paint, metal corrosion
Cadmium	Tires	--	Paint
Pesticide and Phenols			
γ-Hexachlorocyclohexane (Lindane)	--	Mosquito control, seed pretreatment	--
Chlordane	--	Termite control	--
Dieldrin	--	Insecticide	Wood processing
α-Endosulfan	--	Insecticide	--
α-Hexachlorocyclohexane	--	Insecticide	--
Pentachlorophenol	--	Wood preservative	Paint
Polychlorinated biphenyls	--	--	Electrical, insulation, paper adhesives, hydraulic equipment

Source: Wisconsin Department of Natural Resources, and SEWRPC.

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 spill-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.

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 Quaas Creek under planned land use conditions by from 13 percent to 45 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 both the adopted regional water quality management plan and under the priority watershed plan in Table 11. The nonpoint source control measures recommended in this stormwater management plan may be expected to provide levels of pollutant removal substantially in conformance with those recommended in the adopted regional water quality management plan. As already noted, that plan recommended that a 25 percent reduction in nonpoint source pollutant loadings plus construction erosion control, streambank stabilization, and onsite septic system management would be adequate to achieve the established water use objectives and standards.

If fully implemented, the recommended plan measures may be expected to reduce sediment loadings

Table 11

REDUCTION IN NONPOINT SOURCE POLLUTANT LOADINGS

Pollutant	Reductions in Nonpoint Source Pollutant Loadings under Planned Land Use Conditions[a]		
	Regional Water Quality Management Plan (percent)	Priority Watershed Plan Enhancement Goal (percent)	Final Recommended Plan (percent)
Sediment	25	40[b]	23[c]
Phosphorus	25	15[b]	13c
Lead	--[b]	55	45
Copper	--[d]	--[e]	35
Zinc	--[d]	--[e]	36
Cadmium	--[d]	--[e]	36

[a]*The percent reductions listed here are referenced to planned condition loadings in the absence of nonpoint source pollution abatement measures.*

[b]*Under planned land use conditions, the priority watershed study surface water enhancement goal called for loadings of sediment and phosphorus to be reduced to 50 percent and 25 percent, respectively, of the loadings under existing land use conditions. The reduction percentages for sediment and phosphorus are less than 50 percent and 25 percent, respectively, because the conversion of land from agricultural uses under existing conditions to urban uses under planned conditions results in some reduction in loadings of those pollutants even without controls.*

[c]*Levels of control within the subwatershed would equal 25 percent if reductions of about 4 and 23 percent in the rural contributions of sediment and phosphorus, respectively, were achieved.*

[d]*No specific analyses were conducted to establish a level of reduction for metals in the regional water quality management plan.*

[e]*No specific levels of reduction for copper, zinc, and cadmium were established in the priority watershed plan.*

Source: SEWRPC.

by about 23 percent, phosphorus loadings by about 13 percent, and metals loadings by between 35 and 45 percent. Under planned year 2010 conditions, about 54 percent of the subwatershed is anticipated to continue to be in rural land uses, which contribute significant amounts of sediment and phosphorus under existing land management practices. The recommendation of the regional water quality management plan for a 25 percent reduction in both sediment and phosphorus could be achieved through the implementation of additional rural nonpoint source pollution controls along with the recommended urban controls. That plan recommends the implementation of rural land management practices to achieve a 25 percent reduction in nonpoint source pollutant loads delivered to Quaas Creek and its tributaries. Also, the soil erosion control plan prepared by the Regional Planning Commission for Washington County identifies priority areas for cropland soil erosion control and recommends farm management practices intended to reduce cropland soil erosion.[7] Reductions of 4 and 23 percent in the rural contributions of sediment and phosphorus, respectively, along with the recommended level of control of sediment and phosphorus from urban sources as called for here, would result in the achievement of the 25 percent reduction in the loads of each of those pollutants delivered to Quaas Creek and its tributaries, as recommended under the regional water quality management plan. Such reductions in rural contributions should be readily achieved if locally prepared farm plans are prepared as envisioned in the regional water quality management plan, the priority watershed plan, and the County soil erosion control plan. Thus,

[7]*See SEWRPC Community Assistance Planning Report No. 170, Washington County Agricultural Soil Erosion Control Plan, March 1989.*

the combination of the urban controls recommended herein and the rural controls recommended under the regional water quality management plan would meet or exceed the recommended reduction in sediment and phosphorus loads from the Quaas Creek subwatershed called for in the regional water quality management plan.

Implementation of the recommended urban nonpoint source pollution control measures would result in sediment loadings to Quaas Creek under planned conditions which are 34 percent lower than those under existing conditions, phosphorus loadings which are 23 percent lower than under existing conditions, lead loadings which are 20 percent higher than under existing conditions, copper loadings which are about 620 percent higher than under existing conditions, zinc loadings which are about 490 percent higher than under existing conditions, and cadmium loadings which are about 630 percent higher than under existing conditions.

Thus, the goal established in the priority watershed study of achieving a 25 percent reduction in phosphorus would essentially be met, the goal of achieving a 50 percent reduction in sediment would not be achieved through urban controls alone, and the goal of achieving no increase in lead would not be met. The priority watershed study targets the rural areas of the subwatershed for the implementation of substantial nonpoint source pollution controls. With the addition of controls resulting in a 33 percent reduction in sediment loads from rural sources and from streambank erosion, the recommended 50 percent reduction in sediment could be achieved.

The priority watershed study did not establish reduction goals for copper, zinc, and cadmium, although it has generally been assumed that lead could serve as a surrogate for all heavy metals found in urban runoff. Because of the inherent difficulty in reducing loadings of heavy metals and other predominantly urban pollutants when an area experiences significant new urban development, it is suggested that the only practical way to achieve significant additional reductions in those pollutants beyond those attained with the recommended urban best management practices is through the application of source controls, as indicated above.

Considering the constraints on locating wet detention basins in areas tributary to cold-water fishery reaches, City constraints which limit the use of roadside swales to areas of lower-density residential development and certain industrial areas and potential high groundwater levels limiting the use of stormwater infiltration in some commercial areas, the pollutant loading reductions achieved by the plan are the largest which may be expected to be practically attainable through the implementation of best management practices to control runoff from planned urban lands. The anticipated urban loading reductions following complete implementation of the recommended plan, along with rural loading reductions, may be expected to improve the overall water quality conditions of Quaas Creek and its tributaries. Thus, the nonpoint source pollution control measures called for under the recommended plan are considered to be consistent with the regional water quality management plan. In addition, the recommendations are considered to be substantial conformance with the goals of the priority watershed plan.

COSTS OF RECOMMENDED PLAN NONPOINT SOURCE POLLUTION CONTROL FACILITIES

As set forth in Table 9, the total capital cost of the recommended water quality management plan for the Quaas Creek subwatershed is approximately $1,312,000, consisting of $1,123,000 for wet detention basins; $165,000 for infiltration facilities; and $24,000 for increased street, parking lot, and storage area sweeping. The annual operation and maintenance cost attendant to this plan is estimated at $61,900, consisting of $28,400 for wet detention basins; $7,000 for infiltration facilities; and $26,500 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 V 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.[8]

---

[8]*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 are eligible for State cost-sharing funds up to that end date. At the time of publication of this report, extension of the end date to December 31, 1999, was being considered.*

REVIEW OF SHORELAND ZONING ISSUES RELATED TO RECOMMENDED WET DETENTION BASIN SITES

According to Section 59.971(7) of the Wisconsin Statutes, county shoreland zoning regulations remain in effect in areas which are annexed by a city or village after May 7, 1982, unless the requirements of the ordinance of the annexing city or village are at least as stringent as those of the county ordinance. 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 a boundary located 1,000 feet from the ordinary high-water mark of the lake, pond, or flowage or 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 after May 7, 1982. City staff indicated further that they would not pursue construction of wet detention basins which would have a shoreland zone requiring enforcement of the Washington County shoreland zoning regulations.

Five of the 12 recommended wet detention basins, designated QCWD 1 through 5, have already been constructed in the West Bend Industrial Park-South on land annexed prior to May 7, 1982. Wet basin QCWD10 is recommended as a modification to existing dry detention basin "C," which is also located in the Industrial Park-South on land annexed prior to May 7, 1982. Thus, County shoreland zoning regulations do not apply to the lands in the City adjacent to those six basins.

Five of the recommended wet basins, QCWD7 through 9, 11, and 12, are located on lands which are either currently outside the corporate limits of the City or were annexed after May 7, 1982. Those five basins were evaluated to determine whether they would be classified as public or private ponds. If classified as private ponds, there would be no shoreland zone associated with the ponds.

There are two ways by which the ponds could be classified as public: 1) if the pond is connected to a navigable water body by means of an open channel with defined bed and banks and which enters the navigable water body below the ordinary high-water mark of the navigable waterway or 2) if the pond is classified as public as a condition of a permit granted under Chapter 30 of the Wisconsin Statutes, which regulates activities related to navigable waters.

If a proposed pond requires a permit under Chapter 30 of the Statutes and does not meet the legal requirements for mandatory classification as a public water body, the Wisconsin Department of Natural Resources has discretionary power to designate the pond as either public or private. In a March 8, 1994, letter to the City Director of Community Development and to the Commission staff, the Water Regulation and Zoning staff of the Department stated that "the purpose of a wet detention basin is to improve downstream water quality . . . . While these ponds may provide some incidental wildlife habitat, they are not intended to create 'waterfront property' or to provide the public interest elements that Chapter 30 is intended to protect. As a consequence, wet detention basins that are not connected to navigable water (through an open channel which enters a navigable stream below the ordinary high-water mark of that stream) . . . are generally considered private."

On the basis of application of the criteria set forth above and the foregoing statement from the DNR staff, it may be concluded that wet basins QCWD7 through 9, 11, and 12, which are recommended to be constructed on land currently outside the City limits, 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.

Wet basin QCWD13 was constructed on land annexed in 1985. Because the basin has already been constructed, the issue of whether the permanent pond of the basin is classified as public or private is moot from the standpoint of implementation of the recommended plan. However, application of the criteria listed above indicates that the basin should be classified as private and would, thus, have no associated shoreland zone.

SUMMARY

The recommended water quality management plan element for the Quaas Creek subwatershed, which is shown in graphic summary form on Map 3, calls for 12 wet detention basins, which would control runoff from about 881 acres, or 36 percent of the planned urban area; the infiltration of runoff from parking lots serving commercial facilities with a total area of about 28 acres, or 1 percent of the

planned urban area; the treatment of runoff from about 114 acres of land, or 5 percent of the planned urban area, through the sweeping of selected industrial parking and storage areas and adjacent streets; the provision of low-cost measures to promote the infiltration of precipitation in areas of planned medium-density residential development which are tributary to the cold-water fishery reaches of Quaas Creek; preservation of the riparian buffer for natural infiltration and storage of runoff within the primary environmental corridor; and continued enforcement of the City of West Bend construction erosion control ordinance. Five of the 12 recommended wet detention basins have already been constructed in the West Bend Industrial Park-South. An additional recommended wet basin has been constructed on the West Bend Mutual Insurance Company property. It is also recommended that dry detention basins "C" and "E" in the West Bend Industrial Park-South be converted to wet basins to provide increased removal of nonpoint source pollutants contributed by lands in the industrial park and lands tributary to the industrial park. The remaining four wet detention basins would be constructed on current open-space sites as urban development proceeds. The estimated pollutant removal effectiveness and costs of the recommended measures are summarized in Tables 1 through 6 and 9.

In comparison to uncontrolled loadings under planned land use conditions, implementation of the recommended urban nonpoint source pollution control measures would reduce sediment loadings to Quaas Creek by 23 percent, phosphorus loadings by 13 percent, lead loadings by 45 percent, copper loadings by 35 percent, and both zinc and cadmium loadings by 36 percent. The recommended plan levels of control of nonpoint source pollutants, when coupled with control of nonpoint source pollution from rural lands in the subwatershed recommended under the regional water quality management plan, should meet or exceed the 25 percent reduction in nonpoint source pollution loadings from the subwatershed recommended in the regional water quality management plan.

Implementation of the recommended urban control measures would result in sediment loadings under planned land use conditions which are 34 percent lower than those under existing conditions, phosphorus loadings which are 23 percent lower than under existing conditions, lead loadings which are 20 percent higher than under existing conditions, copper loadings which are about 620 percent higher than under existing conditions, zinc loadings which are about 490 percent higher than under existing conditions, and cadmium loadings which are about 630 percent higher than under existing conditions. Thus, the 25 percent reduction goal for phosphorus, in order to meet the water resources objectives for Quaas Creek as established in the priority watershed study, would essentially be achieved. The goal of achieving a 50 percent reduction in sediment would not be achieved through urban controls alone, but it could be met with the addition of rural controls. The goal of achieving no increase in metals would not be met. The priority watershed study did not establish reduction goals for copper, zinc, and cadmium, although it has generally been assumed that lead could serve as a surrogate for all heavy metals found in urban runoff. Because of the inherent difficulty in reducing loadings of heavy metals and other predominantly urban pollutants in areas experiencing significant new urban development, the only practical way to achieve significant additional reductions in those pollutants beyond those attained with the recommended best management practices is through the application of source controls. The nonpoint source pollution control measures called for under the recommended plan are considered to be consistent 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 Quaas Creek subwatershed is approximately $1,312,000, consisting of $1,123,000 for wet detention basins; $165,000 for infiltration facilities; and $24,000 for increased street, parking lot, and storage area sweeping. The attendant annual operation and maintenance cost is estimated at $61,900, consisting of $28,400 for wet detention basins; $7,000 for infiltration facilities; and $26,500 for increased street, parking lot, and storage area sweeping.

Chapter III

ALTERNATIVE STORMWATER DRAINAGE PLANS

INTRODUCTION

This chapter presents the findings and the preliminary recommendations of the stormwater drainage planning program for the City of West Bend as it relates to the Quaas Creek subwatershed. This chapter is divided into eight sections, one for each hydrologic unit to be studied. The hydrologic unit boundaries are shown on Map 1. Each section of this chapter includes: 1) an inventory and evaluation of the existing stormwater management system serving the hydrologic unit, 2) a description and evaluation of alternative stormwater drainage plans to serve the hydrologic unit through the design year 2010, and 3) a preliminary recommended stormwater management system plan for the hydrologic unit.

The general stormwater drainage alternatives which were considered for hydrologic units in the Quaas Creek study area are: 1) storm sewer conveyance, 2) storm sewer conveyance with centralized detention, 3) storm sewer and open channel-roadside swale conveyance, 4) storm sewer and open channel-roadside swale conveyance with centralized detention, and 5) storm sewer and open channel-roadside swale conveyance with expanded centralized detention. Roadside swale and open channel drainage facilities were generally utilized in areas of low-density residential and industrial park development or in areas where there is drainage provided by an existing stream system which can be utilized to provide conveyance or storage of stormwater runoff.

STORMWATER DRAINAGE SYSTEM COSTS

The costs of the alternative plans presented in the following sections of this chapter are based upon planned development of each hydrologic unit. The costs do not include minimum-diameter collector sewers, roadside swale collectors, and roadway 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 $8,300 per acre of area served.

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

The costs presented below reflect only the stormwater drainage plan element and do not include costs for nonpoint source pollution abatement measures. Costs for the entire stormwater management system plan, including those for nonpoint source pollution abatement measures, are presented in Chapter IV of this volume, which describes the overall recommended stormwater management plan, including both the stormwater drainage and water quality management elements.

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

A comparison of the total capital, annual operation and maintenance, and present value costs of the alternative plans developed for each hydrologic unit is set forth in Table 12. The individual hydrologic units are generally hydrologically and hydraulically independent of each other; therefore, the analysis of alternatives and selection of the preliminary recommended plan can be made separately for each unit. The following sections of this report describe the components of the alternative and preliminary recommended plans for each hydrologic unit. Separate detailed component and cost tables are presented for each alternative developed for each hydrologic unit.

Hydrologic Unit QC-A

Evaluation of the Stormwater Management System: Hydrologic Unit QC-A is a 3.28-square-mile area located in the extreme southwestern portion of the Quaas Creek subwatershed, as shown on Map 1 in Chapter I of this volume. Under planned year 2010 conditions, the hydrologic unit would be about 11 percent developed in urban uses and would be entirely outside of the City of West Bend planned urban service area. The hydrologic unit includes the South Branch of Quaas Creek, which originates from Quaas Lake in subbasin QC11 and flows in a generally easterly direction, then in a northerly

Table 12

COSTS OF THE ALTERNATIVE STORMWATER MANAGEMENT PLANS FOR THE QUAAS CREEK SUBWATERSHED WITHIN THE CITY OF WEST BEND STUDY AREA

Hydrologic Unit Designation	Alternative One Storm Sewer Conveyance			Alternative Two Storm Sewer Conveyance with Centralized Detention			Alternative Three Storm Sewer and Open Channel-Roadside Swale Conveyance		
	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]
QC-B	$ 721,000	$1,490	$ 744,000	$ 759,000	$6,010	$ 854,000	--	--	--
QC-C	--	--	--	--	--	--	--	--	--
QC-D, QC-E	--	--	--	--	--	--	--	--	--
QC-F	--	--	--	--	--	--	--	--	--
QC-G	--	--	--	--	--	--	$819,000	$1,160	$837,000
QC-I	865,000	2,260	901,000	863,000	3,940	925,000	--	--	--
Total	$1,586,000	$3,750	$1,645,000	$1,622,000	$9,950	$1,779,000	$819,000	$1,160	$837,000

Hydrologic Unit Designation	Alternative Four Storm Sewer and Open Channel-Roadside Swale Conveyance with Centralized Detention			Alternative Five Storm Sewer and Open Channel-Roadside Swale Conveyance with Expanded Centralized Detention		
	Capital[a]	Annual Operation and Maintenance	Present Value[b]	Capital[a]	Annual Operation and Maintenance	Present Value[b]
QC-B	--	--	--	--	--	--
QC-C	$ 536,000	$2,000	$ 568,000	--	--	--
QC-D, QC-E	877,000	4,020	940,000	--	--	--
QC-F	145,000	160	148,000	$52,000	$2,410	$90,000
QC-G	761,000	2,780	805,000	--	--	--
QC-I	--	--	--	--	--	--
Total	$2,319,000	$8,960	$2,461,000	$52,000	$2,410	$90,000

[a]Includes 35 percent for engineering, administration, and contingencies.Costs are for year 1995 with Engineering News-Record Construction Cost Index = 5,970.

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

Source: SEWRPC.

direction, and discharges to Quaas Creek a short distance downstream of CTH NN (Rusco Road).

Plan Recommendations: Because the hydrologic unit is entirely outside the planned urban service area, minimal urban development may be expected under planned year 2010 conditions. Thus, no new stormwater management measures are recommended for this hydrologic unit.

Hydrologic Unit QC-B

Evaluation of the Stormwater Management System: Hydrologic Unit QC-B is a 1.32-square-mile area located in the northwest portion of the Quaas Creek subwatershed, as shown on Map 1 in Chapter I of this volume. Under 1985 land use conditions, about 11 percent of the hydrologic unit was developed in urban land uses. Under planned year 2010 conditions, about 54 percent of the hydrologic unit would

be developed in urban land uses, and would consist primarily of medium-density residential and commercial uses. The existing stormwater drainage pattern generally consists of overland flow directly to Quaas Creek. Quaas Creek flows in a southerly direction, then in a southeasterly direction to the CTH P (Main Street) bridge at the outlet of the hydrologic unit. The existing stormwater management system also includes a detention basin located on the West Bend Mutual Insurance Company property, as well as roadway curbs and gutters, storm sewer inlets, and storm sewers in Paradise Drive east of USH 45.

Because of 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: Planned urban development in this hydrologic unit would be concentrated in the northern part in subbasins QC177I and QC14 and in the western part in subbasins QC7 and QC7C.

Under planned development conditions, the internally drained subbasin QC177I, which is expected to be fully developed, could be adequately drained to a depression located in the southern part of the subbasin. The depression, which would be preserved as wetlands and open lands, has adequate volume to completely store, with no outflow, the runoff from a 100-year recurrence interval storm event with a duration of 10 days. In order to provide two feet of freeboard between the 100-year recurrence interval ponding elevation during a 10-day storm and buildings, it is recommended that no development be permitted in the subbasin below elevation 996.3 feet above National Geodetic Vertical Datum, 1929 adjustment (NGVD). That elevation limit on development would also be expected to provide sufficient protection during successive, more frequent storms when the runoff accumulated in the depression may not completely infiltrate or evaporate between storms.

The proposed commercial development in subbasin QC14 north of Paradise Drive would be adequately drained by overland flow to Paradise Drive. Runoff from storm events with recurrence intervals up to, and including, 10-years, would be conveyed in the existing storm sewers under Paradise Drive and discharge into the headwaters of Quaas Creek.

The following two alternative stormwater management plans were developed for the remaining areas of the hydrologic unit where additional urban development is expected under planned land use conditions : 1) a storm sewer conveyance plan and 2) a storm sewer conveyance with centralized detention plan.

Alternative Plan No. B-1, Storm Sewer Conveyance: The storm sewer conveyance alternative plan would convey runoff through the provision of 4,272 lineal feet of new storm sewer, ranging in size from 12-inch-diameter reinforced concrete pipe (RCP) to 60-inch-wide by 38-inch-high horizontal elliptical (HE) RCP. The proposed storm sewers in subbasin QC7C would discharge into a wetland, where flows would be concentrated in an existing stream and conveyed under USH 45 through an existing 66-inch-diameter RCP culvert discharging to Quaas Creek. This alternative also calls for the replacement of the 30-inch-diameter corrugated metal pipe (CMP) culvert under CTH NN with a 24-inch-diameter RCP. Alternative Plan No. B-1 assumes utilization of the existing detention basin located in the southwest area of the West Bend Mutual Insurance Company property. The outlet of this basin consists of overland flow to the south into a site that is proposed to be developed as commercial offices. In order to ensure proper drainage of the detention basin, this alternative plan calls for maintaining an overland flow path from the outlet of the basin on the West Bend Mutual Insurance Company Site to the proposed storm sewer inlet at 18th Avenue.

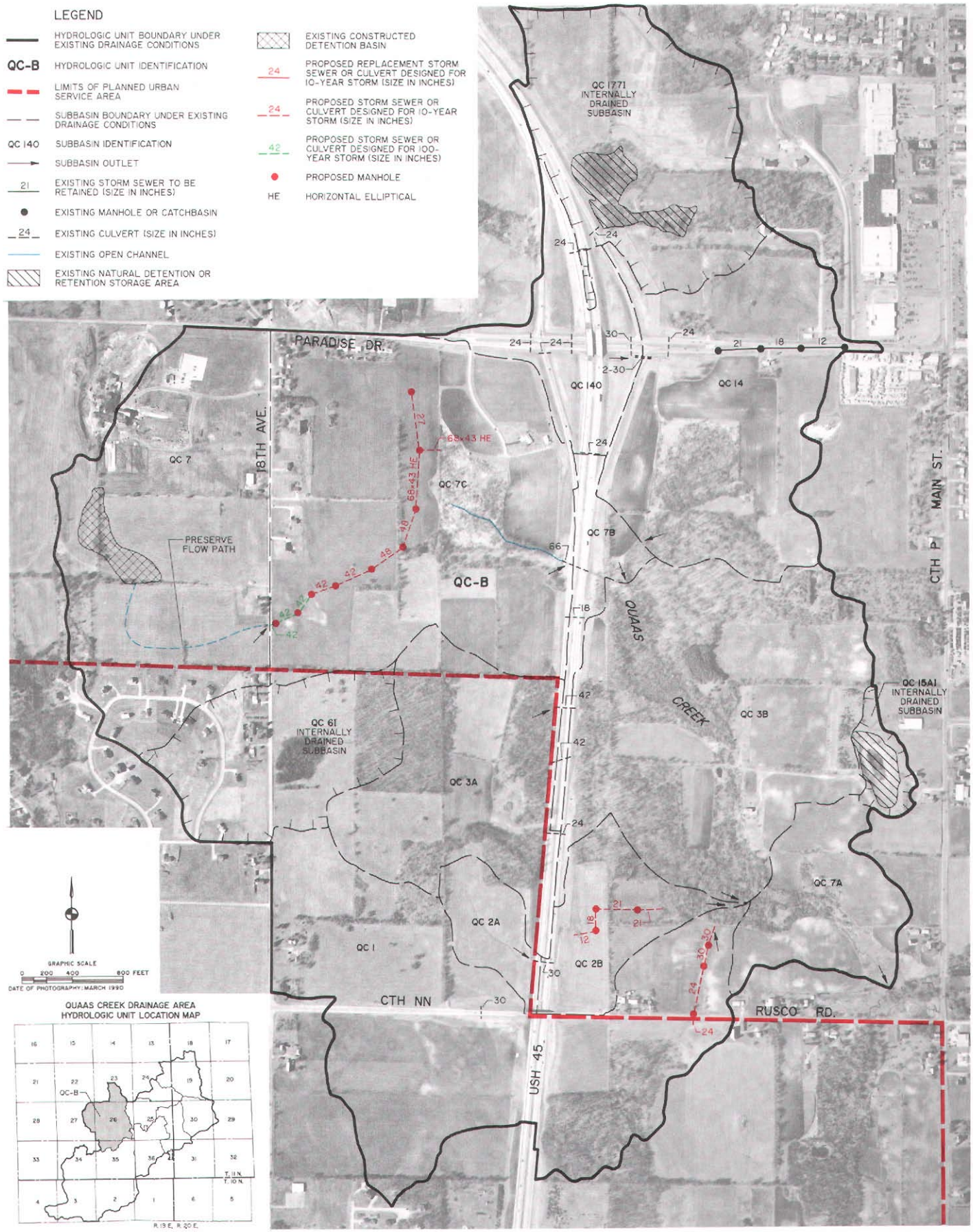
Map 4 shows the approximate location and alignment of the stormwater drainage facilities proposed under this alternative. Table 13 presents the salient characteristics and estimated costs of the proposed storm sewers comprising this alternative plan. The total present-value cost of this alternative plan is $744,000, consisting of an estimated capital cost of about $721,000 and an estimated annual operation and maintenance cost increase of about $1,490.

Alternative Plan No. B-2, Storm Sewer Conveyance with Centralized Detention: This alternative enables the downsizing of 2,230 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. This alternative calls for 4,272 lineal feet of new 15-inch to 30-inch-diameter reinforced concrete storm sewer. The proposed dry detention basin, which

Map 4

STORM SEWER CONVEYANCE ALTERNATIVE PLAN FOR STORMWATER MANAGEMENT IN THE QUAAS CREEK SUBWATERSHED

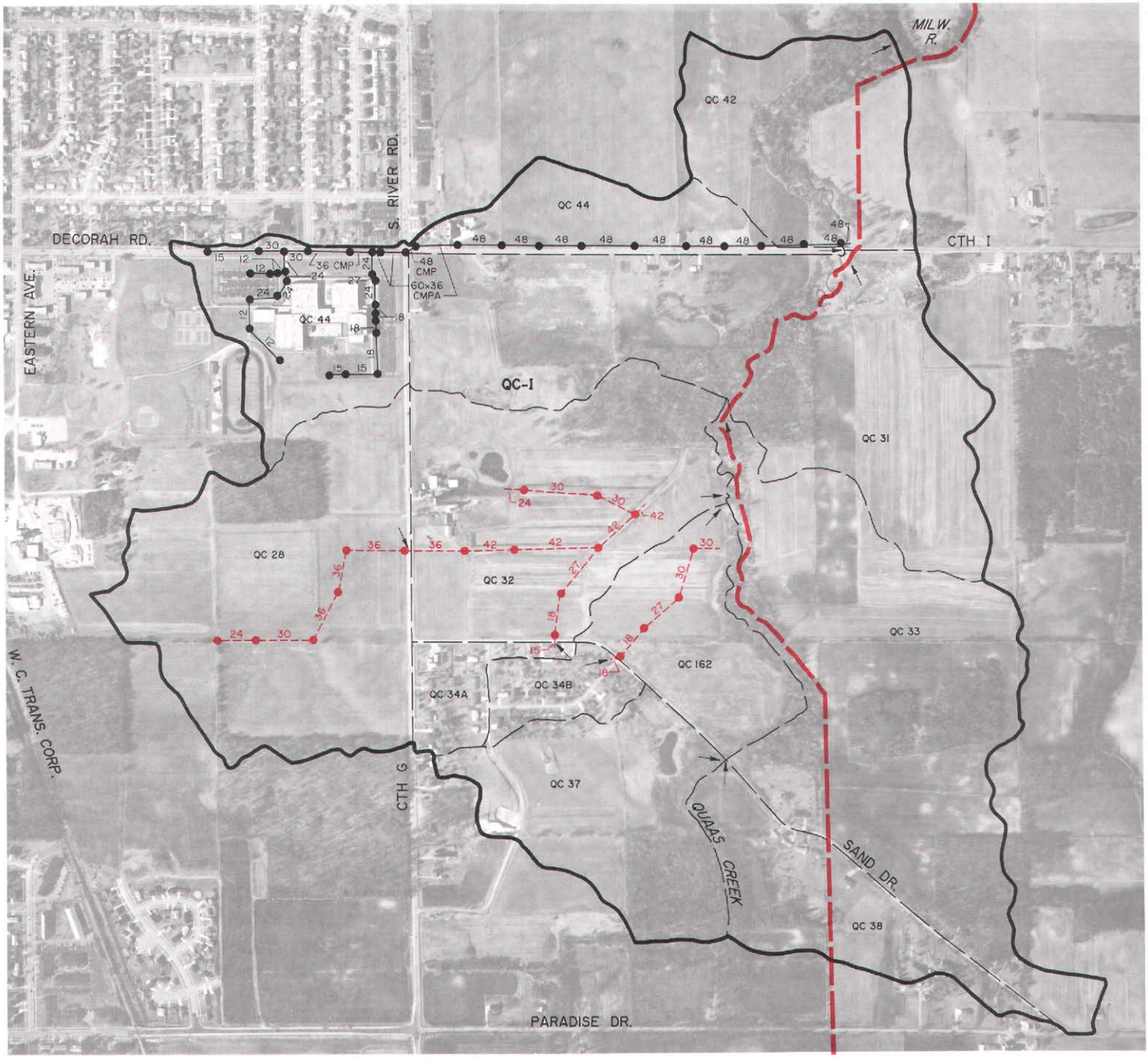
HYDROLOGIC UNIT QC-B



Map 4 (continued)

STORM SEWER CONVEYANCE ALTERNATIVE PLAN FOR STORMWATER MANAGEMENT IN THE QUAAS CREEK SUBWATERSHED

HYDROLOGIC UNIT QC-I

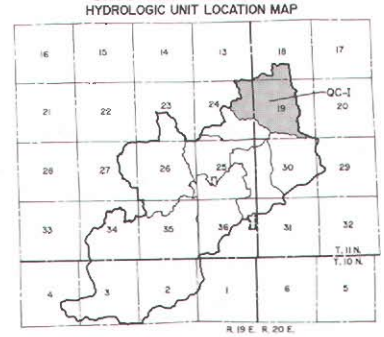


LEGEND

- HYDROLOGIC UNIT BOUNDARY UNDER EXISTING DRAINAGE CONDITIONS
- QC-I HYDROLOGIC UNIT IDENTIFICATION
- LIMITS OF PLANNED URBAN SERVICE AREA
- SUBBASIN BOUNDARY UNDER EXISTING DRAINAGE CONDITIONS
- QC 37 SUBBASIN IDENTIFICATION
- SUBBASIN OUTLET
- 12 EXISTING STORM SEWER TO BE RETAINED (SIZE IN INCHES)
- EXISTING MANHOLE OR CATCHBASIN
- 15 PROPOSED REPLACEMENT STORM SEWER OR CULVERT DESIGNED FOR 10-YEAR STORM (SIZE IN INCHES)
- 36 PROPOSED STORM SEWER OR CULVERT DESIGNED FOR 10 YEAR STORM (SIZE IN INCHES)
- PROPOSED MANHOLE
- CMP CORRUGATED METAL PIPE
- CMPA CORRUGATED METAL PIPE ARCH
- NOTE: PIPES ARE CONSTRUCTED OF REINFORCED CONCRETE UNLESS DESIGNATED AS ABOVE.

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

QUAAS CREEK DRAINAGE AREA
HYDROLOGIC UNIT LOCATION MAP



Source: SEWRPC.

Table 13

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

Hydrologic Unit	Project and Component Description[a]	Estimated Cost	
		Capital[b]	Annual Operation and Maintenance
QC-B	1. Install 170 feet of new 12-inch-diameter storm sewer ...	$ 9,000	$ 80
	2. Install 170 feet of new 18-inch-diameter storm sewer ...	13,000	80
	3. Install 505 feet of new 21-inch-diameter storm sewer ...	43,000	240
	4. Install 402 feet of new 24-inch-diameter storm sewer ...	40,000	190
	5. Install 460 feet of new 27-inch-diameter storm sewer ...	51,000	220
	6. Install 335 feet of new 30-inch-diameter storm sewer ...	42,000	160
	7. Install 985 feet of new 42-inch-diameter storm sewer ...	184,000	230
	8. Install 630 feet of new 48-inch-diameter storm sewer ...	145,000	140
	9. Install 615 feet of new 68-inch-wide by 43-inch-high HE storm sewer	189,000	140
	10. Replace 30-inch-diameter CMP under CTH NN with 24-inch-diameter storm sewer	5,000	10
	Total	$721,000	$1,490

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

[b] *Includes 35 percent for engineering, administration, and contingencies. Costs are for year 1995 with Engineering News-Record CCI = 5,970.*

Source: SEWRPC.

would collect flows from the existing detention basin on the West Bend Mutual Insurance Company site and from the adjoining lands to the south, would be constructed in an existing depression just west of 18th Avenue. Map 5 shows the approximate location, alignment, and configuration of the facilities called for under this alternative. Table 14 presents the salient characteristics and estimated costs of the proposed storm sewers and the 11-acre-foot detention basin which comprise this alternative plan. The total present-value cost of this alternative plan is $854,000, consisting of an estimated capital cost of about $759,000, including land acquisition for the detention basin, and an estimated annual operation and maintenance cost increase of about $6,010.

Evaluation of Alternative Stormwater Drainage Plans: The foregoing information provides a basis for a comparative evaluation of the two alternative stormwater drainage plans. The principal criteria for the comparative evaluation were cost and implementability.

Alternative Plan No. B-1 is less costly than Alternative Plan No. B-2 and could be readily implemented since it would not require purchasing land or easements for the provision of the detention basin.

Preliminary Recommended Stormwater Drainage Plan: Because of the lower cost of Alternative Plan No. B-1, Storm Sewer Conveyance, it was selected as the preliminary recommended plan for Hydrologic Unit QC-B.

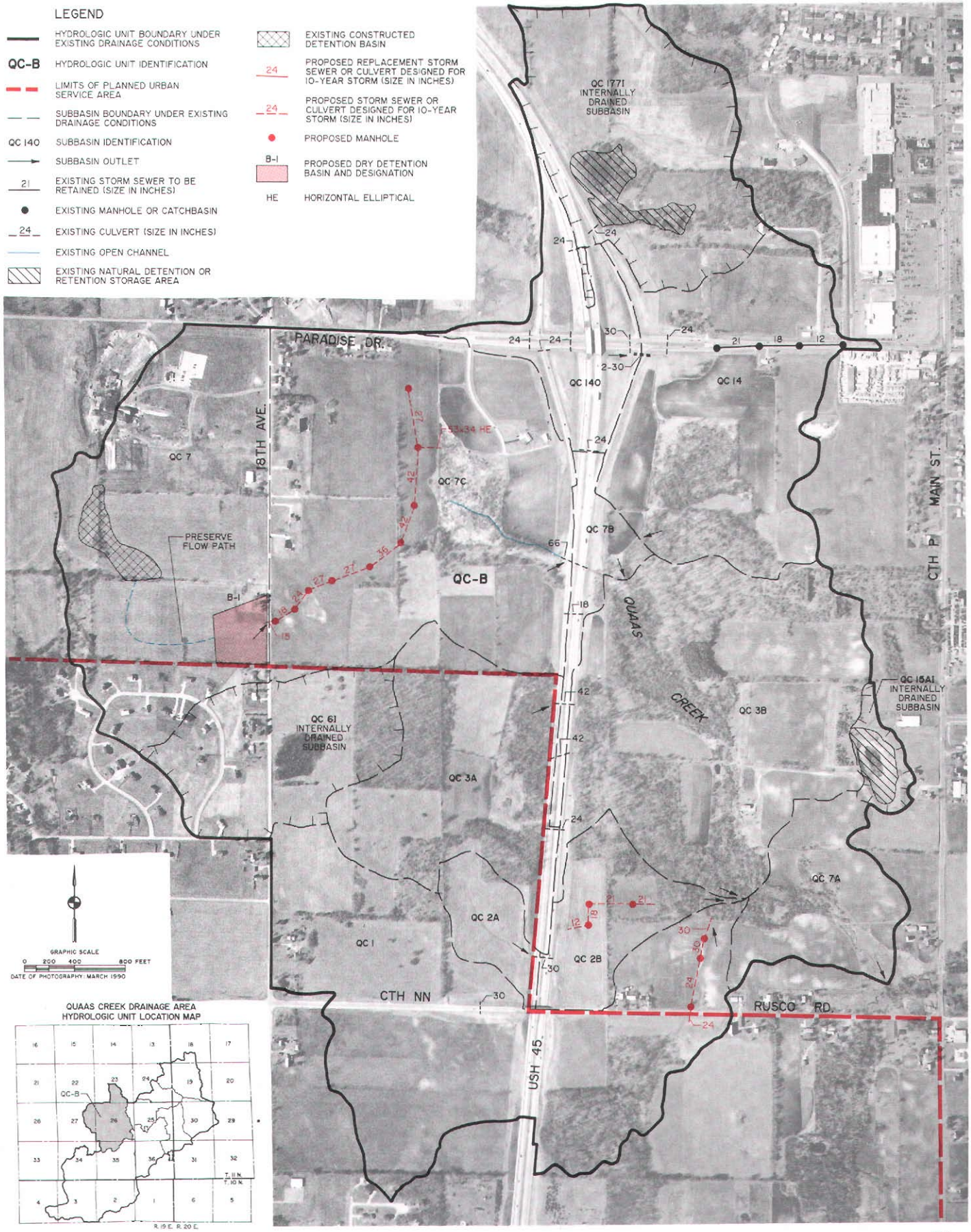
Hydrologic Unit QC-C

Evaluation of the Stormwater Management System: Hydrologic Unit QC-C is a 0.92-square-mile area located as shown on Map 1 in Chapter I of this volume. Under 1985 land use conditions, about 8 percent of the hydrologic unit was developed in urban land uses. Under planned year 2010 conditions, about 64 percent of the hydrologic unit would be developed in urban use, predominantly medium-density residential and industrial uses. The remaining 36 percent would be devoted to wetlands, woodlands and agricultural uses. The

Map 5

STORM SEWER CONVEYANCE WITH CENTRALIZED DETENTION ALTERNATIVE
PLAN FOR STORMWATER MANAGEMENT IN THE QUAAS CREEK SUBWATERSHED

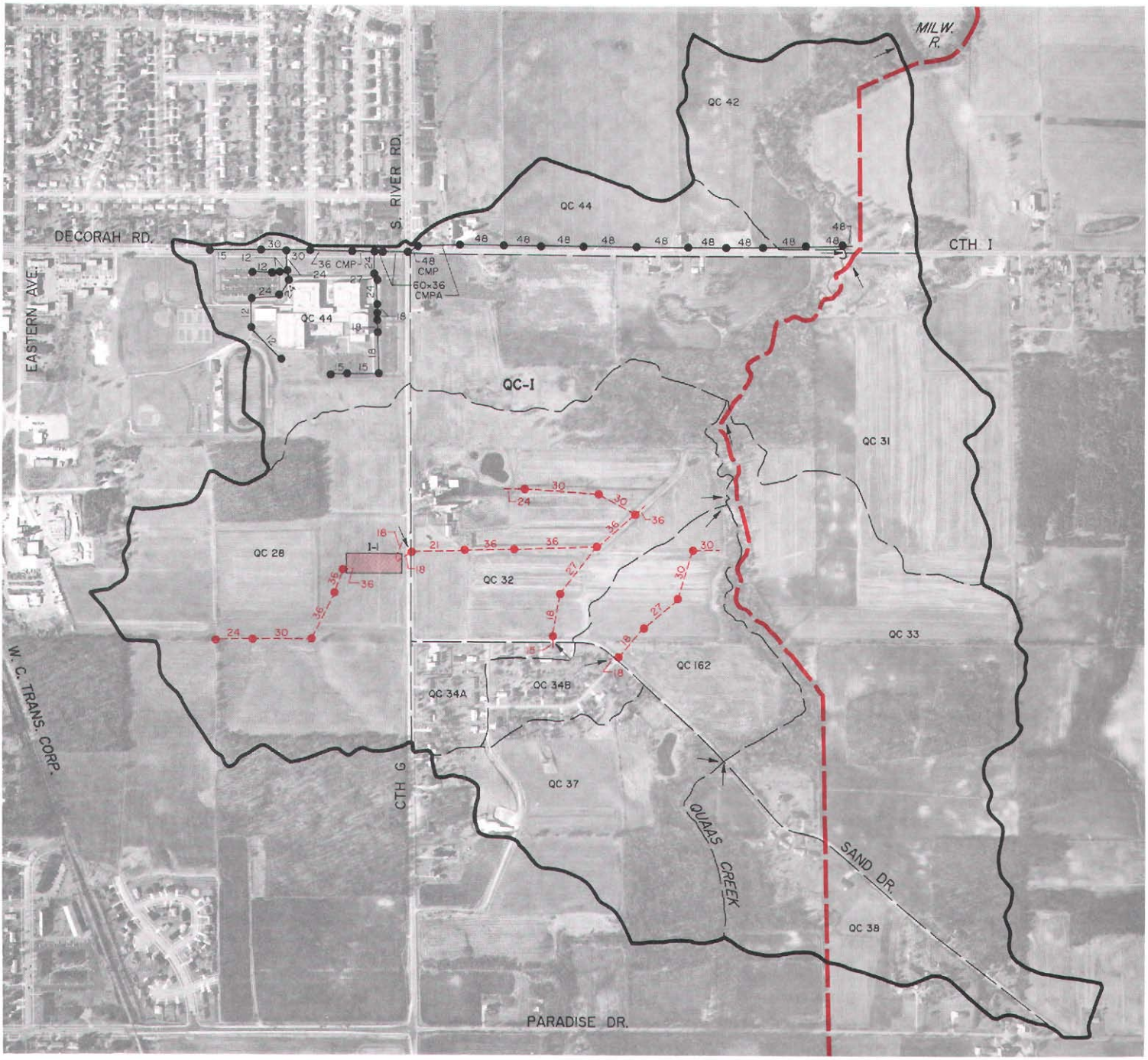
HYDROLOGIC UNIT QC-B



Map 5 (continued)

STORM SEWER CONVEYANCE WITH CENTRALIZED DETENTION ALTERNATIVE PLAN FOR STORMWATER MANAGEMENT IN THE QUAAS CREEK SUBWATERSHED

HYDROLOGIC UNIT QC-I

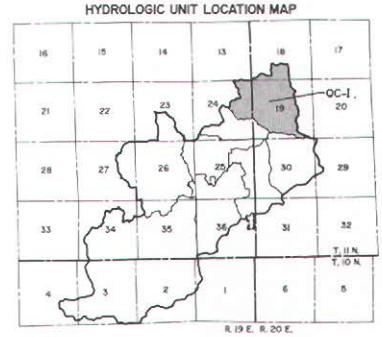


LEGEND

- HYDROLOGIC UNIT BOUNDARY UNDER EXISTING DRAINAGE CONDITIONS
- QC-I — HYDROLOGIC UNIT IDENTIFICATION
- LIMITS OF PLANNED URBAN SERVICE AREA
- SUBBASIN BOUNDARY UNDER EXISTING DRAINAGE CONDITIONS
- QC 37 — SUBBASIN IDENTIFICATION
- SUBBASIN OUTLET
- 12 — EXISTING STORM SEWER TO BE RETAINED (SIZE IN INCHES)
- EXISTING MANHOLE OR CATCHBASIN
- 15 — PROPOSED REPLACEMENT STORM SEWER OR CULVERT DESIGNED FOR 10-YEAR STORM (SIZE IN INCHES)
- 36 — PROPOSED STORM SEWER OR CULVERT DESIGNED FOR 10 YEAR STORM (SIZE IN INCHES)
- PROPOSED MANHOLE
- I-I — PROPOSED DRY DETENTION BASIN AND DESIGNATION
- CMP — CORRUGATED METAL PIPE
- CMPA — CORRUGATED METAL PIPE ARCH
- NOTE: PIPES ARE CONSTRUCTED OF REINFORCED CONCRETE UNLESS DESIGNATED AS ABOVE.

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

QUAAS CREEK DRAINAGE AREA
HYDROLOGIC UNIT LOCATION MAP



Source: SEWRPC.

Table 14

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

Hydrologic Unit	Project and Component Description[a]	Estimated Cost	
		Capital[b]	Annual Operation and Maintenance
QC-B	1. Install 170 feet of new 12-inch-diameter storm sewer ...	$ 9,000	$ 80
	2. Install 385 feet of new 18-inch-diameter storm sewer ...	29,000	180
	3. Install 505 feet of new 21-inch-diameter storm sewer ...	43,000	240
	4. Install 622 feet of new 24-inch-diameter storm sewer ...	62,000	290
	5. Install 980 feet of new 27-inch-diameter storm sewer ...	108,000	460
	6. Install 335 feet of new 30-inch-diameter storm sewer ...	42,000	160
	7. Install 300 feet of new 36-inch-diameter storm sewer ...	47,000	70
	8. Install 780 feet of new 42-inch-diameter storm sewer ...	146,000	170
	9. Install 165 feet of new 53-inch-wide by 34-inch-high HE storm sewer	37,000	40
	10. Construct detention basin B-1 with a storage volume of 11 acre-feet	229,000	4,300
	11. 30 feet of 15-inch-diameter storm sewer for basin B-1 outlet	2,000	10
	12. Replace 30-inch-diameter CMP under CTH NN with 24-inch-diameter storm sewer	5,000	10
	Total	$759,000	$6,010

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

[b] *Includes 35 percent for engineering, administration, and contingencies. Costs are for year 1995 with Engineering News-Record CCI = 5,970.*

Source: SEWRPC.

existing stormwater management system consists of roadside swales, roadway culverts, and four detention basins, ranging in size from 0.6 to nine acre-feet. The detention basins are located in the West Bend Industrial Park-South.

Because of 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 QC-C: 1) a storm sewer and open channel-roadside swale conveyance with centralized detention plan and 2) a storm sewer and open channel-roadside swale conveyance with expanded centralized detention plan.

Alternative Plan No. C-1, Storm Sewer and Open Channel-Roadside Swale Conveyance with Centralized Detention: Alternative Plan No. C-1 calls for the provision of 4,110 lineal feet of new storm sewer, ranging in size from 15-inch-diameter circular RCP to 45-inch-wide by 29-inch-high HE RCP to serve areas of planned medium-density residential development. That development would be concentrated in subbasin QC20A south of Rusco Road (CTH NN). Outflow from those storm sewers that would serve the western part of subbasin QC20A would be conveyed in a 340-foot-long trapezoidal outflow channel which would be grass-lined and would have average side slopes of one vertical on four horizontal, or other hydraulically equivalent shape. This proposed outflow channel would be from two to three feet deep and would have an average bottom width of about 10 feet. It would terminate at an existing drainageway in the primary environmental corridor along Quaas Creek. This drainageway is not classified as an intermittent or perennial stream on the 7.5-minute quadrangle map of the area prepared by the U. S. Geological Survey.

Outflow from those storm sewers which would serve the proposed residential and industrial development in the extreme eastern part of QC20A would be conveyed in a 550-foot-long outflow channel north of Rusco Road. This channel, designated as outflow channel C1, would be located about 30 feet east of a wetland identified on the State Wetland Inventory Maps and the 1990 Regional Planning Commission Land Use Inventory Maps. In order to prevent draining of the wetland, this outflow channel would have a clay liner on its west side. This outflow channel would have an average depth of about two feet, an average bottom width of about five feet, and would terminate at a point about 380 feet south of Quaas Creek.

Proposed storm sewers, which would collect runoff from the central part of planned residential development in subbasin QC20A, would discharge to a 110-foot-long open channel. This outflow channel, designated as channel C2, would be a modification of a relatively small portion of the existing drainageway in the wetland between Rusco Road and Quaas Creek. The proposed channel would have an average depth of 1.5 feet and an average bottom width of three feet. The east side of the channel would be provided with a clay liner to prevent the alteration of groundwater levels in the wetland.

Alternative Plan No. C-1 also calls for the replacement of 18-inch-diameter CMP culvert under Rusco Road about 780 feet east of CTH P (Main Street) with 21-inch-diameter reinforced concrete culvert.

Review of grading plans for proposed medium-density residential development in subbasin QC16 and QC20B indicated that a seven-acre area in the southern portion of subbasin QC151B in Hydrologic Unit QC-F would be graded to drain south into subbasin QC20B in Hydrologic Unit QC-C. The resulting change in the hydrologic unit boundary is shown on Map 6.

Table 15 presents a comparison of peak flows and existing and proposed culvert hydraulic capacities. Table 16 presents the salient characteristics and estimated costs of the stormwater drainage measures called for under this plan. The total present-value cost of this plan is $568,000, consisting of an estimated capital cost of about $536,000, and an estimated annual operation and maintenance cost increase of about $2,000. Map 6 shows the approximate location, alignment, and configuration of the facilities called for under this plan.

Wetland Considerations Related to Alternative Plan No. C-1: The wetland in which open channel C2 would be located is classified as an emergent marsh wetland on wet soils which is grazed (E1Kg). This site was field inspected by Commission biologists on May 16, 1995, and was described as highly disturbed. Disturbances of the plant community in the wetland which were noted at that time included dumping of dredge material.

Construction of the proposed open channel would require a permit from the U. S. Army Corps of Engineers under Section 404 of the Federal Clean Water Act and water quality certification from the Wisconsin Department of Natural Resources. The wetland water quality standards of Chapter NR 103 of the State Administrative Code would be applied by the Department in considering whether or not to grant water quality certification. Chapter NR 103 requires consideration of alternatives to locating a project in a wetland and also requires assessment of the impact of the project on the functional values of the wetland.

The alternative to placing outflow channel C2 in the wetland would consist of conveying this runoff east in storm sewers in Rusco Road. These storm sewers would then discharge in proposed channel C1 described above. That alternative would result in a total estimated capital cost increase of about $80,000 over the alternative which calls for construction of an open channel in the wetland.

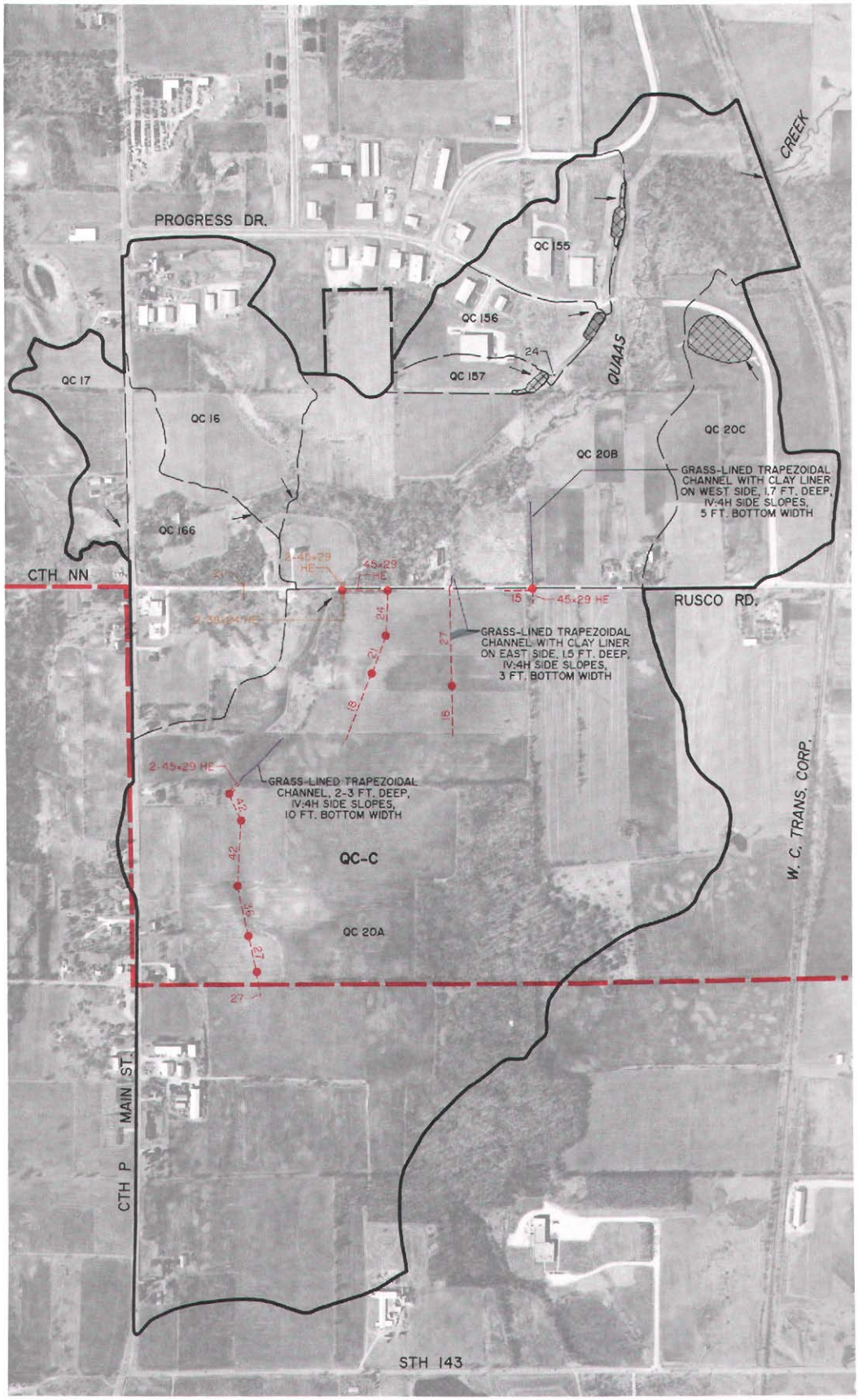
Proposed storm sewers, which would discharge to open channel C2, would collect runoff from a 23-acre area of planned medium-density residential land use. Commission biologists concluded that the additional water discharged from the storm sewers could actually benefit this wetland and enhance the existing plant community. If the alternative of bypassing the wetland through the provision of a storm sewer in Rusco Road were implemented, the source of most of the surface water for the wetland would be eliminated. In addition, channel C2 would be lined to avoid affecting groundwater levels in the wetland.

Alternative Plan No. C-2, Storm Sewer and Open Channel-Roadside Swale Conveyance with Expanded Centralized Detention: Because detention storage already exists in that part of the hydrologic unit where industrial development is expected, the only possible site where such a facility might be needed would be the planned medium-density

Map 6

STORM SEWER AND OPEN CHANNEL-ROADSIDE SWALE CONVEYANCE WITH CENTRALIZED DETENTION ALTERNATIVE PLAN FOR STORMWATER MANAGEMENT IN THE QUAAS CREEK SUBWATERSHED

HYDROLOGIC UNIT QC-C

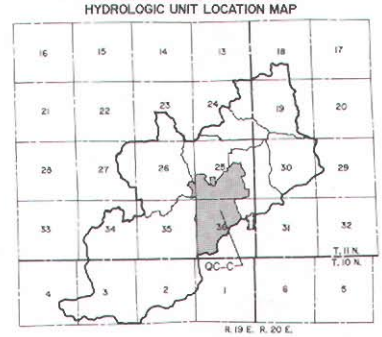


LEGEND

- HYDROLOGIC UNIT BOUNDARY UNDER EXISTING DRAINAGE CONDITIONS
- HYDROLOGIC UNIT BOUNDARY UNDER PLANNED DRAINAGE CONDITIONS
- QC-C HYDROLOGIC UNIT IDENTIFICATION
- LIMITS OF PLANNED URBAN SERVICE AREA
- SUBBASIN BOUNDARY UNDER EXISTING DRAINAGE CONDITIONS
- QC 166 SUBBASIN IDENTIFICATION
- SUBBASIN OUTLET
- 24 EXISTING CULVERT (SIZE IN INCHES)
- EXISTING CONSTRUCTED DETENTION BASIN
- 21 PROPOSED REPLACEMENT STORM SEWER OR CULVERT DESIGNED FOR 50-YEAR STORM (SIZE IN INCHES)
- 21 PROPOSED STORM SEWER OR CULVERT DESIGNED FOR 10-YEAR STORM (SIZE IN INCHES)
- PROPOSED MANHOLE
- PROPOSED OPEN CHANNEL
- HE HORIZONTAL ELLIPTICAL

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

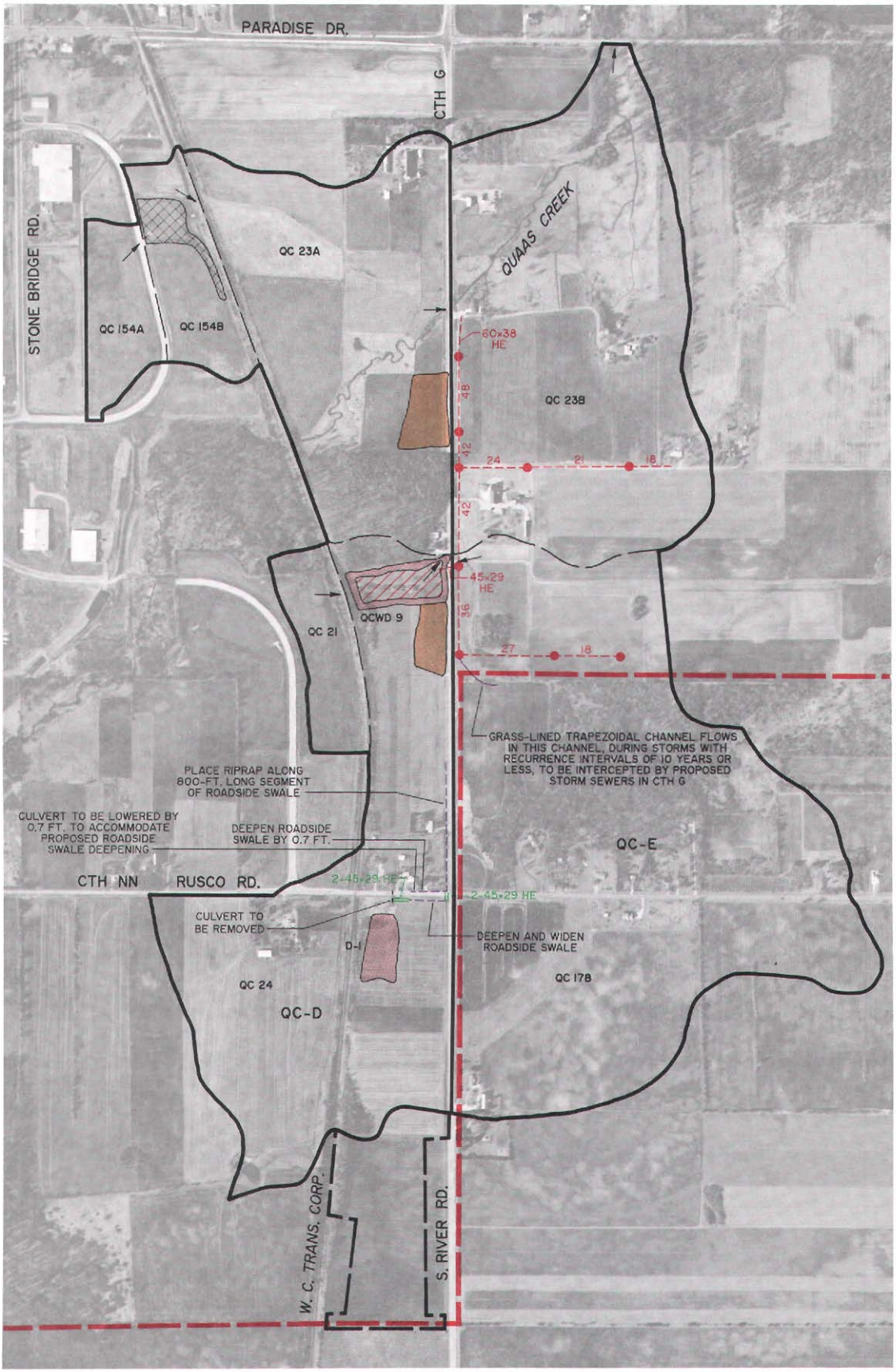
QUAAS CREEK DRAINAGE AREA
HYDROLOGIC UNIT LOCATION MAP



Map 6 (continued)

STORM SEWER AND OPEN CHANNEL-ROADSIDE SWALE CONVEYANCE WITH CENTRALIZED DETENTION ALTERNATIVE PLAN FOR STORMWATER MANAGEMENT IN THE QUAAS CREEK SUBWATERSHED

HYDROLOGIC UNITS QC-D AND QC-E

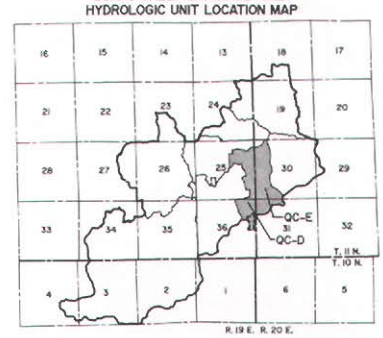


LEGEND

- HYDROLOGIC UNIT BOUNDARY UNDER EXISTING DRAINAGE CONDITIONS
- HYDROLOGIC UNIT BOUNDARY UNDER PLANNED DRAINAGE CONDITIONS
- QC-D — HYDROLOGIC UNIT IDENTIFICATION
- LIMITS OF PLANNED URBAN SERVICE AREA
- SUBBASIN BOUNDARY UNDER EXISTING DRAINAGE CONDITIONS
- QC 24 — SUBBASIN IDENTIFICATION
- SUBBASIN OUTLET
- EXISTING CONSTRUCTED DETENTION BASIN
- 45×29 HE — PROPOSED REPLACEMENT STORM SEWER OR CULVERT DESIGNED FOR 100-YEAR STORM (SIZE IN INCHES)
- 24 — PROPOSED STORM SEWER OR CULVERT DESIGNED FOR 10-YEAR STORM (SIZE IN INCHES)
- PROPOSED MANHOLE
- PROPOSED ROADSIDE SWALE OR OPEN CHANNEL MODIFICATION
- PROPOSED OPEN CHANNEL
- QCWD 9 — PERMANENT POND AREA OF PROPOSED WET DETENTION BASIN AND DESIGNATION
- QCWD 9 — PROPOSED DUAL-PURPOSE DETENTION BASIN AND DESIGNATION
- D-1 — PROPOSED DRY DETENTION BASIN AND DESIGNATION
- AREA OF PLANNED DEVELOPMENT ASSUMED TO BE REGRADED SO AS TO DRAIN TO ROADWAY
- HE — HORIZONTAL ELLIPTICAL

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

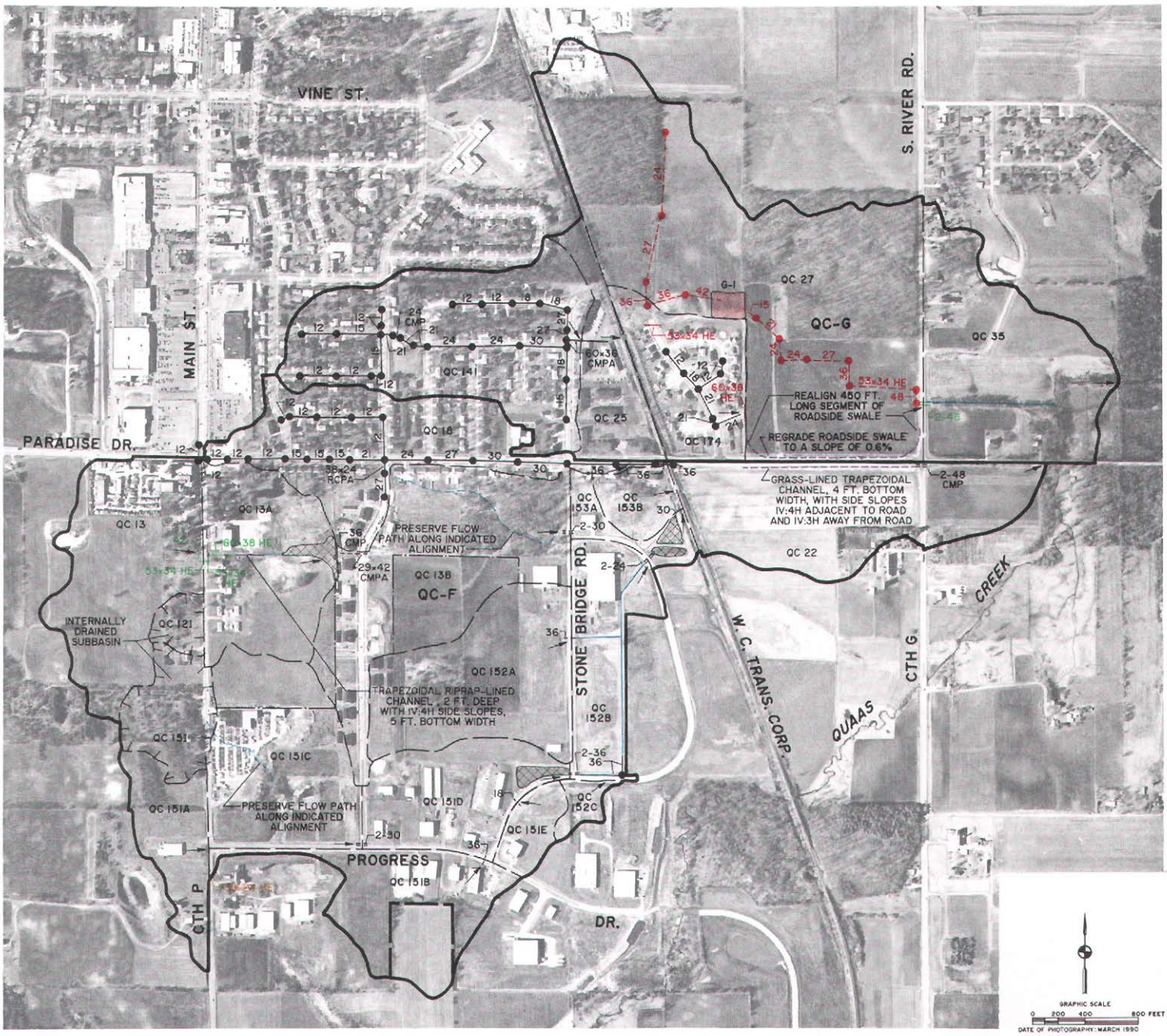
QUAAS CREEK DRAINAGE AREA
HYDROLOGIC UNIT LOCATION MAP



Map 6 (continued)

STORM SEWER AND OPEN CHANNEL-ROADSIDE SWALE CONVEYANCE WITH CENTRALIZED DETENTION ALTERNATIVE PLAN FOR STORMWATER MANAGEMENT IN THE QUAAS CREEK SUBWATERSHED

HYDROLOGIC UNITS QC-F AND QC-G

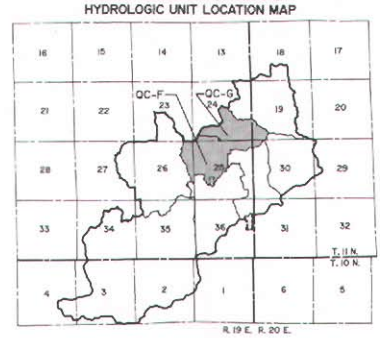


LEGEND

- HYDROLOGIC UNIT BOUNDARY UNDER EXISTING DRAINAGE CONDITIONS
- HYDROLOGIC UNIT BOUNDARY UNDER PLANNED DRAINAGE CONDITIONS
- QC-G HYDROLOGIC UNIT IDENTIFICATION
- SUBBASIN BOUNDARY UNDER EXISTING DRAINAGE CONDITIONS
- SUBBASIN BOUNDARY UNDER PLANNED DRAINAGE CONDITIONS
- QC 13A SUBBASIN IDENTIFICATION
- SUBBASIN OUTLET
- 12 EXISTING STORM SEWER TO BE RETAINED (SIZE IN INCHES)
- EXISTING MANHOLE OR CATCHBASIN
- 36 EXISTING CULVERT (SIZE IN INCHES)
- EXISTING OPEN CHANNEL
- EXISTING CONSTRUCTED DETENTION BASIN
- 60×38 HE PROPOSED REPLACEMENT STORM SEWER OR CULVERT DESIGNED FOR 10-YEAR STORM (SIZE IN INCHES)
- 38×24 HE PROPOSED REPLACEMENT STORM SEWER OR CULVERT DESIGNED FOR 50-YEAR STORM (SIZE IN INCHES)
- 2-48 PROPOSED REPLACEMENT STORM SEWER OR CULVERT DESIGNED FOR 100-YEAR STORM (SIZE IN INCHES)
- 36 PROPOSED STORM SEWER OR CULVERT DESIGNED FOR 10-YEAR STORM (SIZE IN INCHES)
- 42 PROPOSED STORM SEWER OR CULVERT DESIGNED FOR 100-YEAR STORM (SIZE IN INCHES)
- PROPOSED MANHOLE
- PROPOSED ROADSIDE SWALE OR OPEN CHANNEL MODIFICATION
- PROPOSED OPEN CHANNEL
- G-1 PROPOSED DRY DETENTION BASIN AND DESIGNATION

CMP CORRUGATED METAL PIPE
CMPA CORRUGATED METAL PIPE ARCH
HE HORIZONTAL ELLIPTICAL
RCPA REINFORCED CONCRETE PIPE ARCH
NOTE: PIPES ARE CONSTRUCTED OF REINFORCED CONCRETE UNLESS DESIGNATED AS ABOVE.

QUAAS CREEK DRAINAGE AREA
HYDROLOGIC UNIT LOCATION MAP



Source: SEWRPC.

Table 15

COMPARISON OF EXISTING AND PROPOSED FLOWS AND HYDRAULIC CAPACITIES OF CULVERTS: ALTERNATIVE C-1, STORM SEWER AND OPEN CHANNEL-ROADSIDE SWALE CONVEYANCE WITH CENTRALIZED DETENTION

Culvert Location	Existing Size[a] (inches)	Existing Capacity (cfs)	Planned Size[a] (inches)	Length (feet)	Planned Capacity (cfs)	Existing 10-year Storm Flow(cfs)	Planned 10-year Storm Flow (cfs)	Existing 50-year Storm Flow (cfs)	Planned 50-year Storm Flow (cfs)	Frequency Storm Used for Evaluation of Existing Culverts and Replacement of Inadequate Culverts (years)
Under Rusco Road about 780 feet east of Main Street	18 CMP	12	21 at 0.16 percent[b]	49	22[c]	7	14	15	21	50
Under Rusco Road about 1380 feet east of Main Street	36 CMP	65	Two 38 by 24 HE[d]	2 times 21 equals 42	134[c]	23	75	40	113[d]	50
			Two 45 by 29 HE	2 times 21 equals 42	134		96	40	134[d]	

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

[b] *Downstream invert lowered to elevation 934.5 feet above National Geodetic Vertical Datum (NGVD).*

[c] *SEWRPC standard calls for the hydraulic structure under an arterial street or highway to convey the peak 50-year recurrence interval flood flow without overtopping the roadway.*

[d] *The proposed 21-foot-long, 38-inch-wide by 24-inch-high HE culverts would convey the 50-year peak flow collected from the drainage ditch south of Rusco Road. The proposed 21-foot-long, 45-inch-wide by 29-inch-high HE culverts would be in series with the 38-inch-wide by 24-inch-high HE culverts and would convey an additional 21 cfs which would be the 10-year peak flow collected in proposed storm sewers in Rusco Road.*

Source: SEWRPC.

residential development south of Rusco Road. 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 Plan No. C-1. Thus, Alternative Plan No. C-2 was eliminated from further consideration.

Evaluation of Alternative Stormwater Drainage Plans and Preliminary Plan Recommendations: As outlined above, Alternative Plan No. C-1, Storm Sewer and Open Channel-Roadside Swale Conveyance with Centralized Detention, is the preferable alternative and was selected as the preliminary recommended plan for this hydrologic unit.

Hydrologic Units QC-D and E

Evaluation of the Stormwater Management System: Hydrologic Units QC-D and E comprise a 0.67-square-mile area located on the east and west sides of CTH G (S. River Road), as shown on Map 1 in Chapter I of this volume. These hydrologic units were analyzed together because they are hydraulically interconnected. Under 1985 land use conditions, 13 percent of the two hydrologic units was developed in urban land uses. Under planned year 2010 conditions, about 61 percent of the two hydrologic units would be developed in urban uses, primarily low- and medium-density residential, industrial, commercial, and governmental and institutional uses. The remaining rural areas would be devoted to woodlands, wetlands, and agricultural uses. The existing stormwater management system consists of roadside swales, roadway culverts, overland flow directly to Quaas Creek, and a dry detention basin, which is designated as basin E. This basin is located in the West Bend Industrial Park-South just west of the Wisconsin Central Railroad, in subbasin QC154B.

Because of the relatively low development density of Hydrologic Units QC-D and E under existing conditions, there are no known existing, significant stormwater drainage problems in the units.

Alternative Stormwater Drainage Plans: The proposed industrial development in Hydrologic Unit QC-D is well suited to an open channel-roadside swale drainage system. Consistent with the City of West Bend policy, future medium-density residential development in the hydrologic units would be served by storm sewers. The recommended water quality management element plan presented in Chapter II of this volume calls for wet detention basin QCWD9. On this basis, a storm sewer and open channel-roadside swale conveyance with centralized detention plan is the most appropriate plan for these two units and the development of alternatives is not necessary.

Table 16

ALTERNATIVE C-1: COMPONENTS AND COSTS OF THE STORM SEWER AND OPEN CHANNEL-ROADSIDE SWALE CONVEYANCE WITH CENTRALIZED DETENTION STORMWATER DRAINAGE PLAN FOR WEST BEND HYDROLOGIC UNIT QC-C

Hydrologic Unit	Project and Component Description[a]	Estimated Cost	
		Capital[b]	Annual Operation and Maintenance[c]
QC-C	1. Install 170 feet of new 15-inch-diameter storm sewer . . .	$ 11,000	$ 80
	2. Install 840 feet of new 18-inch-diameter storm sewer . . .	62,000	400
	3. Install 260 feet of new 21-inch-diameter storm sewer . . .	22,000	120
	4. Install 280 feet of new 24-inch-diameter storm sewer . . .	28,000	130
	5. Install 1,090 feet of new 27-inch-diameter storm sewer	121,000	520
	6. Install 350 feet of new 36-inch-diameter storm sewer . . .	55,000	80
	7. Install 620 feet of new 42-inch-diameter storm sewer . . .	117,000	140
	8. Install 500 feet of new 45-inch-wide by 29-inch-high HE storm sewer	88,000	120
	9. Replace 41-foot-long, 36-inch-diameter CMP under Rusco Road with double 21-foot-long, 38-inch-wide by 24-inch-high HE storm sewer followed by double 21-foot-long, 45-inch-wide by 29-inch-high HE storm sewer	18,000	10
	10. Replace 18-inch-diameter CMP under Rusco Road with 21-inch- diameter reinforced concrete culvert	6,000	0
	11. Construct 340-foot-long, 10-foot-wide bottom trapezoidal open channel from proposed storm sewer outfall to existing drainage ditch south of Rusco Road	4,000	140
	12. Construct 550-foot-long, 5-foot-wide bottom, grass-lined trapezoidal channel with clay liner on its west side from proposed storm sewer outfall to about 130 feet south of Quaas Creek	3,000	220
	13. Construct 110-foot-long, 3-foot-wide bottom, grass-lined trapezoidal channel with clay liner on its east side from proposed storm sewer outfall to about 380 feet south of Quaas Creek	1,000	40
	Total	$536,000	$2,000

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

[b]Includes 35 percent for engineering, administration, and contingencies. Costs are for year 1995 with Engineering News-Record CCI = 5,970.

[c]Costs were noted to be zero when the alternative proposed replacement of a component with a component having similar operation and maintenance cost.

Source: SEWRPC.

Preliminary Recommended Stormwater Drainage Plan: The preliminary recommended plan calls for the provision of 4,530 lineal feet of new storm sewer, ranging in size from 18-inch-diameter RCP to 60-inch-wide by 38-inch-high HE RCP to serve areas of planned residential development. The preliminary recommended plan also calls for utilizing the existing system of roadside swales, open channels,

culverts, and a dry detention basin which is proposed by the developer of a commercial warehouse development to be located south of Rusco Road in subbasin QC24. Review of the site grading plans for this proposed development indicated that a 15-acre area, which is draining south to the Cedar Creek subwatershed under existing land use conditions, would be graded to drain north into the Quaas Creek subwatershed. The change in the Quaas Creek subwatershed boundary resulting from future grading of the proposed commercial development in subbasin QC24 is shown on Map 6.

In order to accommodate the increase of runoff from future industrial development west of the Wisconsin Central Railroad, in subbasin QC24, and in order to avoid potential flooding of existing houses located northwest of the intersection of CTH G and Rusco Road, the plan calls for conveying runoff during a 100-year recurrence interval storm in a roadside swale along the south side of Rusco Road. The existing roadside swale would be deepened by about one foot and widened to provide greater hydraulic capacity. It 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. An existing 18-inch-diameter CMP culvert, which is located under a private drive about 320 feet west of CTH G, would be replaced by a double 45-inch-wide by 29-inch-high HE RCP. In addition, the existing 24-inch-diameter CMP culvert located under Rusco Road about 400 feet west of CTH G would be removed.

There is a mid-block sag in Rusco Road about 180 feet west of CTH G. During a 100-year recurrence interval flood, overflow from the roadside swale along the south side of Rusco Road would overtop the roadway and spill into an existing roadside swale north of Rusco Road. In order to prevent flooding of the houses located just north of Rusco Road, it is necessary to increase the hydraulic capacity of the northern roadside swale. Thus, the recommended plan calls for the deepening by about one foot of a 210-foot-long segment of that swale. An existing 24-inch-diameter CMP culvert, which is located under a private drive north of Rusco Road and about 160 feet west of CTH G, would also be lowered to accommodate proposed deepening of the roadside swale along the north side of Rusco Road.

In addition, the preliminary recommended plan calls for the replacement of the 24-inch-diameter culvert under Rusco Road just west of CTH G with a double 45-inch-wide by 29-inch-high HE RCP. This replacement culvert would discharge into the existing roadside swale along the west side of CTH G north of Rusco Road. This roadside swale has a steep longitudinal slope which could result in excessive flow velocities and erosion of the channel bank. In order to promote channel stability, riprap would be placed along an 800-foot-long segment of this swale.

The preliminary recommended plan assumes that areas which are located outside the 100-year recurrence interval flood inundation area, along the west side of CTH G, in subbasin QC24, and which would be developed in medium-density residential land uses, would be filled and regraded to drain to the roadway.

It is also recommended that runoff from those rural lands in subbasin QC178 which are located on the east side of CTH G and south of the area of medium-density residential development planned in that subbasin be conveyed in an existing drainage swale running westerly along the southern boundary of the future residential development, which would be extended west to CTH G. During storms with recurrence intervals of 10 years or less, runoff in this swale would be intercepted by the proposed storm sewers in CTH G.

The wet detention basin QCWD9, which is called for under the water quality management element presented in Chapter II of this volume, would be constructed as a dual-purpose basin with a permanent pond area of approximately 1.9 acres. In addition to the permanent pond, this plan calls for 4.9 acre-feet of surcharge storage volume to control runoff from storms with recurrence intervals up to, and including, ten years. The permanent pond elevation would be at about 900.5 feet above National Geodetic Vertical Datum, 1929 adjustment (NGVD). The basin outlet is proposed to be an 80-foot-long, 45-inch-wide by 29-inch-high HE RCP which would discharge to storm sewers proposed to be located in CTH G. The reduction in the 10-year recurrence interval peak flood flow due to the provision of detention storage would enable the provision of smaller storm sewers downstream from the basin.

Table 17 presents a comparison of peak flows and existing and proposed culvert hydraulic capacities. The approximate location, alignment, and configuration of the preliminary recommended facilities are set forth in Map 6. Table 18 presents the salient characteristics and estimated costs of the proposed drainage facilities which comprise this plan. The

Table 17

COMPARISON OF EXISTING AND PROPOSED FLOWS AND HYDRAULIC CAPACITIES OF CULVERTS: ALTERNATIVE D-E-1, STORM SEWER AND OPEN CHANNEL-ROADSIDE SWALE CONVEYANCE WITH CENTRALIZED DETENTION

Culvert Location	Existing Size[a] (inches)	Existing Capacity (cfs)	Planned Size[a] (inches)	Length (feet)	Planned Capacity (cfs)	Existing 10-year Storm Flow (cfs)	Planned 10-year Storm Flow (cfs)	Existing 100-year Storm Flow (cfs)	Planned 100-year Storm Flow (cfs)	Frequency Storm Used for Evaluation of Existing Culverts and Replacement of Inadequate Culverts (years)
Under private drive south of Rusco Road about 320 feet west of CTH G	18 CMP	11	Two 45 by 29 HE at 0.17 percent[b]	24	124[c]	18	67	45	124	100
Under Rusco Road just west of CTH G	24 CMP	22	Two 45 by 29 HE	53	124[c]	18	67	45	124	100

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

[b] *Upstream and downstream inverts at elevations 935.8 and 935.4 feet above National Geodetic Vertical Datum (NGVD) respectively.*

[c] *This structure is designed to convey the peak 100-year recurrence interval flood flow without overtopping Rusco Road. Overtopping Rusco Road would result in potential flooding of existing homes located north of Rusco Road.*

Source: SEWRPC.

total present-value cost of this plan for Hydrologic Units D and E is about $940,000, consisting of an estimated capital cost of about $877,000, and an estimated annual operation and maintenance cost increase of about $4,020.

Hydrologic Unit QC-F

Evaluation of the Stormwater Management System: Hydrologic Unit QC-F is a 0.54-square-mile area located as shown on Map 1 in Chapter I of this volume. Under 1985 land use conditions, about 28 percent of the hydrologic unit was developed in urban land uses. Under planned year 2010 conditions, about 92 percent of the hydrologic unit would be developed in urban uses, predominantly medium- and high-density residential, industrial, and commercial uses. The remaining 8 percent would be devoted to wetlands, woodlands, agricultural, and park and recreational uses. The existing stormwater management system outside subbasin QC18 consists of open channels, roadside swales, roadway culverts, overland flow, a detention basin located in the South Meadows subdivision in subbasin QC13A, and two detention basins in Subbasins QC151D and QC153B in the West Bend Industrial Park-South. Subbasin QC18, which is fully developed under existing conditions, is drained by roadway curb and gutters, storm sewer inlets, and storm sewers. The detention basin in the South Meadows subdivision and basins A and C in the Industrial Park have runoff storage capacities of 3.0, 6.5, and 4.4 acre-feet, respectively, during a 100-year recurrence interval storm.

The minor stormwater drainage system was found to be adequate. There is a mid-block sag in Sylvan Way south of Paradise Drive. Runoff at rates in excess of the hydraulic capacity of the downstream storm sewer in Paradise Drive could collect in the intersection of Sylvan Way and Paradise Drive and overflow to the southeast of the intersection. This overflow could be conveyed as overland flow behind the existing buildings south of Paradise Drive. If the route of this overland flow is maintained, 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 QC-F: 1) a storm sewer and open channel-roadside swale conveyance with centralized detention plan and 2) a storm sewer and open channel-roadside swale conveyance with expanded centralized detention plan.

Alternative Plan No. F-1, Storm Sewer and Open Channel-Roadside Swale Conveyance with Centralized Detention: Alternative Plan No. F-1 calls for an 80-foot-long, 42-inch-diameter RCP culvert to be installed under the future extension of Paradise Parkway to provide drainage to that portion of subbasin QC13 located north of Paradise Parkway. In order to accommodate the increase in runoff from future industrial development in subbasin QC13, this alternative calls for the replacement of the following culverts: 1) the existing 24-inch-diameter

Table 18

ALTERNATIVE D-E-1: COMPONENTS AND COSTS OF THE STORM SEWER AND OPEN CHANNEL-ROADSIDE SWALE CONVEYANCE WITH CENTRALIZED DETENTION STORMWATER DRAINAGE PLAN FOR WEST BEND HYDROLOGIC UNIT QC-D AND QC-E

Hydrologic Unit	Project and Component Description[a]	Estimated Cost	
		Capital[b]	Annual Operation and Maintenance[c]
QC-D, QC-E	1. Install 650 feet of new 18-inch-diameter storm sewer ...	$ 49,000	$ 310
	2. Install 600 feet of new 21-inch-diameter storm sewer ...	50,000	290
	3. Install 450 feet of new 24-inch-diameter storm sewer ...	44,000	210
	4. Install 600 feet of new 27-inch-diameter storm sewer ...	66,000	290
	5. Install 560 feet of new 36-inch-diameter storm sewer ...	88,000	130
	6. Install 790 feet of new 42-inch-diameter storm sewer ...	148,000	180
	7. Install 470 feet of new 48-inch-diameter storm sewer ...	108,000	110
	8. Install 330 feet of new 60-inch-wide by 38-inch-high HE storm sewer	89,000	70
	9. Construct detention basin QCWD9 with a 10-year live storage volume of 4.9-acre-feet. Water quantity control cost	124,000	2,000
	10. 80 feet of 45-inch by 29-inch HE storm sewer for basin QCWD9 outlet	14,000	20
	11. Replace 24-inch-diameter CMP under Rusco Road with double 45-inch by 29-inch HE culvert	26,000	0
	12. Replace 18-inch-diameter CMP under Private Drive in Kreilkamp development with double 45-inch by 29-inch HE culvert at a slope of 0.17 percent	12,000	10
	13. Install riprap along 800 feet of existing roadside swale along west side of CTH G north of Rusco Road	53,000	320
	14. Deepen and widen 220 feet of existing roadside swale along south side of Rusco Road west of CTH G	2,000	0
	15. Deepen 210 feet of existing roadside swale along north side of Rusco Road west of CTH G	1,000	0
	16. Construct 200-foot-long, grass-lined trapezoidal open channel from existing drainage ditch to CTH G	3,000	80
	Total	$877,000	$4,020

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

[b] *Includes 35 percent for engineering, administration, and contingencies. Costs are for year 1995 with Engineering News-Record CCI = 5,970.*

[c] *Costs were noted to be zero when the alternative proposed replacement of a component with a component having similar operation and maintenance cost.*

Source: SEWRPC.

CMP and two-foot-wide by two-foot-high concrete box culvert in series under CTH P (Main Street) and 2) the existing 18-inch-diameter CMP behind the house located just east of CTH P. To prevent flooding of buildings east of CTH P and below the roadway grade, replacement storm sewer pipes were sized to convey runoff from a 100-year storm. The replacement storm sewers would discharge to a proposed 200-foot-long trapezoidal channel. The proposed channel, which would have an average bottom width of five feet, would be riprap-lined and would have average side slopes of one vertical on four

Table 19

COMPARISON OF EXISTING AND PROPOSED FLOWS AND HYDRAULIC CAPACITIES OF CULVERTS IN HYDROLOGIC UNIT QC-F

Culvert Location	Existing Size[a] (inches)	Existing Capacity (cfs)	Planned Size[a] (inches)	Length (feet)	Planned Capacity (cfs)	Existing 10-year Storm Flow (cfs)	Planned 10-year Storm Flow (cfs)	Existing 50-year Storm Flow (cfs)	Planned 50-year Storm Flow (cfs)	Frequency Storm Used for Evaluation of Existing Culverts and Replacement of Inadequate Culverts (years)
Under Main Street about 150 feet south of Progress Drive	24 CMP	24	38 by 24 HE	47	48[b]	4	29	8	42	50

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

[b]*SEWRPC standard calls for the hydraulic structure under an arterial street or highway to convey the peak 50-year recurrence interval flood flow without overtopping the roadway.*

Source: SEWRPC.

horizontal, or other hydraulically equivalent shape. The channel would be about two feet deep and would terminate just upstream of the existing detention basin in the South Meadows subdivision.

In order to accommodate increased runoff from anticipated development in the hydrologic unit, this alternative also calls for the modification of the existing open channel along the south side of Paradise Drive, west of CTH G. This channel would be regraded to a slope of 0.7 percent and would have side slopes of one vertical on four horizontal adjacent to the road and one vertical on three horizontal away from the road. The average depth in this channel would be three feet and its average bottom width would be four feet.

Subbasin QC15I, which is internally drained under existing conditions, is expected to be partly developed in commercial and residential land uses. Under existing conditions, runoff is collected in a depression located in the subbasin. Under planned development conditions, grading of the subbasin could result in the potential filling of the existing natural retention area. In order to provide effective drainage of the subbasin and prevent potential flooding of future development, it is essential that an outflow path, located in the parking lot of the existing commercial development just east of CTH P, be maintained regardless of whether the storage available in the existing depression is preserved or the depression is fully or partially filled.

Map 6 shows the approximate location and alignment of the stormwater drainage facilities proposed under this alternative. Table 19 presents a comparison of peak flows and existing and proposed culvert hydraulic capacities. Table 20 presents the salient characteristics and estimated costs of proposed new and replacement stormwater drainage facilities comprising this alternative plan. The total present-value cost of this alternative plan is $148,000, consisting of an estimated capital cost of about $145,000 and an estimated $160 net annual operation and maintenance cost increase over existing conditions.

Alternative Plan No. F-2, Storm Sewer and Open Channel-Roadside Swale Conveyance with Expanded Centralized Detention: Map 7 shows the approximate location, alignment, and configuration of the facilities called for under this alternative. Aside from the features discussed below, this alternative is identical to Alternative Plan No. F-1.

Because of the reduction in peak 100-year recurrence interval flood flows achieved through the provision of detention storage, this alternative enables retaining existing culverts which would be replaced under Alternative Plan No. F-1. The proposed dry detention basin, which would be located southwest of the intersection of CTH P and the future extension of Paradise Parkway, would have a storage capacity of about 3.4 acre-feet. The construction of this detention basin would permit the utilization of an existing natural depression and therefore would not require any earth excavation. The proposed detention basin would require a total land area of about 1.3 acres. This alternative plan also calls for maintaining the overland flow path downstream of the existing culvert under CTH P. This alternative plan also calls for an 80-foot-long, 42-inch-diameter RCP culvert to be installed under the future extension of Paradise Parkway to provide

Table 20

ALTERNATIVE F-1: COMPONENTS AND COSTS OF THE STORM SEWER AND OPEN CHANNEL-ROADSIDE SWALE CONVEYANCE WITH CENTRALIZED DETENTION STORMWATER DRAINAGE PLAN FOR WEST BEND HYDROLOGIC UNIT QC-F

Hydrologic Unit	Project and Component Description[a]	Estimated Cost	
		Capital[b]	Annual Operation and Maintenance[c]
QC-F	1. Install one 80-foot-long, 42-inch-diameter reinforced concrete pipe culvert under future Paradise Parkway ...	$ 15,000	$ 20
	2. Replace 24-inch-diameter CMP and 2-foot-wide by 2-foot-high concrete box culvert under CTH P with a 53-inch by 34-inch HE storm sewer	19,000	10
	3. Install 30 feet of new 53-by 34-inch HE storm sewer	7,000	10
	4. Replace 18-inch-diameter CMP behind house east of CTH P with a 60-inch by 38-inch HE storm sewer	80,000	50
	5. Replace 24-inch-diameter CMP under CTH P with 38-inch by 24-inch concrete horizontal elliptical (H.E.) culvert	9,000	-10
	6. Construct 200-foot-long, riprap-lined trapezoidal open channel from proposed storm sewer outfall to existing detention basin in South Meadows Subdivision	13,000	80
	7. Modification of the 1,300-foot-long segment of roadside swale on the south side of Paradise Drive	2,000	0
	Total	$145,000	$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 1995 with Engineering News-Record CCI = 5,970.*

[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 lesser operation and maintenance cost than that of the existing facility.*

Source: SEWRPC.

drainage to that portion of subbasin QC13 located north of Paradise Parkway.

Table 19 presents a comparison of peak flows and existing and proposed storm sewer hydraulic capacities. Table 21 presents the salient characteristics and estimated costs of the new storm sewer, the new and replacement roadway culverts, and the 3.4-acre-foot detention basin which comprise this alternative plan. The total present-value cost of this alternative plan is $90,000, consisting of an estimated capital cost of about $52,000, including land acquisition for the detention basin, and an estimated annual operation and maintenance cost increase of about $2,410.

Consideration of Storm Sewers in Paradise Drive: Storm sewers in the segment of Paradise Drive between the Wisconsin Central Railroad and the Paradise Drive crossing of Quaas Creek would collect and convey flows from areas in both Hydrologic Units QC-F and QC-G. The storm sewers are described in the subsequent section of this Chapter which describes the alternative plans for Hydrologic Unit QC-G. It was concluded that the provision of storm sewers in Paradise Drive would be more costly than conveying stormwater in the existing roadside swales on either side of Paradise Drive.

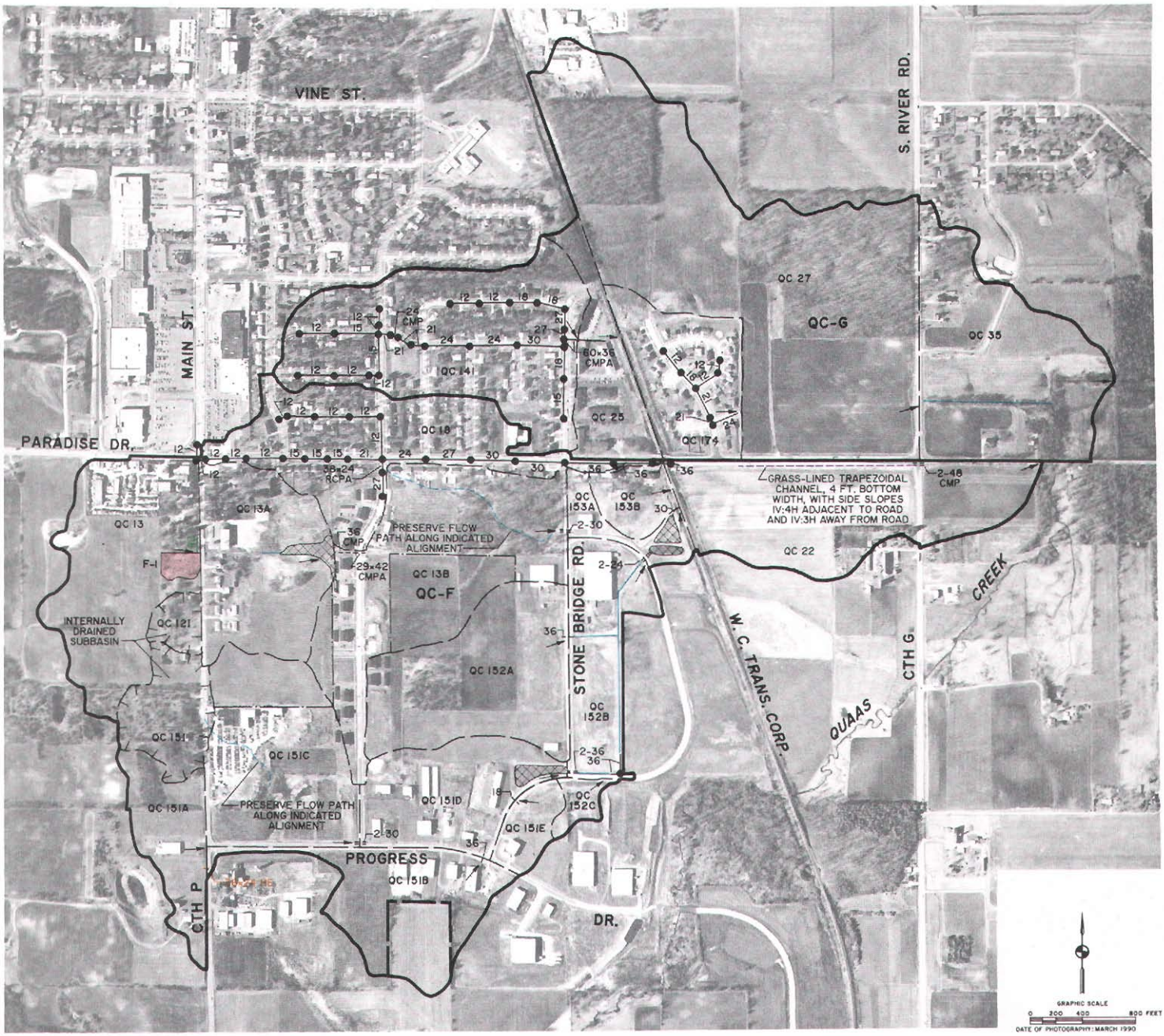
Evaluation of Alternative Stormwater Drainage Plans: The foregoing information provides a basis for a comparative evaluation of the two alternative stormwater drainage plans. The principal criteria for the comparative evaluation are cost and implementability.

Alternative Plan No. F-2 is less costly than Alternative Plan No. F-1, but Alternative Plan No. F-1

Map 7

STORM SEWER AND OPEN CHANNEL-ROADSIDE SWALE CONVEYANCE WITH EXPANDED CENTRALIZED DETENTION ALTERNATIVE PLAN FOR STORMWATER MANAGEMENT IN THE QUAAS CREEK SUBWATERSHED

HYDROLOGIC UNITS QC-F AND QC-G



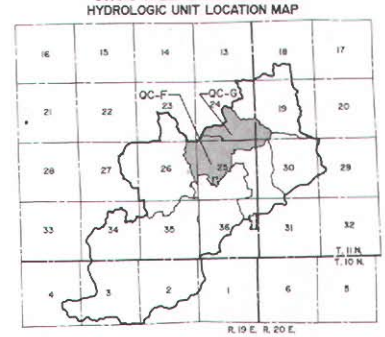
LEGEND

- HYDROLOGIC UNIT BOUNDARY UNDER EXISTING DRAINAGE CONDITIONS
- HYDROLOGIC UNIT BOUNDARY UNDER PLANNED DRAINAGE CONDITIONS
- QC-G HYDROLOGIC UNIT IDENTIFICATION
- SUBBASIN BOUNDARY UNDER EXISTING DRAINAGE CONDITIONS
- SUBBASIN BOUNDARY UNDER PLANNED DRAINAGE CONDITIONS
- QC 13A SUBBASIN IDENTIFICATION
- SUBBASIN OUTLET
- 12 EXISTING STORM SEWER TO BE RETAINED (SIZE IN INCHES)
- EXISTING MANHOLE OR CATCHBASIN
- 36 EXISTING CULVERT (SIZE IN INCHES)
- EXISTING OPEN CHANNEL
- EXISTING CONSTRUCTED DETENTION BASIN
- 38x24 HE PROPOSED REPLACEMENT STORM SEWER OR CULVERT DESIGNED FOR 50-YEAR STORM (SIZE IN INCHES)
- 42 PROPOSED STORM SEWER OR CULVERT DESIGNED FOR 100-YEAR STORM (SIZE IN INCHES)
- PROPOSED ROADSIDE SWALE OR OPEN CHANNEL MODIFICATION
- F-1 PROPOSED DRY DETENTION BASIN AND DESIGNATION

CMP CORRUGATED METAL PIPE
CMPA CORRUGATED METAL PIPE ARCH
HE HORIZONTAL ELLIPTICAL
RCPA REINFORCED CONCRETE PIPE ARCH

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

QUAAS CREEK DRAINAGE AREA
HYDROLOGIC UNIT LOCATION MAP



Source: SEWRPC.

Table 21

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

Hydrologic Unit	Project and Component Description[a]	Estimated Cost	
		Capital[b]	Annual Operation and Maintenance[c]
QC-F	1. Install one 80-foot-long, 42-inch-diameter reinforced concrete pipe culvert under future Paradise Parkway	$15,000	$ 20
	2. Replace 24-inch-diameter CMP under CTH P with 38-inch by 24-inch concrete horizontal elliptical (HE) culvert	9,000	-10
	3. Construct detention basin F-1 with a 100-year storage volume of 3.4-acre-feet	26,000	2,400
	4. Modification of the 1,300-foot-long segment of roadside swale on the south side of Paradise Drive	2,000	0
	Total	$52,000	$2,410

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

[b] *Includes 35 percent for engineering, administration, and contingencies. Costs are for year 1995 with Engineering News-Record CCI = 5,970.*

[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 lesser operation and maintenance cost than that of the existing facility.*

Source: SEWRPC.

would be more readily implemented since it would not require purchasing land or easements for the provision of the detention basin.

Preliminary Recommended Stormwater Drainage Plan: Because of the lower cost of Alternative Plan No. F-2, Storm Sewer and Open Channel-Roadside Swale Conveyance with Expanded Centralized Detention, it was selected as the preliminary recommended plan for Hydrologic Unit QC-F.

Hydrologic Unit QC-G

Evaluation of the Stormwater Management System: Hydrologic Unit QC-G is a 0.36-square-mile area located as shown on Map 1 in Chapter I of this volume. Under 1985 land use conditions, approximately 40 percent of the hydrologic unit was developed in urban land uses. Under planned year 2010 conditions, about 84 percent of the hydrologic unit would be developed in urban land uses, which would consist primarily of medium- and high-density residential, industrial, and commercial uses. The remaining 16 percent would be devoted to woodlands, wetlands, and other open lands for recreational uses. Under existing conditions, runoff from the urbanized eastern portion of this hydrologic unit is conveyed in roadway curbs and gutters, storm sewer inlets, storm sewers, and a drainage ditch along the northern and western boundaries of the Forest Highlands subdivision just east of the Wisconsin Central Railroad. This drainage ditch discharges into a roadside ditch, which runs in an easterly direction on the north side of Paradise Drive and then northerly along the west side of CTH G (South River Road). The ditch discharges, through a field-measured 56-inch-diameter CMP culvert under CTH G, to an unnamed intermittent stream tributary to Quaas Creek.

Problems with inadequate minor system hydraulic capacities were identified in this hydrologic unit. As seen in Table 22, a comparison of the existing 10-year recurrence interval storm flows with the capacity of the existing culverts under Indiana Avenue and Crocus Court shows that the culverts have inadequate capacity to meet the minor system requirement of passing the peak rate of runoff from a 10-year storm.

Table 22

COMPARISON OF EXISTING AND PROPOSED FLOWS AND HYDRAULIC CAPACITIES OF CULVERTS: ALTERNATIVE G-1: STORM SEWER AND OPEN CHANNEL-ROADSIDE SWALE CONVEYANCE

Culvert Location	Existing Size[a] (inches)	Existing Capacity (cfs)	Planned Size[a] (inches)	Length (feet)	Planned Capacity (cfs)	Existing 10-year Storm Flow (cfs)	Planned 10-year Storm Flow (cfs)	Existing 100-year Storm Flow (cfs)	Planned 100-year Storm Flow (cfs)	Frequency Storm Used for Evaluation of Existing Culverts and Replacement of Inadequate Culverts (years)
Under Indiana Avenue about 1,120 feet north of Paradise Drive	58 by 36 CMPA	61	53 by 34 HE at 0.50 percent[b]	121	94[c]	92	92	154	154	10
Under Crocus Court about 200 feet east of Indiana Avenue	65 by 40 CMPA	70	60 by 38 HE at 0.15 percent	82	107[c]	108	108	182	182	10

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

[b] *Lower downstream invert to elevations 903.0 feet above National Geodetic Vertical Datum (NGVD).*

[c] *SEWRPC standard calls for the hydraulic structure under a minor or collector street to convey the peak 10-year recurrence interval flood flow without overtopping the roadway.*

Source: SEWRPC.

Alternative Stormwater Drainage Plans: The following two alternative stormwater management plans were developed for Hydrologic Unit QC-G: 1) a storm sewer and open channel-roadside swale conveyance plan and 2) a storm sewer and open channel-roadside swale conveyance with centralized detention plan.

Alternative Plan No. G-1, Storm Sewer and Open Channel-Roadside Swale Conveyance: Under the storm sewer and open channel-roadside swale conveyance alternative plan, runoff from areas of planned urban development would be conveyed through the provision of 3,850 lineal feet of new storm sewer, ranging in size from 24-inch-diameter RCP to 68-inch-wide by 38-inch-high HE RCP. Conceptual street layouts for future development in subbasin QC27 were obtained from the City of West Bend and were used to size stormwater drainage facilities. The proposed storm sewers would discharge into the aforementioned stream tributary to Quaas Creek east of CTH G. Backwater from this tributary during a 100-year recurrence interval storm event would extend into the area northwest of the intersection of Paradise Drive and CTH G. In order to provide two feet of freeboard between buildings and the 100-year recurrence interval flood inundation elevation on the above described site, all development should be located above elevation 895.5 feet above National Geodetic Vertical Datum, 1929 adjustment (NGVD).

To abate potential street flooding in the Forest Highlands subdivision during a 10-year recurrence interval storm, this alternative calls for the replacement of: 1) the 121-foot-long, 58-inch-wide by 36-inch-high corrugated metal pipe arch (CMPA) under Indiana Avenue with a 53-inch-wide by 34-inch-high HE RCP and 2) the 85-foot-long, 65-inch-wide by 40-inch-high CMPA under Crocus Court with a 60-inch-wide by 38-inch-high HE RCP.

In addition, this alternative calls for maintaining the existing roadside swale along the north side of Paradise Drive, west of CTH G, to convey runoff from the Forest Highlands subdivision and tributary developments during storms with recurrence intervals of 10 years or less. It is recommended, however, that right- angle bends in this roadside swale be eliminated, as shown on Map 8, in order to reduce the likelihood of erosion of the channel bank.

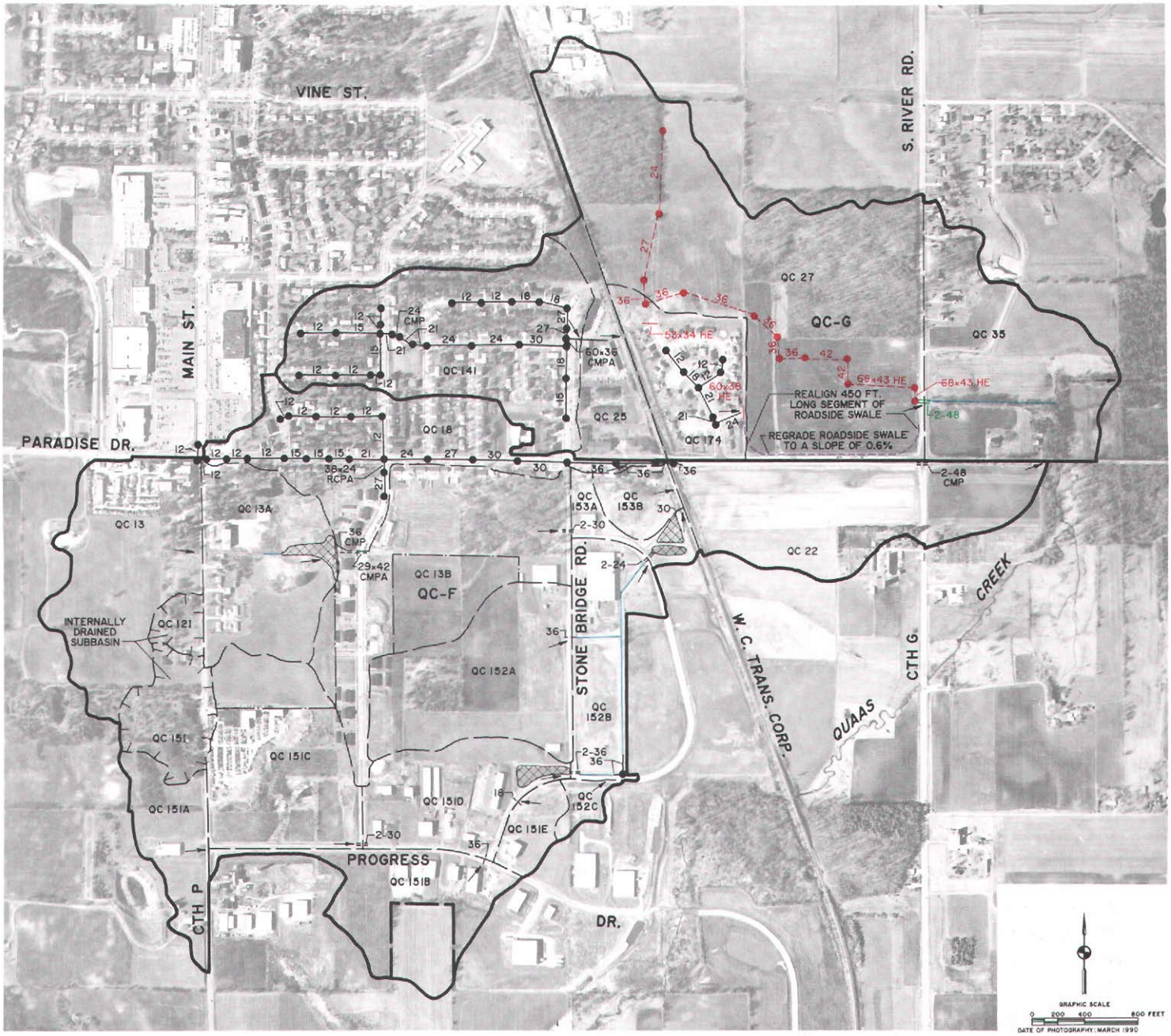
During storms larger than a 10-year recurrence interval event, runoff would be conveyed south in Indiana Avenue and then east in Crocus Court. It is recommended that under planned development conditions, streets in subbasin QC27 east of the Forest Highlands subdivision which would connect to Crocus Court be graded to effectively convey these flows to the outlet of subbasin QC27.

Map 8 shows the approximate location and alignment of the storm sewers proposed under this alter-

Map 8

STORM SEWER AND OPEN CHANNEL ROADSIDE SWALE CONVEYANCE ALTERNATIVE PLAN FOR STORMWATER MANAGEMENT IN THE QUAAS CREEK SUBWATERSHED

HYDROLOGIC UNITS QC-F AND QC-G



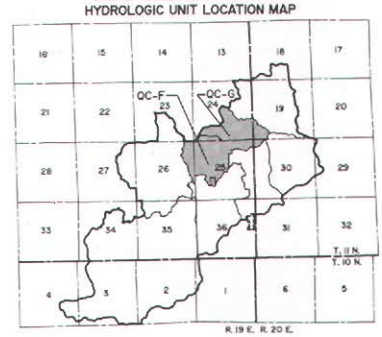
LEGEND

- HYDROLOGIC UNIT BOUNDARY UNDER EXISTING DRAINAGE CONDITIONS
- HYDROLOGIC UNIT BOUNDARY UNDER PLANNED DRAINAGE CONDITIONS
- QC-G HYDROLOGIC UNIT IDENTIFICATION
- SUBBASIN BOUNDARY UNDER EXISTING DRAINAGE CONDITIONS
- SUBBASIN BOUNDARY UNDER PLANNED DRAINAGE CONDITIONS
- QC 13A SUBBASIN IDENTIFICATION
- SUBBASIN OUTLET
- 12 EXISTING STORM SEWER TO BE RETAINED (SIZE IN INCHES)
- EXISTING MANHOLE OR CATCHBASIN
- 36 EXISTING CULVERT (SIZE IN INCHES)
- EXISTING OPEN CHANNEL
- EXISTING CONSTRUCTED DETENTION BASIN
- 60x38 HE PROPOSED REPLACEMENT STORM SEWER OR CULVERT DESIGNED FOR 10-YEAR STORM (SIZE IN INCHES)
- 2-48 PROPOSED REPLACEMENT STORM SEWER OR CULVERT DESIGNED FOR 100-YEAR STORM (SIZE IN INCHES)
- 36 PROPOSED STORM SEWER OR CULVERT DESIGNED FOR 10-YEAR STORM (SIZE IN INCHES)
- PROPOSED MANHOLE
- PROPOSED ROADSIDE SWALE OR OPEN CHANNEL MODIFICATION

CMP CORRUGATED METAL PIPE
CMPA CORRUGATED METAL PIPE ARCH
HE HORIZONTAL ELLIPTICAL
RCPA REINFORCED CONCRETE PIPE ARCH

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

QUAAS CREEK DRAINAGE AREA
HYDROLOGIC UNIT LOCATION MAP



Source: SEWRPC.

Table 23

ALTERNATIVE G-1: COMPONENTS AND COSTS OF THE STORM SEWER AND OPEN CHANNEL-ROADSIDE SWALE CONVEYANCE WITH CENTRALIZED DETENTION STORMWATER DRAINAGE PLAN FOR WEST BEND HYDROLOGIC UNIT QC-G

Hydrologic Unit	Project and Component Description[a]	Estimated Cost	
		Capital[b]	Annual Operation and Maintenance[c]
QC-G	1. Install 630 feet of new 24-inch-diameter storm sewer	$ 62,000	$ 300
	2. Install 480 feet of new 27-inch-diameter storm sewer	53,000	230
	3. Install 1,625 feet of new 36-inch-diameter storm sewer	257,000	360
	4. Install 495 feet of new 42-inch-diameter storm sewer	93,000	110
	5. Install 620 feet of new 68-inch-wide by 43-inch-high HE storm sewer	190,000	140
	6. Replace 91 feet of 56-inch CMP culvert under CTH G with double 48-inch storm sewer	56,000	20
	7. Replace 121 feet of 58-inch by 36-inch CMPA under Indiana Avenue with a 53-inch by 34-inch HE culvert at a slope of 0.52 percent	38,000	0
	8. Replace 85 feet of 65-inch by 40-inch CMPA under Crocus Court with a 60-inch by 38-inch HE culvert	32,000	0
	9. Regrade 900 feet of roadside swale north of Paradise Drive and west of CTH G	13,000	0
	10. Realign 450 feet of roadside swale north of Paradise Drive and west of CTH G	25,000	0
	Total	$819,000	$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 1995 with Engineering News-Record CCI = 5,970.*

[c] *Costs were noted to be zero when the alternative proposed replacement of a component with a component having similar operation and maintenance cost.*

Source: SEWRPC.

native. Table 22 presents a comparison of peak flows and existing and proposed culvert capacities. Table 23 presents the salient characteristics and estimated costs of the drainage components comprising this alternative plan. The total present-value cost of this alternative plan is $837,000, consisting of an estimated capital cost of about $819,000 and an estimated annual operation and maintenance cost increase of about $1,160 compared to existing conditions.

Alternative Plan No. G-2, Storm Sewer and Open Channel-Roadside Swale Conveyance with Centralized Detention: Map 6 shows the approximate location, alignment, and configuration of the facilities called for under this alternative. Aside from the features discussed below, this alternative is identical to Alternative Plan No. G-1. 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 1,695 lineal feet of proposed storm sewers. In addition, 170 lineal feet of proposed storm sewer which would be called for under Alternative Plan No. G-1 is located at the proposed detention basin site and would, therefore, be eliminated under this alternative. The proposed 1.4 acre-foot dry detention basin, which would require a total land area of 0.9 acre, would be located just northeast of the Forest Highlands subdivision on lands which would be devoted to recreational and park uses under planned land use conditions.

The proposed storm sewers under this alternative would also discharge into the unnamed stream tributary to Quaas Creek east of CTH G. As under

Table 24

COMPARISON OF EXISTING AND PROPOSED FLOWS AND HYDRAULIC CAPACITIES OF CULVERTS: ALTERNATIVE G-2: STORM SEWER AND OPEN CHANNEL-ROADSIDE SWALE CONVEYANCE WITH CENTRALIZED DETENTION

Culvert Location	Existing Size[a] (inches)	Existing Capacity (cfs)	Planned Size[a] (inches)	Length (feet)	Planned Capacity (cfs)	Existing 10-year Flow (cfs)	Planned 10-year Storm Flow (cfs)	Existing 100-year Storm Flow (cfs)	Planned 100-year Storm Flow (cfs)	Frequency Storm Used for Evaluation of Existing Culverts and Replacement of Inadequate Culverts (years)
Under Indiana Avenue about 1,120 feet north of Paradise Drive	58 by 36 CMPA	61	53 by 34 HE at 0.50 percent[b]	121	94[c]	92	92	154	154	10
Under Crocus Court about 200 feet east of Indiana Avenue	65 by 40 CMPA	70	60 by 38 HE at 0.15 percent	82	107[c]	108	108	182	182	10

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

[b] *Lower downstream invert to elevations 903.0 feet above National Geodetic Vertical Datum (NGVD).*

[c] *SEWRPC standard calls for the hydraulic structure under a minor or collector street to convey the peak 10-year recurrence interval flood flow without overtopping the roadway.*

Source: SEWRPC.

Alternative Plan No. G-1, during a 100-year recurrence interval storm event, backwater from this tributary would extend into the area northwest of the intersection of Paradise Drive and CTH G. In order to provide two feet of freeboard between buildings and the 100-year recurrence interval flood inundation elevation in this area, all development should be located above elevation 893.0 feet above National Geodetic Vertical Datum, 1929 adjustment (NGVD).

Table 24 presents a comparison of peak flows and existing and proposed culvert capacities. Table 25 presents the salient characteristics and estimated costs of the proposed drainage components comprising this alternative plan. The total present-value cost of this alternative plan is $805,000, consisting of an estimated capital cost of about $761,000, and an estimated annual operation and maintenance cost increase of about $1,890.

Consideration of Storm Sewers in Paradise Drive: The provision of storm sewers in the segment of Paradise Drive between the Wisconsin Central Railroad and the Paradise Drive crossing of Quaas Creek was also investigated, but eliminated from consideration. New storm sewers in Paradise Drive would intercept the existing storm sewers in Paradise Drive west of the Railroad and would also replace portions of the existing roadside swales both north and south of the roadway. If the new storm sewers were sized to convey the peak rate of runoff from a 10-year recurrence interval storm, overflow to the north could occur at the intersection of Paradise Drive and Indiana Avenue during storms with recurrence intervals ranging from 10 to 100 years. The peak rate of that overflow could exceed the hydraulic capacity of the existing major drainage system north of Paradise Drive. In order to prevent such overflow, about 800 feet of storm sewer in Paradise Drive would have to be sized to carry the peak flows from a 100-year recurrence interval storm. Downstream of that section of storm sewer, an additional 1900 feet of storm sewer would be required to convey the peak 10-year recurrence interval storm flows east to the Paradise Drive crossing of Quaas Creek.

There is a mid-block sag in Paradise Drive about 50 feet west of CTH G. Runoff rates in excess of the 10-year recurrence interval flood hydraulic capacity of the storm sewers in this section of the roadway could pond in this sag. Ponded runoff could result in overland flow and flooding of buildings in future commercial and residential developments located respectively north and south of Paradise Drive. In order to prevent such overland flow and provide an outlet for runoff ponded in the sag, sections of the existing roadside swales would need to be preserved.

On the basis of the above findings, it was concluded that the provision of storm sewers in Paradise Drive would be more costly than conveying storm-

Table 25

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

Hydrologic Unit	Project and Component Description[a]	Estimated Cost	
		Capital[b]	Annual Operation and Maintenance[c]
QC-G	1. Install 225 feet of new 21-inch-diameter storm sewer . . .	$ 19,000	$ 110
	2. Install 885 feet of new 24-inch-diameter storm sewer . . .	97,000	470
	3. Install 785 feet of new 27-inch-diameter storm sewer . . .	87,000	380
	4. Install 665 feet of new 36-inch-diameter storm sewer . . .	105,000	140
	5. Install 105 feet of new 48-inch-diameter storm sewer . . .	24,000	20
	6. Install 515 feet of new 53-inch-wide by 34-inch-high HE storm sewer	114,000	120
	7. Replace 91 feet of 56-inch CMP culvert under CTH G with double 48-inch storm sewer	56,000	20
	8. Replace 121 feet of 58-inch by 36-inch CMPA under Indiana Avenue with a 53-inch by 34-inch HE culvert at a slope of 0.52 percent	38,000	0
	9. Replace 85 feet of 65-inch by 40-inch CMPA under Crocus Court with a 60-inch by 38-inch HE culvert	32,000	0
	10. Regrade 900 feet of roadside swale north of Paradise Drive and west of CTH G	13,000	0
	11. Realign 450 feet of roadside swale north of Paradise Drive and west of CTH G	25,000	0
	12. Construct dry detention basin G-1 with a storage volume of 1.4-acre-feet	92,000	1,400
	13. 270 feet of 42-inch storm sewer for basin G-1 inlet	51,000	60
	14. 130 feet of 15-inch storm sewer for basin G-1 outlet	8,000	60
	Total	$761,000	$2,780

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

[b] *Includes 35 percent for engineering, administration, and contingencies. Costs are for year 1995 with Engineering News-Record CCI = 5,970.*

[c] *Costs were noted to be zero when the alternative proposed replacement of a component with a component having similar operation and maintenance cost.*

Source: SEWRPC.

water in the existing roadside swales both south and north of Paradise Drive. As a result, the provision of storm sewers in Paradise Drive was not considered further.

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 and to alleviate potential drainage problems in existing developments within the hydrologic unit. Thus, the principal criteria for the comparative evaluation were cost and implementability.

Alternative Plan No. G-2 is less costly than Alternative Plan No. G-1 and Alternative Plan No. G-2 would be more easily implemented since it would require less filling in the area of planned development northwest of the intersection of Paradise Drive

and CTH G. In addition, dry detention basin G-1 called for under Alternative Plan No. G-2 is proposed to be located on public lands and would not require purchasing land.

Preliminary Recommended Stormwater Drainage Plan: Because of the lower cost and more favorable implementability of Alternative Plan No. G-2, Storm Sewer and Open Channel-Roadside Swale Conveyance with Centralized Detention, it was selected as the preliminary recommended plan for Hydrologic Unit QC-G.

Hydrologic Unit QC-H

Evaluation of the Stormwater Management System: Hydrologic Unit QC-H is a 0.71-square-mile area located as shown on Map 1 in Chapter I of this volume. Under 1985 land use conditions, approximately 6 percent of the hydrologic unit was developed in urban land uses. Under planned year 2010 conditions, about 27 percent of the hydrologic unit would be developed in urban land uses, which would consist primarily of low- and medium-density residential. The remaining 73 percent would be devoted to woodlands, wetlands, and agricultural uses. The existing stormwater drainage pattern generally consists of overland flow directly to an unnamed intermittent stream tributary to Quaas Creek. This tributary was identified on the 7.5-minute U. S. Geological Survey quadrangle maps of the area. Review of ratioed and rectified aerial photographs, which are prepared for the Regional Planning Commission every five years, indicated that portions of this tributary were realigned and straightened in the late 1970s.

Preliminary Recommended Plan: The hydrologic unit concerned is predominantly undeveloped and it has drainage patterns consisting primarily of overland flow directly to the unnamed tributary to Quaas Creek. The configuration of the stormwater management system for such an area would, to a large extent, be dictated by a future street layout. On the basis of the density of the planned land uses in this hydrologic unit and because runoff from the unit drains directly to the tributary, 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 could be considered at the time of development if the provision of such storage would achieve 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 QC-I

Evaluation of the Stormwater Management System: Hydrologic Unit QC-I is a 0.94-square mile area located as shown on Map 1 in Chapter I of this volume. Under 1985 land use conditions, only about 16 percent of the hydrologic unit was developed in urban land uses. Under planned year 2010 conditions, the hydrologic unit would be about 54 percent developed in urban uses, predominantly medium-density residential, but would also include governmental and institutional and industrial uses. The remaining 46 percent would be devoted to agricultural, woodlands, wetlands, park and recreational uses.

The existing stormwater management system in the hydrologic unit generally consists of roadside swales, roadway culverts, and overland flow directly to Quaas Creek. Subbasin QC44, which includes the West Bend High Schools campus, is drained by roadway curbs and gutters, storm sewer inlets, and storm sewers.

Minor system capacity was found to be adequate. Problems with the major system capacity were identified at two locations in subbasin QC44 where overflow would occur to the north into Hydrologic Unit MR-Q in the Milwaukee River drainage area. In the intersection of Decorah Road and Sheridan Drive, ponding in a mid-block sag in the road could result in overland flow to the north in Sheridan Drive. The second location where overflow into the Milwaukee River drainage area could occur is at the intersection of S. River Road and Decorah Road. Runoff in excess of existing storm sewer capacity in Decorah Road would overflow into S. River Road north of Decorah Road. Overflow from both locations was accounted for under the recommended stormwater management plan for the Milwaukee River drainage area within the City of West Bend, presented in Volume Three of this report.

Alternative Stormwater Drainage Plans: Future urban development in this hydrologic unit would be concentrated in that portion of the hydrologic unit west of Quaas Creek. The following two alternative stormwater management plans were developed for subbasins QC28, QC32, and QC162: 1) a storm

Table 26

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

Hydrologic Unit	Project and Component Description[a]	Estimated Cost	
		Capital[b]	Annual Operation and Maintenance[c]
QC-I	1. Install 620 feet of new 18-inch-diameter storm sewer	$ 47,000	$ 280
	2. Install 330 feet of new 24-inch-diameter storm sewer	33,000	160
	3. Install 710 feet of new 27-inch-diameter storm sewer	78,000	340
	4. Install 1,765 feet of new 30-inch-diameter storm sewer	222,000	840
	5. Install 1,485 feet of new 36-inch-diameter storm sewer	235,000	340
	6. Install 1,320 feet of new 42-inch-diameter storm sewer	248,000	300
	7. Replace 29-foot-long, 12-inch-diameter CMP under Sand Drive with 15-inch-diameter storm sewer	2,000	0
	Total	$865,000	$2,260

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

[b] *Includes 35 percent for engineering, administration, and contingencies. Costs are for year 1995 with Engineering News-Record CCI = 5,970.*

[c] *Costs were noted to be zero when the alternative proposed replacement of a component with a component having similar operation and maintenance cost.*

Source: SEWRPC.

sewer conveyance plan and 2) a storm sewer conveyance with centralized detention plan.

The remaining areas of this hydrologic unit where urban development is expected have drainage patterns consisting primarily of overland flow directly to Quaas Creek. The configuration of the stormwater management system for such areas would, to a large extent, be dictated by future street layouts. Based on the density of the planned land uses in these areas and because runoff drains directly to Quaas Creek, stormwater drainage systems 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 developments. Detention storage could be considered at the time of development if the provision of such storage would achieve cost savings in the conveyance system through the reduction of peak flows within the hydrologic unit. Drainage improvements in these developments would have only a small impact on the City capital improvements budget since most facilities would be paid for by private developers.

Alternative Plan No. I-1, Storm Sewer Conveyance: Under planned land use conditions, this alternative plan would provide for the conveyance of runoff through the provision of 6,230 lineal feet of new reinforced concrete storm sewer, ranging in size from 18-inch-diameter to 42-inch-diameter pipe. Proposed storm sewers would discharge directly to Quaas Creek. This alternative plan also calls for the replacement of the 12-inch-diameter CMP culvert under Sand Drive located about 900 feet east of CTH G (S. River Road).

Map 4 shows the approximate location and alignment of the storm sewers proposed under this alternative. Table 26 presents the salient characteristics and estimated costs of the proposed drainage components comprising this alternative plan. The total present-value cost of this alternative plan is $901,000, consisting of an estimated capital cost of about $865,000, and an estimated annual operation and maintenance cost increase of about $2,260.

Alternative Plan No. I-2, Storm Sewer Conveyance with Centralized Detention: This alterna-

Table 27

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

Hydrologic Unit	Project and Component Description[a]	Estimated Cost	
		Capital[b]	Annual Operation and Maintenance[c]
QC-I	1. Install 620 feet of new 18-inch-diameter storm sewer	$ 47,000	$ 280
	2. Install 360 feet of new 21-inch-diameter storm sewer	30,000	170
	3. Install 330 feet of new 24-inch-diameter storm sewer	33,000	160
	4. Install 710 feet of new 27-inch-diameter storm sewer	78,000	340
	5. Install 1,765 feet of new 30-inch-diameter storm sewer	222,000	840
	6. Install 1,870 feet of new 36-inch-diameter storm sewer	295,000	420
	7. Construct detention basin I-1 with a storage volume of 1.7-acre-feet	129,000	1,600
	8. 120 feet of 18-inch-diameter storm sewer for basin I-1 inlet	9,000	60
	9. 60 feet of 36-inch-diameter storm sewer for basin I-1 inlet	9,000	10
	10. 120 feet of 18-inch-diameter storm sewer for basin I-1 outlet	9,000	60
	11. Replace 29-foot-long, 12-inch-diameter CMP under Sand Drive with 15-inch-diameter storm sewer	2,000	0
	Total	$863,000	$3,940

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

[b]Includes 35 percent for engineering, administration, and contingencies. Costs are for year 1995 with Engineering News-Record CCI = 5,970.

[c]Costs were noted to be zero when the alternative proposed replacement of a component with a component having similar operation and maintenance cost.

Source: SEWRPC.

tive enables the downsizing of 1,800 lineal feet of proposed new storm sewers due to the reduction in peak flood flows achieved through the provision of detention storage for the control of runoff. This alternative calls for 5,955 lineal feet of new 18-inch- to 36-inch-diameter reinforced concrete storm sewer. The proposed 1.7-acre-foot detention basin would be located west of CTH P and would collect flows from subbasin QC28. As under Alternative Plan No. I-1, Alternative Plan No. I-2 calls for the replacement of the 12-inch-diameter CMP culvert under Sand Drive.

Map 5 shows the approximate location, alignment, and configuration of the facilities called for under this alternative. Table 27 presents the salient characteristics and estimated costs of the proposed storm sewers and the detention basin which comprise this alternative plan. The total present-value cost of this alternative plan is $925,000, consisting of an estimated capital cost of about $863,000, including land acquisition for the detention basin, and an estimated annual operation and maintenance cost increase of about $3,940.

Evaluation of Alternative Stormwater Management Plans: The foregoing information provides a basis for a comparative evaluation of the two alternative stormwater drainage plans. The principal criteria for the comparative evaluation were cost and implementability.

Alternative Plan No. I-1 is less costly than Alternative Plan No. I-2 and would be more readily implemented since it would not require purchasing land or easements for the provision of the detention basin.

Preliminary Recommended Stormwater Drainage Plan: Because of the lower cost of Alternative Plan No. I-1, Storm Sewer Conveyance, it was selected as the preliminary recommended plan for Hydrologic Unit QC-I.

SUMMARY OF THE PRELIMINARY RECOMMENDED STORMWATER DRAINAGE PLAN

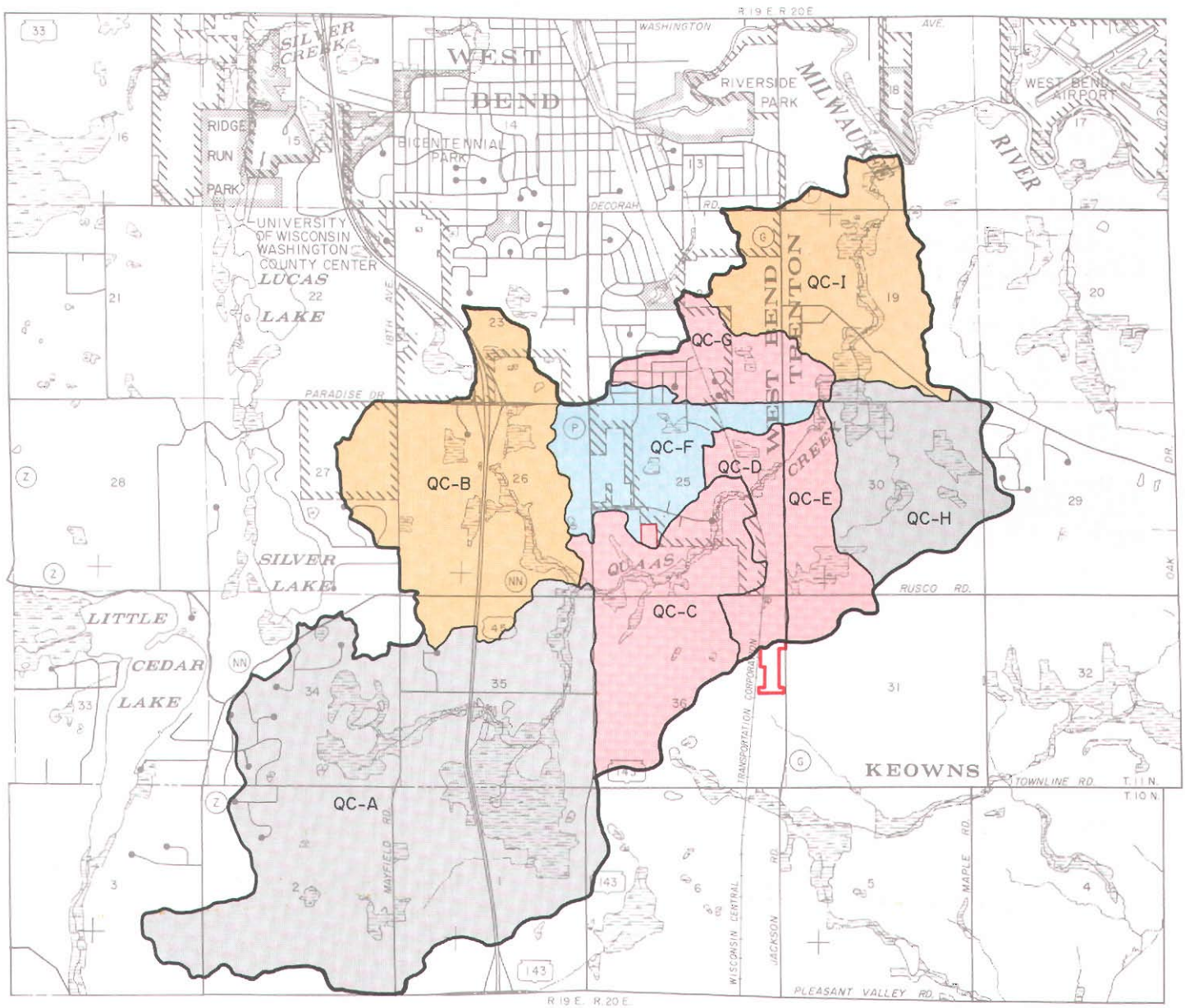
Preliminary recommended stormwater drainage plans were developed for Hydrologic Units QC-B, QC-C, QC-D, QC-E, QC-F, QC-G, and QC-I.[1] As shown on Map 9, the preliminary recommended stormwater drainage plan for the Quaas Creek subwatershed consists of storm sewer conveyance in Hydrologic Units QC-B and QC-I; storm sewer and open channel-roadside swale conveyance with centralized detention in Hydrologic Units QC-C, QC-D, QC-E, and QC-G; and storm sewer and open channel-roadside swale conveyance with expanded centralized detention in Hydrologic Unit QC-F. Those selected alternatives were combined with the recommended water quality management plan element set forth in Chapter II to produce the recommended stormwater management plan. The recommended plan is set forth in the next chapter of this report.

---

[1]*Hydrologic unit QC-A is located outside the planned urban service area, where little urban development is anticipated through the plan design year 2010. Hydrologic Unit QC-H is predominantly undeveloped and has drainage patterns consisting primarily of overland flow directly to an unnamed tributary of Quaas Creek. The configuration of the stormwater management system for that unit would be dictated by a future street layout and would probably consist of a combination of storm sewers and overland flow. Thus, specific stormwater drainage plans were not developed for Hydrologic Units QC-A and QC-H.*

Map 9

SELECTED COMBINATION OF ALTERNATIVE STORMWATER DRAINAGE PLANS FOR THE QUAAS CREEK SUBWATERSHED



LEGEND

- SUBWATERSHED BOUNDARY
- SUBWATERSHED BOUNDARY UNDER PLANNED DRAINAGE CONDITIONS
- HYDROLOGIC UNIT BOUNDARY
- HYDROLOGIC UNIT BOUNDARY UNDER PLANNED DRAINAGE CONDITIONS
- QC-H HYDROLOGIC UNIT DESIGNATION
- STORM SEWER CONVEYANCE ALTERNATIVE PLAN COMPONENTS
- STORM SEWER AND OPEN CHANNEL-ROADSIDE SWALE CONVEYANCE WITH CENTRALIZED DETENTION ALTERNATIVE PLAN COMPONENTS
- STORM SEWER AND OPEN CHANNEL-ROADSIDE SWALE CONVEYANCE WITH EXPANDED CENTRALIZED DETENTION ALTERNATIVE PLAN COMPONENTS
- HYDROLOGIC UNITS FOR WHICH NO DETAILED STORMWATER DRAINAGE RECOMMENDATIONS ARE MADE

GRAPHIC SCALE
0 1 MILE
0 1000 2000 3000 4000 FEET

Source: SEWRPC.

Chapter IV

RECOMMENDED STORMWATER MANAGEMENT SYSTEM PLAN

INTRODUCTION

The recommended stormwater management plan for the Quaas Creek subwatershed consists of three elements: a water quality management element, a stormwater drainage element, and a floodland management element. A preliminary recommended water quality management element and a preliminary recommended stormwater drainage element were presented in Chapters II and III of this volume, respectively. This chapter describes the recommended plan which combines the water quality management and the stormwater drainage elements. This chapter also evaluates the effect of the recommended plan on flood stages in Quaas Creek; presents auxiliary plan recommendations regarding preservation of natural resources and open spaces, revisions to the City floodplain map, and maintenance of stormwater management facilities; and provides estimates of the cost of the recommended plan.

RECOMMENDED STORMWATER MANAGEMENT PLAN

Based on the comparative evaluation of the various alternative plans considered, the minor and major stormwater management system components recommended for inclusion in the stormwater drainage plan element are set forth in Table 28 by hydrologic unit. The recommended stormwater management plan is summarized in graphic form on Map 10. Summary descriptions of the recommended stormwater management plan components for each of the nine hydrologic units in the Quaas Creek subwatershed are provided below.

Hydrologic Unit QC-A

Under planned year 2010 conditions, about 11 percent of Hydrologic Unit QC-A would be developed in urban land uses. These urban land uses would be located entirely outside the City of West Bend planned urban service area. Because minimal urban development would be expected under planned year 2010 conditions, no new stormwater management measures are recommended for this hydrologic unit.

Hydrologic Unit QC-B

Approximately 11 percent of Hydrologic Unit QC-B was developed for urban land uses in 1985. In the plan design, it was assumed that about 54 percent of the hydrologic unit would be developed for urban land uses by the year 2010. Planned urban development would be concentrated in the northern part of this hydrologic unit, in subbasins QC177I and QC14, and in the western part, in subbasins QC7 and QC7C.

Under planned development conditions, the internally drained subbasin QC177I, which is expected to be fully developed for urban uses, could be adequately drained to a depression located in the southern part of the subbasin. The depression, which would be preserved as wetlands and open lands, has adequate volume to store completely, with no outflow, the runoff from a 100-year recurrence interval storm event with a duration of 10 days. In order to provide two feet of freeboard between the 100-year recurrence interval ponding elevation during a 10-day storm and buildings, it is recommended that no development be permitted in the subbasin below elevation 996.3 feet above National Geodetic Vertical Datum (NGVD), 1929 adjustment. That elevation limit on development would also be expected to provide protection during successive, more frequent storms, when the runoff accumulated in the depression may not completely infiltrate or evaporate between storms.

The proposed commercial development in subbasin QC14 north of Paradise Drive would be adequately drained by overland flow to Paradise Drive. Runoff from storm events with recurrence intervals up to, and including, 10 years, would be conveyed in the existing storm sewers under Paradise Drive, which discharge into the headwaters of Quaas Creek.

To accommodate anticipated runoff conditions in the remaining areas of Hydrologic Unit QC-B, the recommended stormwater drainage plan calls for 3,657 lineal feet of new reinforced concrete pipe (RCP) storm sewer, ranging in diameter from 12 inches to 48 inches and 615 lineal feet of 60-inch-

Table 28

COMPONENTS AND COSTS OF THE RECOMMENDED STORMWATER MANAGEMENT PLAN FOR THE QUAAS CREEK SUBWATERSHED IN THE CITY OF WEST BEND STUDY AREA

Hydrologic Unit	Project and Component Description[a]	Estimated Cost	
		Capital[b]	Annual Operation and Maintenance[c]
QC-B	Stormwater Drainage Plan Element		
	1. Install 170 feet of new 12-inch-diameter storm sewer	$ 9,000	$ 80
	2. Install 170 feet of new 18-inch-diameter storm sewer	13,000	80
	3. Install 505 feet of new 21-inch-diameter storm sewer	43,000	240
	4. Install 402 feet of new 24-inch-diameter storm sewer	40,000	190
	5. Install 460 feet of new 27-inch-diameter storm sewer	51,000	220
	6. Install 335 feet of new 30-inch-diameter storm sewer	42,000	160
	7. Install 985 feet of new 42-inch-diameter storm sewer	184,000	230
	8. Install 630 feet of new 48-inch-diameter storm sewer	145,000	140
	9. Install 615 feet of new 68-inch-wide by 43-inch-high HE storm sewer	189,000	140
	10. Replace 30-inch-diameter CMP under CTH NN with 24-inch-diameter storm sewer	5,000	10
	Stormwater Drainage Subtotal	$ 721,000	$ 1,490
	Water Quality Management Plan Element		
	11. Infiltrate runoff from 3.8 acres of commercial parking lots	$ 75,000	$ 3,000
	12. Wet basin QCWD13 with a permanent pond area of 3.37 acres and a pond storage volume of 2.3 acre-feet	--	1,800
	Water Quality Subtotal	$ 75,000	$ 4,800
	Subtotal	$ 796,000	$ 6,290
QC-C	Stormwater Drainage Plan Element		
	1. Install 170 feet of new 15-inch-diameter storm sewer	$ 11,000	$ 80
	2. Install 840 feet of new 18-inch-diameter storm sewer	62,000	400
	3. Install 260 feet of new 21-inch-diameter storm sewer	22,000	120
	4. Install 280 feet of new 24-inch-diameter storm sewer	28,000	130
	5. Install 1,090 feet of new 27-inch-diameter storm sewer	121,000	520
	6. Install 350 feet of new 36-inch-diameter storm sewer	55,000	80
	7. Install 620 feet of new 42-inch-diameter storm sewer	117,000	140
	8. Install 500 feet of new 45-inch-wide by 29-inch-high HE storm sewer	88,000	120
	9. Replace 41-foot-long, 36-inch-diameter CMP under Rusco Road with double 21-foot-long, 38-inch-wide by 24-inch-high HE storm sewer followed by double 21-foot-long, 45-inch-wide by 29-inch-high HE storm sewer	18,000	10
	10. Replace 18-inch-diameter CMP under Rusco Road with 21-inch-diameter reinforced concrete culvert	6,000	0
	11. Construct 340-foot-long, 10-foot-wide bottom trapezoidal open channel from proposed storm sewer outfall to existing drainage swale south of Rusco Road	4,000	140
	12. Construct 550-foot-long, 5-foot-wide bottom, grass-lined trapezoidal open channel with clay liner on its west side from proposed storm sewer outfall to about 130 feet south of Quaas Creek	3,000	220
	13. Construct 110-foot-long, 3-foot-wide bottom, grass-lined trapezoidal open channel with clay liner on its east side from proposed storm sewer outfall to about 380 feet south of Quaas Creek	1,000	40
	Stormwater Drainage Subtotal	$ 536,000	$ 2,000

Table 28 (continued)

Hydrologic Unit	Project and Component Description[a]	Estimated Cost	
		Capital[b]	Annual Operation and Maintenance[c]
QC-C (continued)	Water Quality Management Plan Element		
	14. Infiltrate runoff from 1.9 acres of commercial parking lots	$ 90,000	$ 4,000
	15. Sweep about 35 acres of industrial parking lots and storage areas	21,000	23,100
	16. Wet basin QCWD3 with a permanent pond area of 1.46 acres and a pond storage volume of 3.5 acre-feet	--[d]	2,100
	17. Wet basin QCWD4 with a permanent pond area of 0.30 acres and a pond storage volume of 0.6 acre-feet	--[d]	1,400
	18. Wet basin QCWD5 with a permanent pond area of 0.34 acres and a pond storage volume of 1.0 acre-feet	--[d]	1,500
	Water Quality Subtotal	$ 111,000	$32,100
	Subtotal	$ 647,000	$34,100
QC-D, QC-E	Stormwater Drainage Plan Element		
	1. Install 650 feet of new 18-inch-diameter storm sewer	$ 49,000	$ 310
	2. Install 600 feet of new 21-inch-diameter storm sewer	50,000	290
	3. Install 450 feet of new 24-inch-diameter storm sewer	44,000	210
	4. Install 600 feet of new 27-inch-diameter storm sewer	66,000	290
	5. Install 560 feet of new 36-inch-diameter storm sewer	88,000	130
	6. Install 790 feet of new 42-inch-diameter storm sewer	148,000	180
	7. Install 470 feet of new 48-inch-diameter storm sewer	108,000	110
	8. Install 330 feet of new 60-inch-wide by 38-inch-high HE storm sewer	89,000	70
	9. Construct dual purpose wet basin QCWD9 with a 10-year live storage volume of 4.9 acre-feet Water quantity control cost	124,000	2,000
	10. 80 feet of 45-inch-wide by 29-inch-high HE storm sewer for basin QCWD9 outlet	14,000	20
	11. Replace 24-inch-diameter CMP under Rusco Road with double 45-inch-wide by 29-inch-high HE culvert	26,000	0
	12. Replace 18-inch-diameter CMP under Private Drive in Kreilkamp development with double 45-inch-wide by 29-inch-high HE culvert at a slope of 0.17 percent	12,000	10
	13. Install riprap along 800 feet of existing roadside swale along west side of CTH G north of Rusco Road	53,000	320
	14. Deepen and widen 220 feet of existing roadside swale along south side of Rusco Road west of CTH G	2,000	0
	15. Deepen 210 feet of existing roadside swale along north side of Rusco Road west of CTH G	1,000	0
	16. Construct 200-foot-long, grass-lined trapezoidal open channel from existing drainage swale to CTH G	3,000	80
	Stormwater Drainage Subtotal	$ 877,000	$ 4,020
	Water Quality Management Plan Element		
	17. Dual purpose wet basin QCWD9 with a permanent pond area of 1.90 acres and a pond storage volume of 9.5 acre-feet. Water quality control cost	$ 275,000	$ 4,600
	18. Wet basin QCWD12 with a permanent pond area of 0.47 acres and a pond storage volume of 2.4 acre-feet[e]	89,000	1,900
	Water Quality Subtotal	$ 364,000	$ 6,500
	Subtotal	$1,241,000	$10,520

Table 28 (continued)

Hydrologic Unit	Project and Component Description[a]	Estimated Cost	
		Capital[b]	Annual Operation and Maintenance[c]
QC-F	Stormwater Drainage Plan Element		
	1. Install one 80-foot-long, 42-inch-diameter reinforced concrete pipe culvert under future Paradise Parkway	$ 15,000	$ 20
	2. Replace 24-inch-diameter CMP under CTH P with 38-inch-wide by 24-inch-high concrete HE culvert	9,000	-10
	3. Construct detention basin F-1 with a 100-year storage volume of 3.4-acre-feet	26,000	2,400
	Stormwater Drainage Subtotal	$ 50,000	$ 2,410
	Water Quality Management Plan Element		
	4. Wet basin QCWD1 with a permanent pond area of 0.73 acres and a pond storage volume of 2.0 acre-feet	--[d]	$ 1,700
	5. Wet basin QCWD2 with a permanent pond area of 0.33 acres and a pond storage volume of 1.2 acre-feet	--[d]	1,500
	6. Wet basin QCWD8 with a permanent pond area of 0.74 acres and a pond storage volume of 3.7 acre-feet	$ 146,000	2,200
	7. Wet basin QCWD10 with a permanent pond area of 1.0 acres and a pond storage volume of 5.0 acre-feet[e]	161,000	2,900
	Water Quality Subtotal	$ 307,000	$ 8,300
	Subtotal	$ 357,000	$10,710
QC-G	Stormwater Drainage Plan Element		
	1. Install 225 feet of new 21-inch-diameter storm sewer	$ 19,000	$ 110
	2. Install 885 feet of new 24-inch-diameter storm sewer	97,000	470
	3. Install 785 feet of new 27-inch-diameter storm sewer	87,000	380
	4. Install 665 feet of new 36-inch-diameter storm sewer	105,000	140
	5. Install 105 feet of new 48-inch-diameter storm sewer	24,000	20
	6. Install 515 feet of new 53-inch-wide by 34-inch-high HE storm sewer	114,000	120
	7. Replace 91 feet of 56-inch CMP culvert under CTH G with double 48-inch storm sewer	56,000	20
	8. Replace 121 feet of 58-inch-wide by 36-inch-high CMPA under Indiana Avenue with a 53-inch-wide by 34-inch-high HE culvert at a slope of 0.52 percent	38,000	0
	9. Replace 85 feet of 65-inch-wide by 40-inch-high CMPA under Crocus Court with a 60-inch-wide by 38-inch-high HE culvert	32,000	0
	10. Regrade 900 feet of roadside swale north of Paradise Drive and west of CTH G	48,000	0
	11. Realign 450 feet of roadside swale north of Paradise Drive and west of CTH G	65,000	0
	12. Construct dry detention basin G-1 with a storage volume of 1.4-acre-feet	92,000	1,400
	13. 270 feet of 42-inch storm sewer for basin G-1 inlet	51,000	60
	14. 130 feet of 15-inch storm sewer for basin G-1 outlet	8,000	60
	Stormwater Drainage Subtotal	$ 836,000	$ 2,780
	Water Quality Management Plan Element		
	15. Sweep about 2.5 acres of industrial parking lots and storage areas	$ 2,000	$ 1,600
	Water Quality Subtotal	$ 2,000	$ 1,600
	Subtotal	$ 838,000	$ 4,380

Table 28 (continued)

Hydrologic Unit	Project and Component Description[a]	Estimated Cost	
		Capital[b]	Annual Operation and Maintenance[c]
QC-I	Stormwater Drainage Plan Element		
	1. Install 620 feet of new 18-inch-diameter storm sewer	$ 47,000	$ 280
	2. Install 330 feet of new 24-inch-diameter storm sewer	33,000	160
	3. Install 710 feet of new 27-inch-diameter storm sewer	78,000	340
	4. Install 1,765 feet of new 30-inch-diameter storm sewer	222,000	840
	5. Install 1,485 feet of new 36-inch-diameter storm sewer	235,000	340
	6. Install 1,320 feet of new 42-inch-diameter storm sewer	248,000	300
	7. Replace 29-foot-long, 12-inch-diameter CMP under Sand Drive with 15-inch-diameter storm sewer	2,000	0
	Stormwater Drainage Subtotal	$ 865,000	$ 2,260
	Water Quality Management Plan Element		
	8. Wet detention basin QCWD11 with a permanent pond area of 0.76 acres and a pond storage volume of 3.8 acre-feet	$ 154,000	$ 2,200
	9. Sweep about five acres of industrial parking lots and storage areas	3,000	3,400
	Water Quality Subtotal	$ 157,000	$ 5,600
	Subtotal	$1,022,000	$ 7,860
--	Total	$4,901,000	$73,860

NOTE: The following abbreviations have been used:

CMP	Corrugated metal pipe
CMPA	Corrugated metal pipe arch
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 1995 with Engineering News-Record CCI = 5,970.*

[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] *Wet basins constructed in Industrial Park-South since the 1985 baseline date for which existing condition nonpoint source pollutant loadings were estimated. No capital cost assigned.*

[e] *Expansions of Industrial Park-South dry detention basins E and C, respectively, to include permanent ponds.*

Source: SEWRPC.

wide by 38-inch-high horizontal elliptical (HE) RCP. Discharge from proposed storm sewers in subbasin QC7C would be conveyed through a wetland in an existing drainageway and then under USH 45 through an existing 66-inch-diameter RCP culvert which discharges to Quaas Creek. In addition, the recommended plan calls for the replacement of the 30-inch-diameter corrugated metal pipe (CMP) culvert under CTH NN with a 24-inch-diameter RCP.

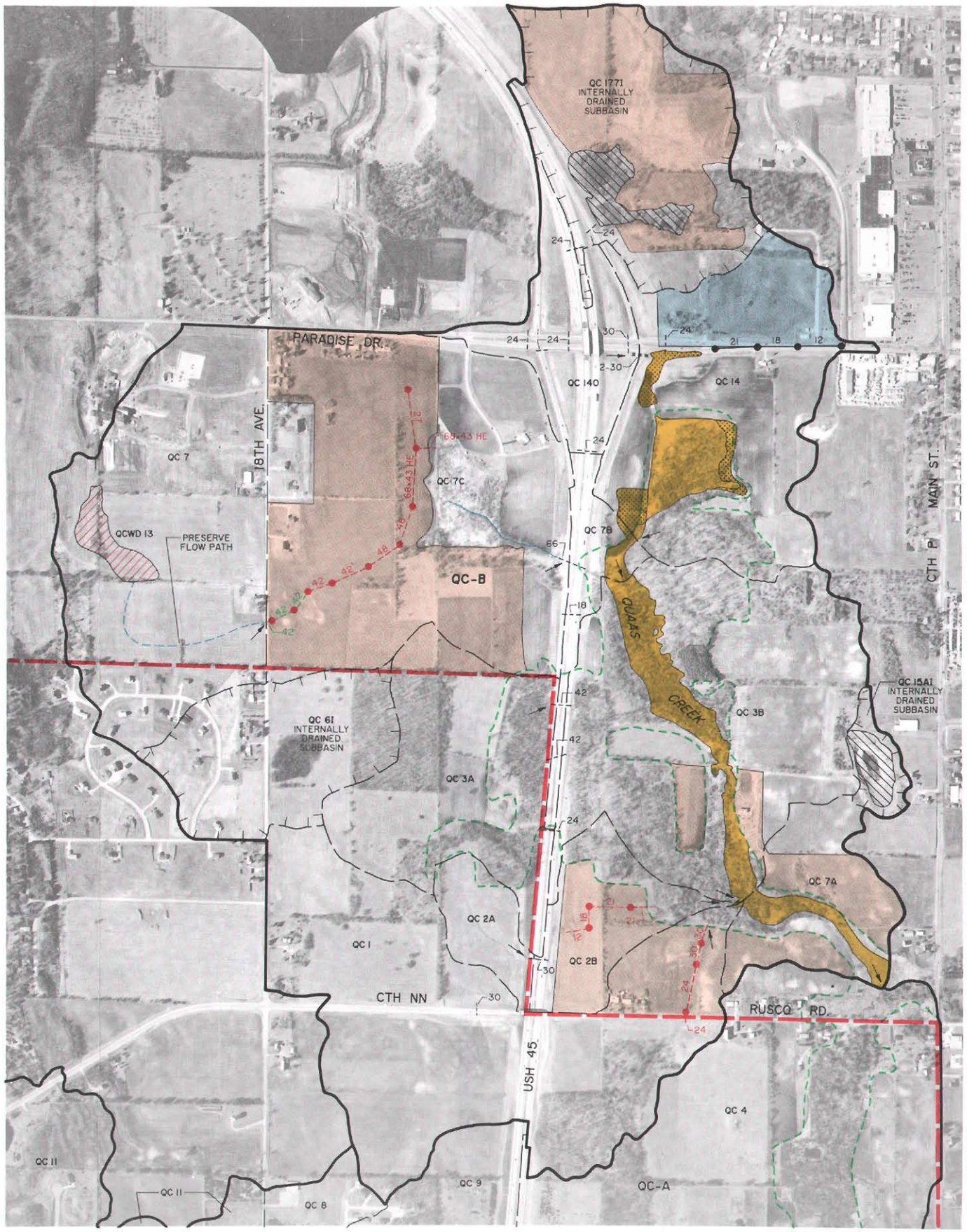
The recommended plan assumes utilization of the existing detention basin located in the southwest area of the West Bend Mutual Insurance Company property. This detention basin provides both stormwater quality and quantity control, has a permanent pond area of about 3.3 acres, and its outlet consists of overland flow to the south into an area which is proposed to be developed as commercial offices. The recommended plan calls for maintaining a flow path to convey flows from this detention basin to the proposed storm sewer inlet at 18th Avenue. The alignment of that flow path, as shown on Map 10, may be altered to suit site development conditions.

The recommended water quality management plan element presented in Chapter II of this volume

Map 10

RECOMMENDED SYSTEM PLAN FOR STORMWATER MANAGEMENT FOR THE QUAAS CREEK SUBWATERSHED

HYDROLOGIC UNITS QC-A AND QC-B



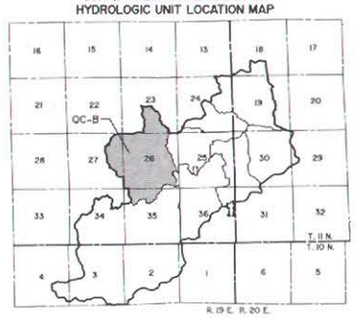
LEGEND

- HYDROLOGIC UNIT BOUNDARY UNDER EXISTING DRAINAGE CONDITIONS
- QC-B HYDROLOGIC UNIT IDENTIFICATION
- LIMITS OF PLANNED URBAN SERVICE AREA
- SUBBASIN BOUNDARY UNDER EXISTING DRAINAGE CONDITIONS
- QC 3A SUBBASIN IDENTIFICATION
- SUBBASIN OUTLET
- 12 EXISTING STORM SEWER TO BE RETAINED (SIZE IN INCHES)
- EXISTING MANHOLE OR CATCHBASIN
- 42 EXISTING CULVERT (SIZE IN INCHES)
- EXISTING OPEN CHANNEL
- EXISTING NATURAL DETENTION OR RETENTION STORAGE AREA
- 24 PROPOSED REPLACEMENT STORM SEWER OR CULVERT DESIGNED FOR 10-YEAR STORM (SIZE IN INCHES)
- 42 PROPOSED STORM SEWER OR CULVERT DESIGNED FOR 10-YEAR STORM (SIZE IN INCHES)
- 42 PROPOSED STORM SEWER OR CULVERT DESIGNED FOR 100-YEAR STORM (SIZE IN INCHES)
- PROPOSED MANHOLE
- QCWD 13 PERMANENT POND AREA OF WET DETENTION BASIN AND DESIGNATION
- PRIMARY ENVIRONMENTAL CORRIDOR BOUNDARY
- 100-YEAR RECURRENCE INTERVAL FLOOD INUNDATION AREA UNDER PLANNED 2010 LAND USE AND RECOMMENDED DRAINAGE CONDITIONS
- PROPOSED INFILTRATION SYSTEMS TO RETAIN RUNOFF FROM 50% OF COMMERCIAL PARKING LOTS
- AREAS OF PLANNED MEDIUM DENSITY AND TWO-FAMILY RESIDENTIAL DEVELOPMENT TO BE SERVED BY STORM SEWERS AND WHERE LOW-COST RUNOFF INFILTRATION PRACTICES ARE TO BE ENCOURAGED
- AREA OF DISTURBED TOPOGRAPHY. FLOOD INUNDATION AREA IS APPROXIMATED USING SITE GRADING PLANS AND LIMITED AS-BUILT DATA, BOTH OF WHICH WERE PROVIDED BY THE CITY OF WEST BEND.

HE HORIZONTAL ELLIPTICAL

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

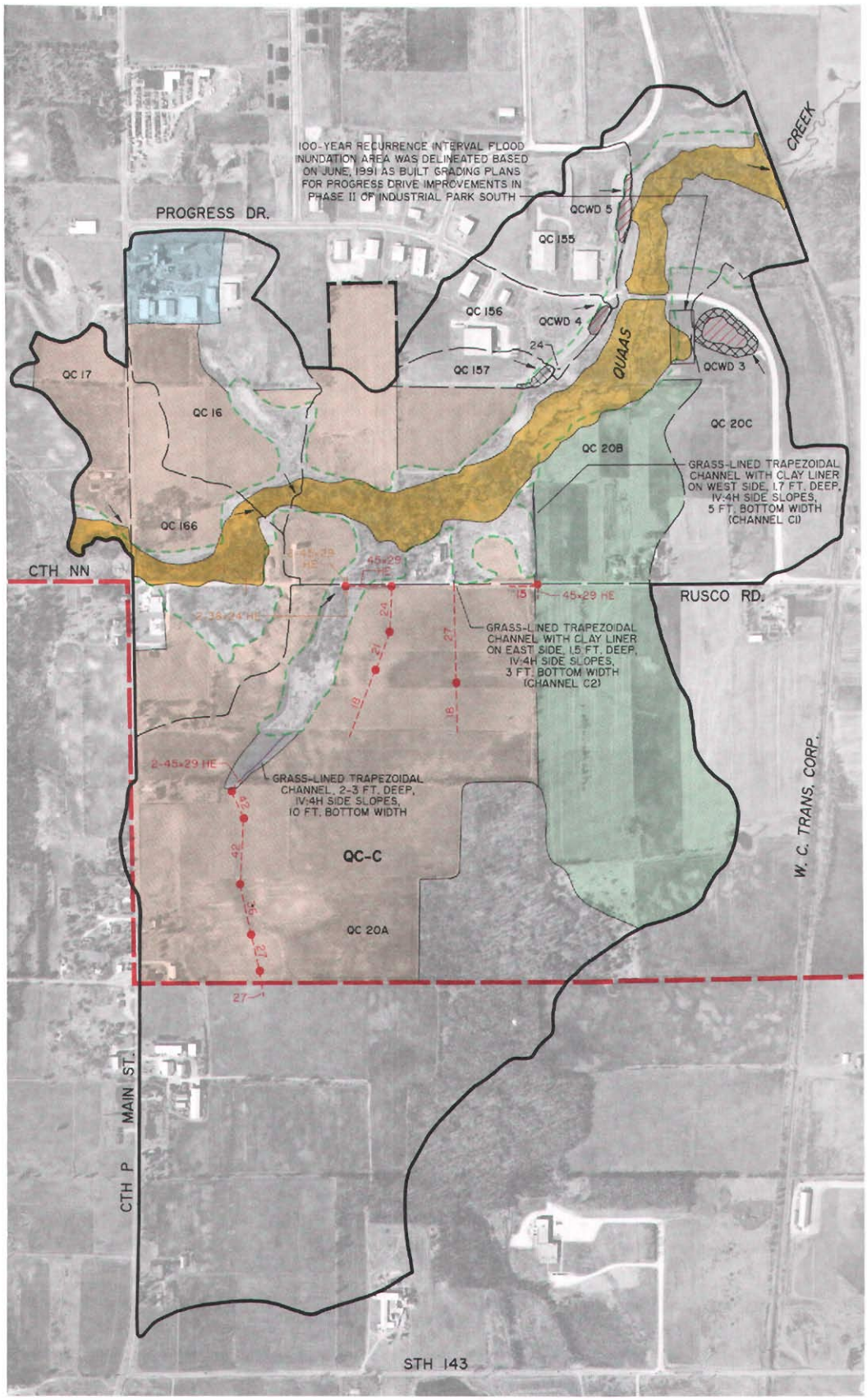
QUAAS CREEK DRAINAGE AREA
HYDROLOGIC UNIT LOCATION MAP



Map 10 (continued)

RECOMMENDED SYSTEM PLAN FOR STORMWATER MANAGEMENT FOR THE QUAAS CREEK SUBWATERSHED

HYDROLOGIC UNIT QC-C

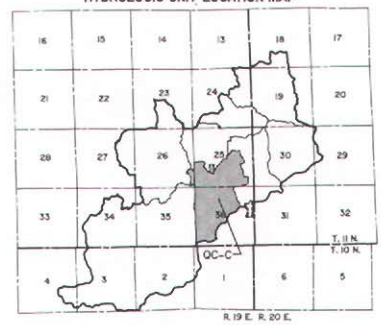


LEGEND

- HYDROLOGIC UNIT BOUNDARY UNDER EXISTING DRAINAGE CONDITIONS
- HYDROLOGIC UNIT BOUNDARY UNDER PLANNED DRAINAGE CONDITIONS
- QC-C HYDROLOGIC UNIT IDENTIFICATION
- LIMITS OF PLANNED URBAN SERVICE AREA
- SUBBASIN BOUNDARY UNDER EXISTING DRAINAGE CONDITIONS
- QC 166 SUBBASIN IDENTIFICATION
- SUBBASIN OUTLET
- 24 EXISTING CULVERT (SIZE IN INCHES)
- EXISTING CONSTRUCTED DETENTION BASIN
- 21 PROPOSED REPLACEMENT STORM SEWER OR CULVERT DESIGNED FOR 50-YEAR STORM (SIZE IN INCHES)
- 21 PROPOSED STORM SEWER OR CULVERT DESIGNED FOR 10-YEAR STORM (SIZE IN INCHES)
- PROPOSED MANHOLE
- PROPOSED OPEN CHANNEL
- QCWD 3 PERMANENT POND AREA OF WET DETENTION BASIN AND DESIGNATION
- PRIMARY ENVIRONMENTAL CORRIDOR BOUNDARY
- 100-YEAR RECURRENCE INTERVAL FLOOD INUNDATION AREA UNDER PLANNED 2010 LAND USE AND RECOMMENDED DRAINAGE CONDITIONS
- PROPOSED INFILTRATION SYSTEMS TO RETAIN RUNOFF FROM 50% OF COMMERCIAL PARKING LOTS
- AREA TRIBUTARY TO INDUSTRIAL PARKING LOT OR STORAGE AREA TO BE SWEPT WEEKLY IN SPRING, SUMMER, AND FALL
- AREAS OF PLANNED MEDIUM DENSITY AND TWO-FAMILY RESIDENTIAL DEVELOPMENT TO BE SERVED BY STORM SEWERS AND WHERE LOW-COST RUNOFF INFILTRATION PRACTICES ARE TO BE ENCOURAGED
- HE HORIZONTAL ELLIPTICAL

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

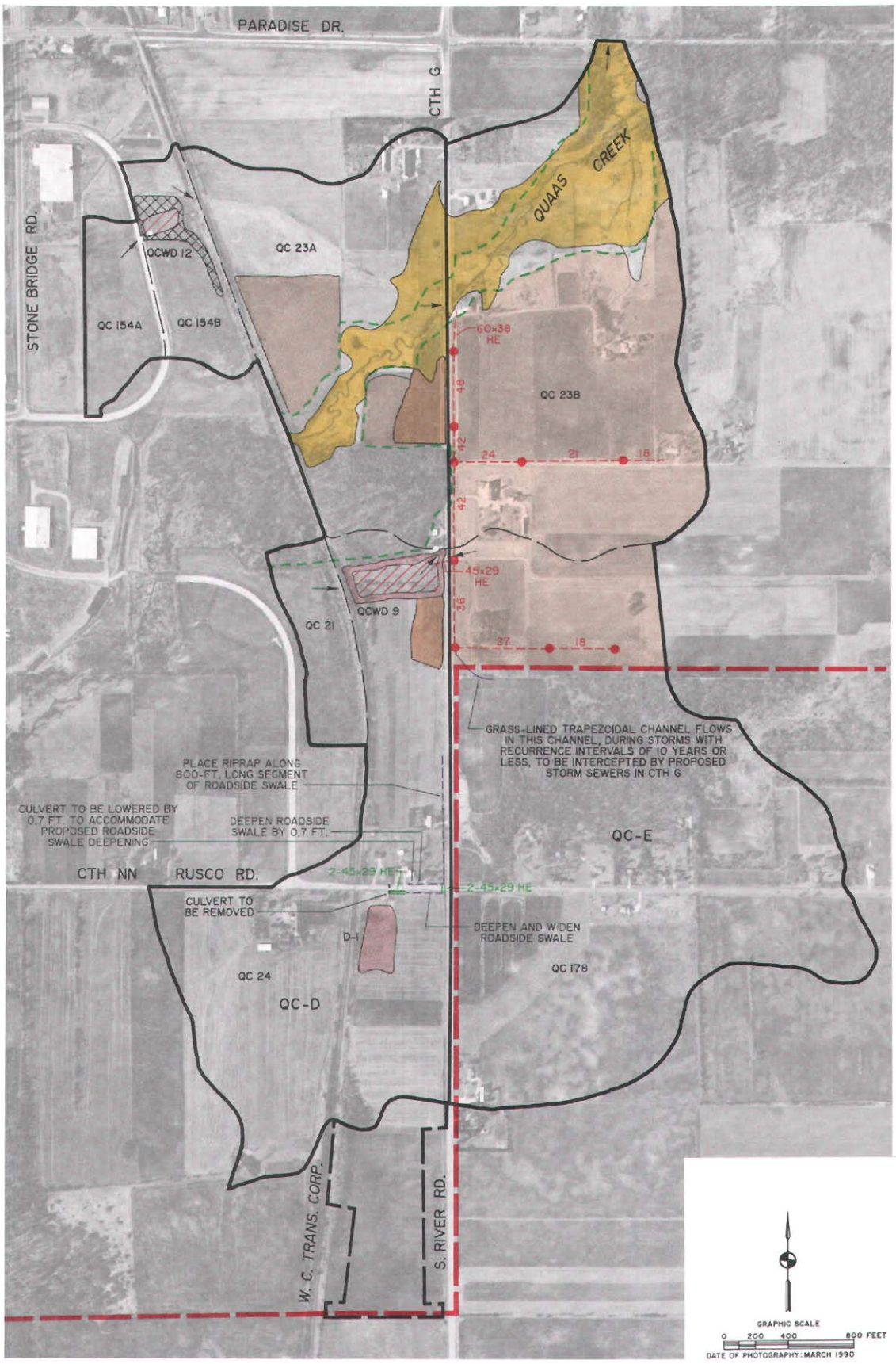
QUAAS CREEK DRAINAGE AREA
HYDROLOGIC UNIT LOCATION MAP



Map 10 (continued)

RECOMMENDED SYSTEM PLAN FOR STORMWATER MANAGEMENT FOR THE QUAAS CREEK SUBWATERSHED

HYDROLOGIC UNITS QC-D AND QC-E

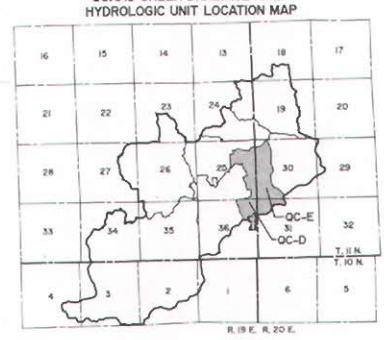


LEGEND

- HYDROLOGIC UNIT BOUNDARY UNDER EXISTING DRAINAGE CONDITIONS
- HYDROLOGIC UNIT BOUNDARY UNDER PLANNED DRAINAGE CONDITIONS
- QC-D — HYDROLOGIC UNIT IDENTIFICATION
- LIMITS OF PLANNED URBAN SERVICE AREA
- SUBBASIN BOUNDARY UNDER EXISTING DRAINAGE CONDITIONS
- QC 24 — SUBBASIN IDENTIFICATION
- SUBBASIN OUTLET
- EXISTING CONSTRUCTED DETENTION BASIN
- 45×29 HE — PROPOSED REPLACEMENT STORM SEWER OR CULVERT DESIGNED FOR 100-YEAR STORM (SIZE IN INCHES)
- 24 — PROPOSED STORM SEWER OR CULVERT DESIGNED FOR 10-YEAR STORM (SIZE IN INCHES)
- PROPOSED MANHOLE
- PROPOSED ROADSIDE SWALE OR OPEN CHANNEL MODIFICATION
- PROPOSED OPEN CHANNEL
- QCWD 9 — PERMANENT POND AREA OF PROPOSED WET DETENTION BASIN AND DESIGNATION
- QCWD 9 — PROPOSED DUAL-PURPOSE DETENTION BASIN AND DESIGNATION
- D-I — PROPOSED DRY DETENTION BASIN AND DESIGNATION
- AREA OF PLANNED DEVELOPMENT ASSUMED TO BE REGRADED SO AS TO DRAIN TO ROADWAY
- PRIMARY ENVIRONMENTAL CORRIDOR BOUNDARY
- 100-YEAR RECURRENCE INTERVAL FLOOD INUNDATION AREA UNDER PLANNED 2010 LAND USE AND RECOMMENDED DRAINAGE CONDITIONS
- AREAS OF PLANNED MEDIUM DENSITY AND TWO-FAMILY RESIDENTIAL DEVELOPMENT TO BE SERVED BY STORM SEWERS AND WHERE LOW-COST RUNOFF INFILTRATION PRACTICES ARE TO BE ENCOURAGED
- HE — HORIZONTAL ELLIPTICAL

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

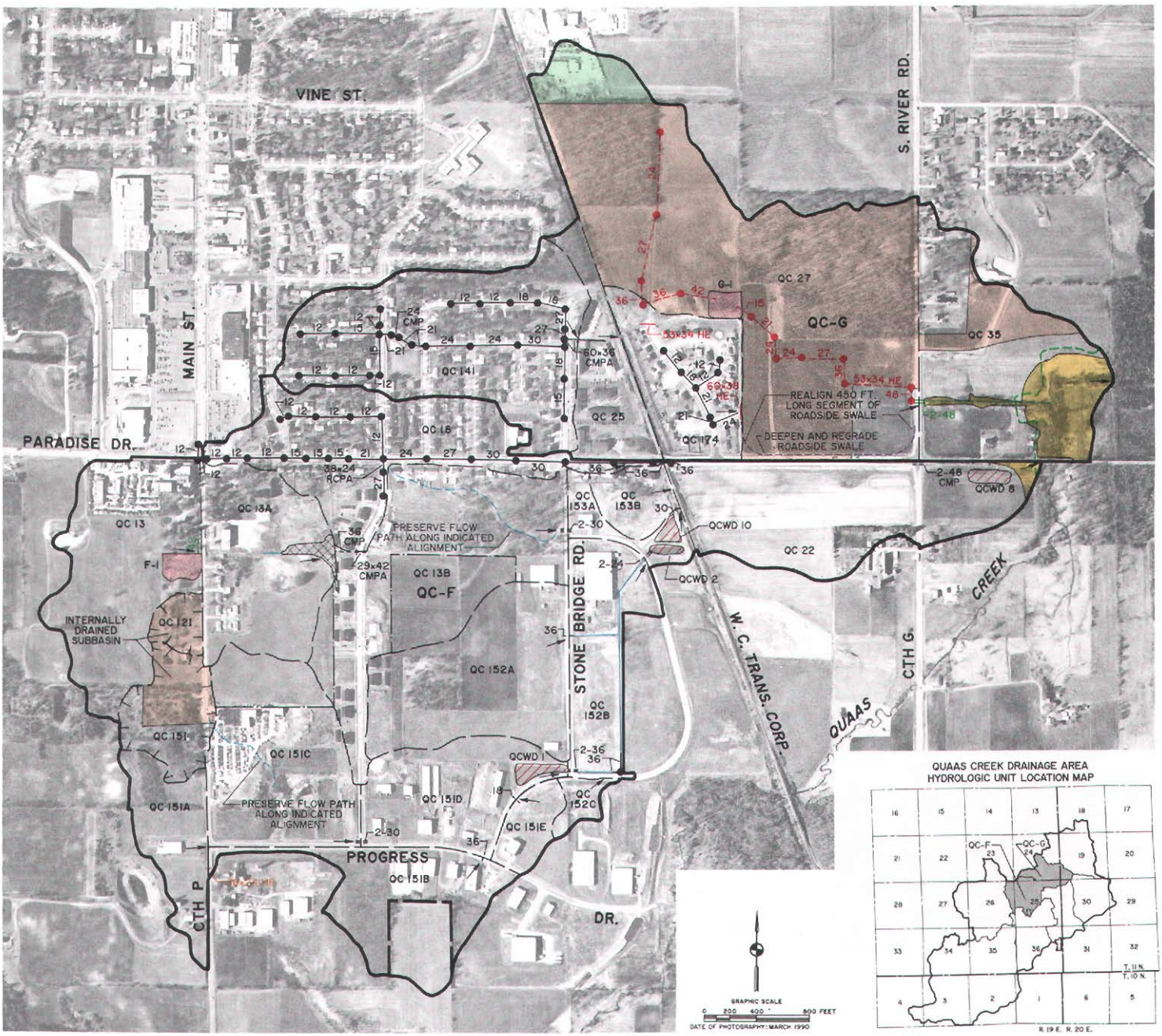
QUAAS CREEK DRAINAGE AREA
HYDROLOGIC UNIT LOCATION MAP



Map 10 (continued)

RECOMMENDED SYSTEM PLAN FOR STORMWATER MANAGEMENT FOR THE QUAAS CREEK SUBWATERSHED

HYDROLOGIC UNITS QC-F AND QC-G



QUAAS CREEK DRAINAGE AREA
HYDROLOGIC UNIT LOCATION MAP

LEGEND

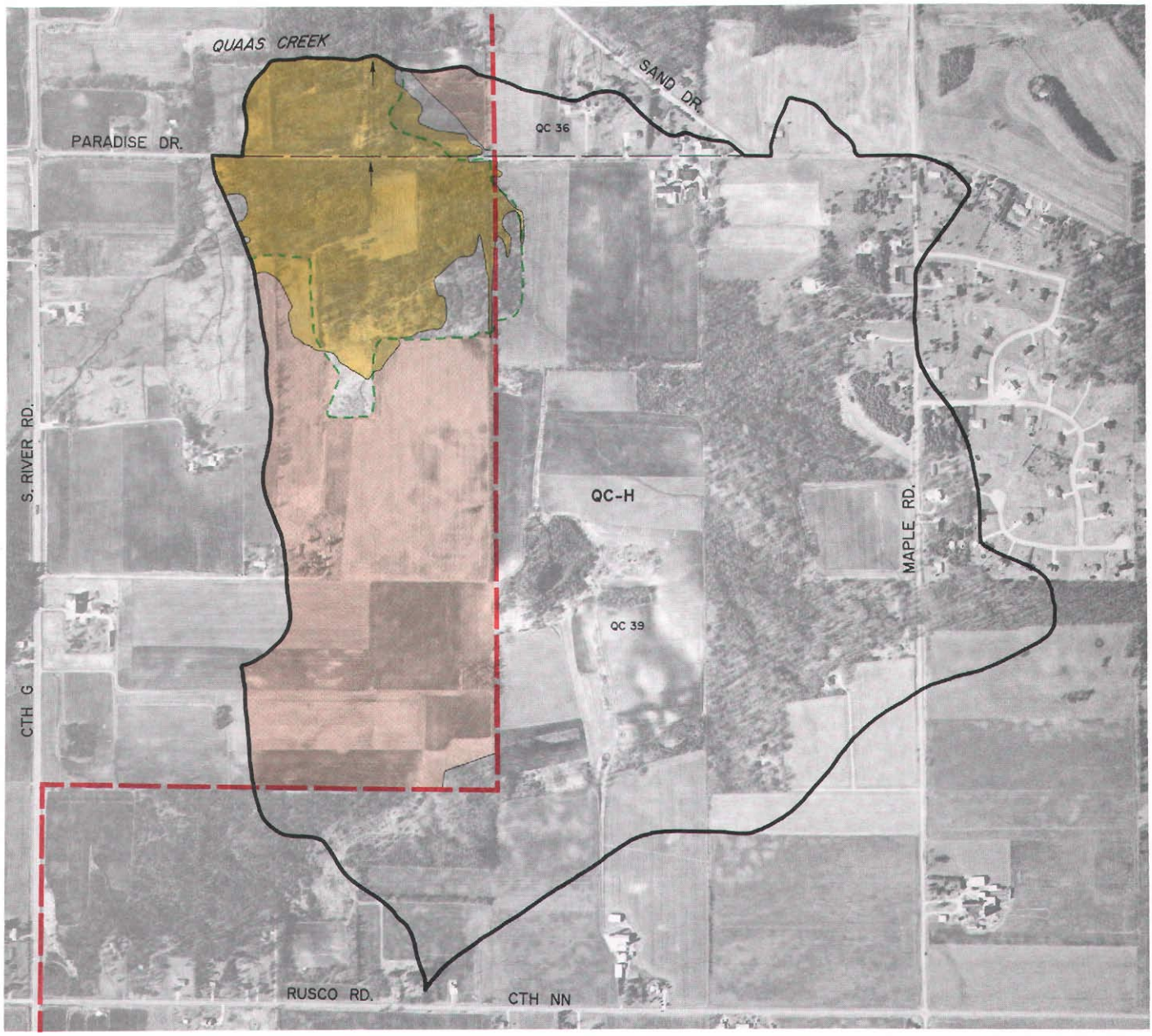
- HYDROLOGIC UNIT BOUNDARY UNDER EXISTING DRAINAGE CONDITIONS
- HYDROLOGIC UNIT BOUNDARY UNDER PLANNED DRAINAGE CONDITIONS
- QC-G HYDROLOGIC UNIT IDENTIFICATION
- SUBBASIN BOUNDARY UNDER EXISTING DRAINAGE CONDITIONS
- SUBBASIN BOUNDARY UNDER PLANNED DRAINAGE CONDITIONS
- QC 13A SUBBASIN IDENTIFICATION
- SUBBASIN OUTLET
- 12 EXISTING STORM SEWER TO BE RETAINED (SIZE IN INCHES)
- EXISTING MANHOLE OR CATCHBASIN
- 36 EXISTING CULVERT (SIZE IN INCHES)
- EXISTING OPEN CHANNEL
- EXISTING CONSTRUCTED DETENTION BASIN
- 60×38 HE PROPOSED REPLACEMENT STORM SEWER OR CULVERT DESIGNED FOR 10-YEAR STORM (SIZE IN INCHES)
- 38×24 HE PROPOSED REPLACEMENT STORM SEWER OR CULVERT DESIGNED FOR 50-YEAR STORM (SIZE IN INCHES)
- 2-48 PROPOSED REPLACEMENT STORM SEWER OR CULVERT DESIGNED FOR 100-YEAR STORM (SIZE IN INCHES)
- 36 PROPOSED STORM SEWER OR CULVERT DESIGNED FOR 10-YEAR STORM (SIZE IN INCHES)
- 42 PROPOSED STORM SEWER OR CULVERT DESIGNED FOR 100-YEAR STORM (SIZE IN INCHES)
- PROPOSED MANHOLE
- PROPOSED ROADSIDE SWALE OR OPEN CHANNEL MODIFICATION
- QCWD 2 PERMANENT POND AREA OF WET DETENTION BASIN AND DESIGNATION
- G-1 PROPOSED DRY DETENTION BASIN AND DESIGNATION
- PRIMARY ENVIRONMENTAL CORRIDOR BOUNDARY
- 100-YEAR RECURRENCE INTERVAL FLOOD INUNDATION AREA UNDER PLANNED 2010 LAND USE AND RECOMMENDED DRAINAGE CONDITIONS
- AREA TRIBUTARY TO INDUSTRIAL PARKING LOT OR STORAGE AREA TO BE SWEPT WEEKLY IN SPRING, SUMMER, AND FALL
- AREAS OF PLANNED MEDIUM DENSITY AND TWO-FAMILY RESIDENTIAL DEVELOPMENT TO BE SERVED BY STORM SEWERS AND WHERE LOW-COST RUNOFF INFILTRATION PRACTICES ARE TO BE ENCOURAGED

CMP CORRUGATED METAL PIPE
CMPA CORRUGATED METAL PIPE ARCH
HE HORIZONTAL ELLIPTICAL
RCPA REINFORCED CONCRETE PIPE ARCH
NOTE: PIPES ARE CONSTRUCTED OF REINFORCED CONCRETE UNLESS DESIGNATED AS ABOVE.

Map 10 (continued)

RECOMMENDED SYSTEM PLAN FOR STORMWATER MANAGEMENT FOR THE QUAAS CREEK SUBWATERSHED

HYDROLOGIC UNIT QC-H

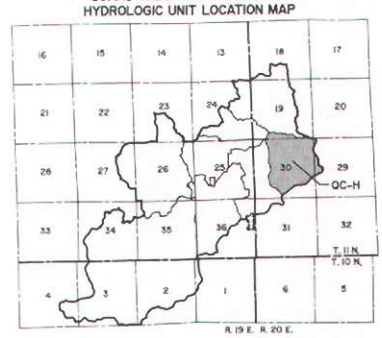


LEGEND

- HYDROLOGIC UNIT BOUNDARY UNDER EXISTING DRAINAGE CONDITIONS
- QC-H HYDROLOGIC UNIT IDENTIFICATION
- LIMITS OF PLANNED URBAN SERVICE AREA
- SUBBASIN BOUNDARY UNDER EXISTING DRAINAGE CONDITIONS
- QC 39 SUBBASIN IDENTIFICATION
- SUBBASIN OUTLET
- PRIMARY ENVIRONMENTAL CORRIDOR BOUNDARY
- 100-YEAR RECURRENCE INTERVAL FLOOD INUNDATION AREA UNDER PLANNED 2010 LAND USE AND RECOMMENDED DRAINAGE CONDITIONS
- AREAS OF PLANNED MEDIUM DENSITY AND TWO-FAMILY RESIDENTIAL DEVELOPMENT TO BE SERVED BY STORM SEWERS AND WHERE LOW-COST RUNOFF INFILTRATION PRACTICES ARE TO BE ENCOURAGED

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

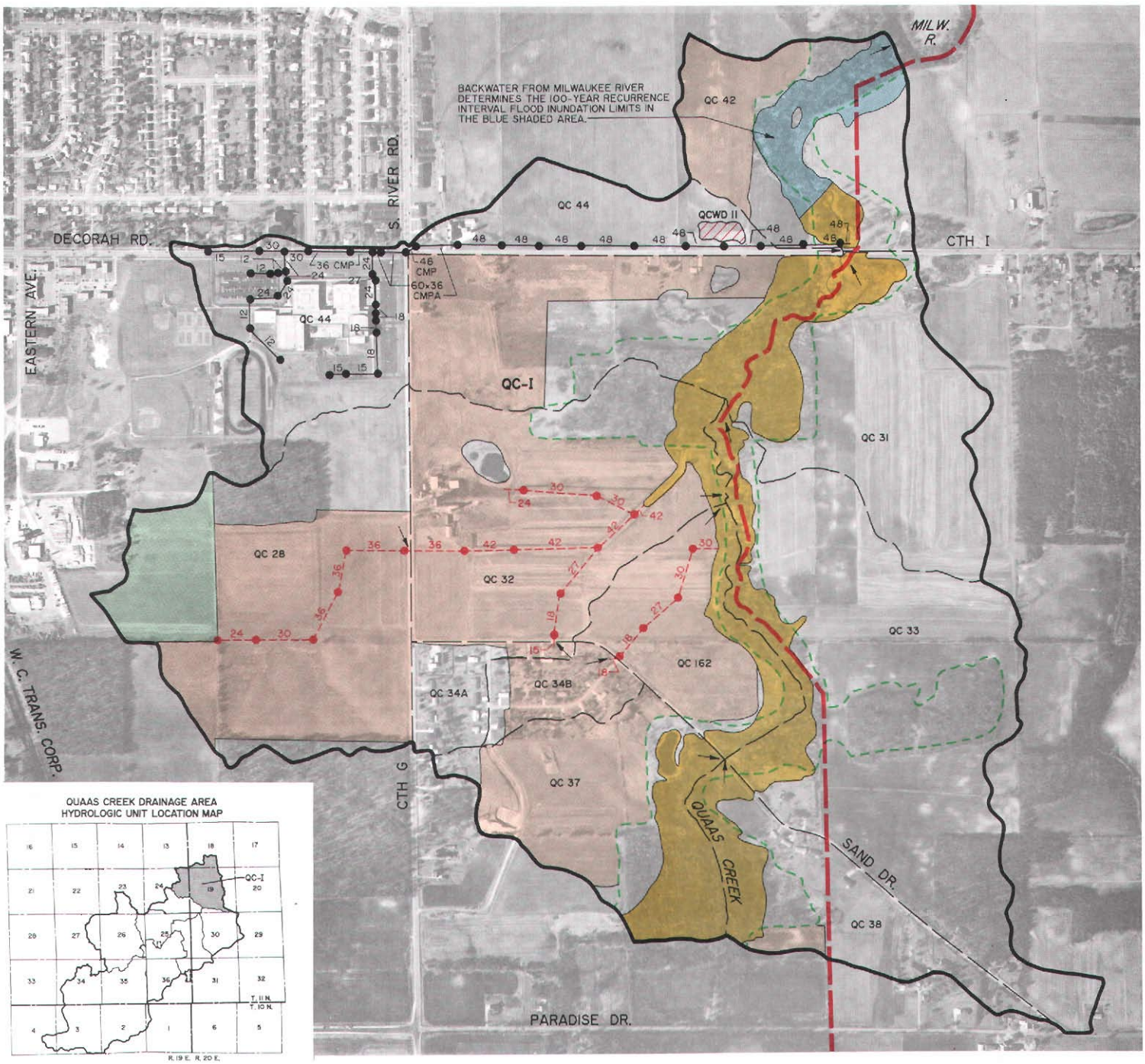
QUAAS CREEK DRAINAGE AREA
HYDROLOGIC UNIT LOCATION MAP



Map 10 (continued)

RECOMMENDED SYSTEM PLAN FOR STORMWATER MANAGEMENT FOR THE QUAAS CREEK SUBWATERSHED

HYDROLOGIC UNIT QC-I



LEGEND

- HYDROLOGIC UNIT BOUNDARY UNDER EXISTING DRAINAGE CONDITIONS
- QC-I — HYDROLOGIC UNIT IDENTIFICATION
- LIMITS OF PLANNED URBAN SERVICE AREA
- SUBBASIN BOUNDARY UNDER EXISTING DRAINAGE CONDITIONS
- QC 32 — SUBBASIN IDENTIFICATION
- SUBBASIN OUTLET
- 48 — EXISTING STORM SEWER TO BE RETAINED (SIZE IN INCHES)
- EXISTING MANHOLE OR CATCHBASIN
- 15 — PROPOSED REPLACEMENT STORM SEWER OR CULVERT DESIGNED FOR 10-YEAR STORM (SIZE IN INCHES)
- 36 — PROPOSED STORM SEWER OR CULVERT DESIGNED FOR 10-YEAR STORM (SIZE IN INCHES)
- PROPOSED MANHOLE
- QCWD II — PERMANENT POND AREA OF WET DETENTION BASIN AND DESIGNATION
- PRIMARY ENVIRONMENTAL CORRIDOR BOUNDARY
- 100-YEAR RECURRENCE INTERVAL FLOOD INUNDATION AREA UNDER PLANNED 2010 LAND USE AND RECOMMENDED DRAINAGE CONDITIONS
- AREA TRIBUTARY TO INDUSTRIAL PARKING LOT OR STORAGE AREA TO BE SWEPT WEEKLY IN SPRING, SUMMER, AND FALL
- AREAS OF PLANNED MEDIUM DENSITY AND TWO-FAMILY RESIDENTIAL DEVELOPMENT TO BE SERVED BY STORM SEWERS AND WHERE LOW-COST RUNOFF INFILTRATION PRACTICES ARE TO BE ENCOURAGED
- CMP — CORRUGATED METAL PIPE
- CMPA — CORRUGATED METAL PIPE ARCH
- NOTE: PIPES ARE CONSTRUCTED OF REINFORCED CONCRETE UNLESS DESIGNATED AS ABOVE.

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

Source: SEWRPC.

calls for providing practices which promote infiltration of runoff in the areas of proposed medium-density residential development. In addition, it is recommended that infiltration systems to retain runoff from 50 percent of commercial parking lots be installed north of Paradise Drive and east of USH 45. Primary environmental corridor lands are to be preserved and protected in their natural state to serve as riparian buffers which will aid in the maintenance of stream base flows and of cool stream water temperatures. Areas to be served by low-cost stormwater infiltration measures, areas to be served by infiltration systems, and primary environmental corridors are shown on Map 10. The estimated non-point source pollutant removal effectiveness and costs of each of the stormwater quality management measures recommended for Hydrologic Unit QC-B are summarized in Table 9.

Hydrologic Unit QC-C

Approximately 8 percent of Hydrologic Unit QC-C was developed for urban land uses in 1985. In the plan design, it was assumed that about 64 percent of the hydrologic unit would be developed for urban land uses by the year 2010. The recommended plan for Hydrologic Unit QC-C was formulated to include consideration of existing detention basin QCWD3 (City-designated "Basin D") in the Industrial Park-South.

To accommodate anticipated runoff conditions in areas of planned medium-density residential development which would be concentrated in subbasin QC20A south of Rusco Road (CTH NN), the recommended plan calls for the provision of 3,610 lineal feet of RCP storm sewer, ranging in diameter from 15 inches to 42 inches and 500 lineal feet 45-inch-wide by 29-inch-high HE RCP.

Three open channels to provide outlets for proposed storm sewers are called for under the recommended plan for this hydrologic unit.

The first outflow channel would convey flows discharged from proposed storm sewers that would serve the western part of subbasin QC20A. This channel would be 340 feet long, would be grass-lined, and would have a trapezoidal cross-section with average side slopes of one vertical on four horizontal or other hydraulically equivalent shape. The maximum depth of the channel would be about three feet and its average bottom width would be about 10 feet. The channel would terminate at an existing drainageway which is located in the primary environmental corridor along Quaas Creek. This drainageway is not classified as either an intermittent or perennial stream on the 7.5-minute quadrangle map of the area prepared by the U. S. Geological Survey.

The second outflow channel would convey flows discharged from those storm sewers which would serve the proposed residential and industrial development in the extreme eastern part of QC20A. This channel, designated as channel C1, would be 550 feet long and would be located north of Rusco Road about 30 feet east of a wetland identified on the State Wetland Inventory Maps and the 1990 Regional Planning Commission Land Use Inventory Maps. In order to prevent drainage of the wetland, this outflow channel would have a clay liner on its west side. It would have an average depth of about two feet, an average bottom width of about five feet, and would terminate at a point about 380 feet south of Quaas Creek. This channel would have a trapezoidal cross-section, with average side slopes of one vertical on four horizontal or other hydraulically equivalent shape.

The third outflow channel would convey flows discharged from the storm sewers which would collect runoff from the central part of planned residential development in subbasin QC20A. This channel, designated as channel C2, would be 110 feet long and would be a modification of a relatively small portion of the existing drainageway in the wetland between Rusco Road and Quaas Creek. The proposed channel would have an average depth of about 1.5 feet and an average bottom width of about three feet. The east side of the channel would be provided with a clay liner to prevent the alteration of groundwater levels in the wetland. This channel could have a trapezoidal cross-section, with average side slopes of one vertical on four horizontal or other hydraulically equivalent shape.

Construction of proposed outflow channel C2 in the wetland would require a permit from the U. S. Army Corps of Engineers under Section 404 of the Federal Clean Water Act and water quality certification from the Wisconsin Department of Natural Resources. A systems-level wetlands evaluation and alternatives analysis is included in that section of Chapter III of this volume which presents and evaluates alternative stormwater drainage plans for Hydrologic Unit QC-C. This evaluation concludes that the construction of proposed outflow channel C2 in the wetland is the only practicable alterna-

tive for conveying runoff discharged from those storm sewers which are proposed to serve the central part of planned residential development in subbasin QC20A.

The recommended plan also calls for the replacement of the 18-inch-diameter CMP culvert under Rusco Road about 780 feet east of CTH P (Main Street) with a 21-inch-diameter reinforced concrete culvert. Review of grading plans for a proposed medium-density residential development in subbasin QC16 and QC20B indicated that a seven-acre area in the southern portion of subbasin QC151B in Hydrologic Unit QC-F would be graded to drain south into subbasin QC20B in Hydrologic Unit QC-C. The resulting change in the hydrologic unit boundary is shown on Map 10.

The recommended water quality plan element presented in Chapter II of this volume calls for practices which promote infiltration of runoff in areas of planned medium-density residential development. In addition, it is recommended that areas in subbasins QC20A and QC20B which are tributary to industrial parking lot or storage areas be swept weekly in spring, summer, and fall. The recommended plan also assumes utilization of existing wet detention basins QCWD3, QCWD4, and QCWD5, in the West Bend Industrial Park-South in subbasins QC20C, QC155, and QC156, respectively. Infiltration systems are recommended to treat runoff from 50 percent of the parking lot area of the existing commercial development located in subbasin QC16. Primary environmental corridor lands are to be preserved and protected in their natural state to serve as riparian buffers.

The estimated nonpoint source pollutant removal effectiveness and costs of each of the stormwater quality management measures recommended for Hydrologic Unit QC-C are summarized in Table 9.

Hydrologic Units QC-D and E

Approximately 13 percent of Hydrologic Units QC-D and QC-E was developed for urban land uses in 1985. In the plan design, it was assumed that about 61 percent of the two hydrologic units would be developed for urban land uses by the year 2010.

The recommended plan calls for the provision of 4,530 lineal feet of new storm sewer, ranging in size from 18-inch-diameter RCP to 60-inch-wide by 38-inch-high HE RCP to serve areas of planned residential development. The recommended plan also calls for utilizing the existing system of roadside swales, open channels; culverts; existing detention basin QCWD12 (City-designated "Basin E") in the Industrial Park-South and dry detention basin D-1, which is proposed by the developer of a commercial warehouse development to be located south of Rusco Road in subbasin QC24. Basins QCWD12 and D-1 have 100-year storage volumes of approximately 6.3 and 4.0 acre-feet, respectively.[1]

In order to accommodate anticipated increased runoff from future industrial development west of the Wisconsin Central Railroad, former Chicago & North Western Railway, in subbasin QC24, and in order to avoid potential flooding of existing houses located northwest of the intersection of CTH G and Rusco Road, the plan calls for modifying the existing roadside swale along the south side of Rusco Road to convey runoff during a 100-year recurrence interval storm. This roadside swale would be deepened by about one foot and widened to provide greater hydraulic capacity. The modified 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 roadway and a one vertical on three horizontal side slope away from the roadway. An existing 18-inch-diameter CMP culvert under a private drive about 320 feet west of CTH G would be replaced by a double 45-inch-wide by 29-inch-high HE RCP. In addition, the existing 24-inch-diameter CMP culvert under Rusco Road about 400 feet west of CTH G would be removed.

During a 100-year recurrence interval flood, overflow from the roadside swale along the south side of Rusco Road would collect at a mid-block sag about 180 feet west of CTH G, would overtop the roadway, and would spill into the existing roadside swale north of Rusco Road. In order to prevent flooding of the houses located just north of Rusco Road, it will be necessary to increase the hydraulic capacity of the northern roadside swale. Thus, the recommended plan calls for deepening by about one foot of

---

[1]*During larger storms, runoff collected in detention basins QCWD2 and QCWD10 in hydrologic unit QC-F would overflow into basin QCWD12. During a 10-year recurrence interval storm, the peak inflow to QCWD12 from QCWD2 and 10 would be 74 cfs. During a 100-year recurrence interval storm, the peak inflow to QCWD12 would be 228 cfs.*

a 210-foot-long segment of that swale. An existing 24-inch-diameter CMP culvert under a private drive north of Rusco Road and about 160 feet west of CTH G would be lowered to accommodate proposed deepening of the roadside swale. The deepening of this swale and relaying of the culvert could be avoided if Rusco Road west of CTH G were raised to a minimum elevation of 939.0 feet above National Geodetic Vertical Datum, 1929 adjustment. To protect the houses north of Rusco Road from possible flooding, such a raising of the road grade should be accomplished prior to, or concurrent with, the occurrence of urban development in subbasin QC24, west of the Wisconsin Central Railroad.

In addition, the recommended plan calls for the replacement of the 24-inch-diameter culvert under Rusco Road just west of CTH G with a double 45-inch-wide by 29-inch-high HE RCP. This replacement culvert would discharge into the existing roadside swale along the west side of CTH G north of Rusco Road. This roadside swale has a steep longitudinal slope which could result in excessive flow velocities and erosion of the channel bank. In order to promote channel stability, riprap would be placed along an 800-foot-long segment of this swale.

The recommended plan assumes that areas which are located outside the 100-year recurrence interval flood inundation area, along the west side of CTH G in subbasin QC24, and which would be developed in medium-density residential land uses, would be filled and regraded to drain to the roadway. It is also recommended that runoff from those rural lands in subbasin QC178, which are located on the east side of CTH G and south of the area of medium-density residential development planned in that subbasin, be conveyed in an existing drainage swale running westerly along the southern boundary of future residential development, and which would be extended west to CTH G. During storms with recurrence intervals of 10 years or less, runoff in this swale would be intercepted by the proposed storm sewers in CTH G.

The wet detention basin QCWD9, which is called for under the water quality management plan element presented in Chapter II of this volume, would be constructed as a dual-purpose basin with a permanent pond area of approximately 1.9 acres and a permanent pond volume of 9.5 acre-feet. In addition to the permanent pond, this plan calls for 4.9 acre-feet of surcharge storage volume to control runoff from storms with recurrence intervals up to, and including, 10 years. The permanent pond elevation would be at about 900.5 feet above National Geodetic Vertical Datum (NGVD), 1929 adjustment. The basin outlet is proposed to be an 80-foot-long, 45-inch-wide by 29-inch-high HE RCP which would discharge to storm sewers proposed to be located in CTH G.

The recommended water quality management plan element also calls for the conversion and expansion of dry detention basin "E," which is located in subbasin QC154B in the West Bend Industrial Park-South, to a permanent pond. The recommended expanded wet basin, designated as QCWD12, would have a permanent pond area of approximately 0.47 acres and a permanent pond volume of about 2.4 acre-feet and would improve the nonpoint source pollutant removal effectiveness of the control system in the industrial park under planned land use conditions.

In addition, it is recommended that infiltration of stormwater runoff in areas of planned medium-density residential development in subbasins QC23A, QC23B, and QC178 be promoted through the use of low-cost runoff infiltration practices. Primary environmental corridor lands are to be preserved and protected in their natural state to serve as riparian buffers.

The estimated nonpoint source pollutant removal effectiveness and costs of each of the stormwater quality management measures recommended for Hydrologic Units QC-D and QC-E are summarized in Table 9.

Hydrologic Unit QC-F

Approximately 28 percent of Hydrologic Unit QC-F was developed for urban land uses in 1985. In the plan design, it was assumed that about 92 percent of the hydrologic unit would be developed for urban land uses by the year 2010.

The recommended plan for Hydrologic Unit QC-F was designed to include the existing detention basin located in the South Meadows Subdivision and existing basins QCWD1 and QCWD2 (City-designated "Basin A" and "Basin C") located in the Industrial Park-South. The stormwater drainage plan also calls for the provision of a dry detention basin located in subbasin QC13 southwest of the intersection of CTH P (Main Street) and the future extension of Paradise Parkway. The proposed basin would have a 100-year storage capacity of about 3.4

acre-feet, and would require a total land area of about 1.3 acres. Construction of this basin would permit the following existing culverts to be retained as components of the major stormwater drainage system: 1) the 24-inch-diameter CMP and two-foot-wide by two-foot-high concrete box culvert in series under CTH P and 2) the 18-inch-diameter CMP behind the house located just east of CTH P. The recommended plan also calls for maintaining the overland flow path downstream of the existing culvert under CTH P.

An 80-foot-long, 42-inch-diameter RCP culvert is recommended to be installed under the future extension of Paradise Parkway to provide drainage to that portion of subbasin QC13 lying north of Paradise Parkway.

At a January 25, 1996, interagency staff meeting, the City staff provided additional information to Regional Planning Commission staff pertaining to the 1,300-foot-long segment of existing open channel located along the south side of Paradise Drive, west of CTH G. The capacity of this segment of open channel was reevaluated on the basis of the additional information, and was found to be adequate for conveyance of the increased runoff attendant to anticipated development within the tributary drainage area, assuming localized low spots adjacent to the channel are filled and graded when development of the lands concerned occurs. Therefore, no modification to this segment of open channel was considered to be necessary.

Subbasin QC15I, which is internally drained under existing conditions, may be expected to be partly developed in commercial and residential land uses. Under existing conditions, runoff is collected in a depression located in the subbasin. Under planned development conditions, grading of the subbasin could result in the potential filling of the existing natural retention area. In order to provide effective drainage of the subbasin and prevent potential flooding of future development, it is essential that an outflow path, located in the existing commercial parking lot just east of CTH P, be maintained regardless of whether the storage available in the existing depression is preserved or the depression is partially or fully filled.

There is a mid-block sag in Sylvan Way south of Paradise Drive. Runoff at rates in excess of the hydraulic capacity of the downstream storm sewer in Paradise Drive would collect in the intersection of Sylvan Way and Paradise Drive and overflow to the southeast of the intersection. This overflow could be conveyed as overland flow behind the existing buildings south of Paradise Drive. In order for the major system to have adequate capacity and to prevent flooding of buildings during storms with recurrence intervals up to, and including, 100 years, it is recommended that the route of this overland flow be maintained through a combination of drainage easements and designation as a public drainageway.

The recommended water quality management plan element presented in Chapter II of this volume calls for the utilization of the existing wet detention basins and the system of open channels and roadside swales located in the City of West Bend Industrial Park-South. Existing wet basins QCWD1 and QCWD2 located in subbasins QC151D and QC153A respectively have permanent pond volumes of 2.0 and 1.2 acre-feet. The recommended plan also calls for expanding dry detention basin "C," which is located in subbasin QC153A in the West Bend Industrial Park-South, to include a permanent pond. The recommended expanded wet basin, designated as QCWD10, would have a permanent pond area of approximately one acre and a permanent pond volume of about five acre-feet. The recommended water quality management plan element also calls for the construction of wet detention basin QCWD8 on currently undeveloped lands in subbasin QC22 southeast of the intersection of Paradise Drive and CTH G. This wet basin would have a permanent pond area of 0.74 acres and a permanent pond volume of about 3.7 acre-feet. Primary environmental corridor lands in the hydrologic unit are to be preserved and protected in their natural state to serve as riparian buffers and infiltration of runoff is to be promoted in areas of planned medium-density residential development.

The estimated nonpoint source pollutant removal effectiveness and costs of each of the stormwater quality management measures recommended for Hydrologic Unit QC-F are summarized in Table 9.

Hydrologic Unit QC-G

Approximately 40 percent of Hydrologic Unit QC-G was developed for urban land uses in 1985. In the plan design, it was assumed that about 84 percent of the hydrologic unit would be developed for urban land uses by the year 2010.

Under existing conditions, two minor stormwater drainage system problems were identified in the Forest Highlands subdivision. To abate potential street flooding due to the inadequate hydraulic capacities of two culverts located in the subdivision, the recommended plan calls for the replacement of: the 121-foot-long, 58-inch-wide by 36-inch-high corrugated metal pipe arch (CMPA) under Indiana Avenue with a 53-inch-wide by 34-inch-high HE concrete pipe culvert and the 85-foot-long, 65-inch-wide by 40-inch-high CMPA under Crocus Court with a 60-inch-wide by 38-inch-high HE concrete pipe culvert.

To accommodate anticipated increased runoff from planned land use development in the hydrologic unit, the recommended stormwater drainage plan calls for 2,665 lineal feet of new RCP storm sewer, ranging in diameter from 21 inches to 48 inches, and 515 lineal feet of 53-inch-wide by 34-inch-high HE concrete pipe storm sewer. In addition, the recommended plan proposes the construction of a dry detention basin for the control of the runoff from a 100-year recurrence interval storm. The proposed 1.4 acre-foot detention basin would require a total land area of 0.9 acre and would be located just northeast of the Forest Highlands subdivision on lands which would be devoted to recreational and park uses under planned land use conditions.

Proposed storm sewers would discharge into an unnamed stream tributary to Quaas Creek east of CTH G. During a 100-year recurrence interval storm event, backwater from this tributary would extend into an area of planned urban development located northwest of the intersection of Paradise Drive and CTH G. In order to provide two feet of freeboard between buildings and the 100-year recurrence interval flood inundation elevation in this area, it is recommended that all new urban development be located above elevation 893.0 feet above National Geodetic Vertical Datum (NGVD), 1929 adjustment.

The recommended plan also calls for maintaining a roadside swale along the north side of Paradise Drive and along the west side of CTH G to convey runoff from the Forest Highlands subdivision and other tributary areas during storms with recurrence intervals of 10 years or less. It is recommended, however, that right-angle bends in the existing roadside swale be eliminated, as shown on Map 10, in order to reduce the likelihood of erosion of the channel bank. The alternative to maintaining roadside swales would be to install storm sewers in the segment of Paradise Drive between the Wisconsin Central Railroad and the Paradise Drive crossing of Quaas Creek. The provision of such storm sewers was investigated but eliminated from consideration, as described in Chapter III of this volume.[2]

During storms larger than a 10-year recurrence interval event, runoff would be conveyed south in Indiana Avenue and then east in Crocus Court. It is recommended that under planned development conditions, streets in subbasin QC27 east of the Forest Highlands subdivision which would connect to Crocus Court be graded to convey these flows effectively to the outlet of subbasin QC27.

The recommended water quality management plan element presented in Chapter II of this volume calls for wet detention basin QCWD7 for the control of nonpoint source pollutants. The basin, which would be located northeast of the intersection of Paradise Drive and CTH G in subbasin QC35, as shown on Map 10, would collect runoff from essentially the entire area in Hydrologic Unit QC-G. The basin would have a permanent pond area of 1.93 acres and a permanent pond volume of 9.6 acre feet. The estimated nonpoint source pollutant removal effectiveness and the cost of recommended wet basin QCWD7 are set forth in Table 9.[3]

Hydrologic Unit QC-H

Approximately 6 percent of Hydrologic Unit QC-H was developed for urban land uses in 1985. In the plan design, it was assumed that about 27 percent of the hydrologic unit would be developed for urban land uses by the year 2010. The hydrologic unit includes an unnamed tributary which flows in a generally northerly direction and discharges to Quaas Creek a short distance downstream of

---

[2]*Modified storm sewer and roadside swale alternatives are described and evaluated in a subsequent section of this chapter which sets forth refinements to the recommended plan.*

[3]*Basin QCWD7 was subsequently eliminated from the plan in response to comments from City staff. The reasons for that elimination are set forth in the section of this chapter which describes refinements to the recommended plan.*

Paradise Drive. This tributary is shown on the 7.5-minute U. S. Geological Survey quadrangle maps of the area as an intermittent stream. Review of ratioed and rectified aerial photographs, which are prepared for the Regional Planning Commission every five years, indicated that portions of this tributary were realigned and straightened in the late 1970s.

Specific stormwater drainage measures were not developed for Hydrologic Unit QC-H. This hydrologic unit was largely undeveloped in 1990 and it had a drainage pattern consisting primarily of overland flow directly to the unnamed tributary to Quaas Creek. The configuration of the stormwater management system for such an area would, to a large extent, be dictated by a future street layout. On the basis of the density of the planned land uses in this hydrologic unit and because runoff from the unit drains directly to the tributary, 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 could be considered at the time of development if the provision of such storage would achieve savings in the conveyance system costs 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.

The recommended water quality management plan element presented in Chapter II of this volume calls for providing low-cost stormwater infiltration measures in the areas of planned medium-density residential developments in this hydrologic unit. In addition, primary environmental corridor lands are to be preserved and protected in their natural state to serve as riparian buffers.

Hydrologic Unit QC-I

Approximately 16 percent of Hydrologic Unit QC-I was developed for urban land uses in 1985. In the plan design, it was assumed that about 54 percent of the hydrologic unit would be developed for urban land uses by the year 2010.

Problems with the major system capacity were identified at two locations in subbasin QC44 where overflow would occur to the north into Hydrologic Unit MR-Q in the Milwaukee River drainage area. At the intersection of Decorah Road and Sheridan Drive, ponding in a sag in the road could result in overland flow to the north in Sheridan Drive. The second location where overflow into the Milwaukee River drainage area could occur is at the intersection of S. River Road and Decorah Road. Runoff in excess of the existing storm sewer capacity in Decorah Road would overflow into S. River Road north of Decorah Road. Overflow from both locations was accounted for under the recommended stormwater management plan for the Milwaukee River drainage area within the City of West Bend, as presented in Volume Three of this report.

Future urban development in this hydrologic unit would be concentrated in that portion of the hydrologic unit west of Quaas Creek. Detailed stormwater drainage facilities were developed for subbasins QC28, QC32, and QC162. To accommodate the increased runoff from planned land use development in these subbasins, the recommended plan proposes installing 6,230 lineal feet of new reinforced concrete storm sewer, ranging in size from 18-inch diameter to 42-inch diameter pipe. Proposed storm sewers would discharge to the primary environmental corridor adjacent to Quaas Creek. The recommended plan also calls for the replacement of the 29-foot-long, 12-inch-diameter CMP culvert under Sand Drive about 900 feet east of CTH G (S. River Road) with a 15-inch diameter RCP storm sewer.

The remaining areas of this hydrologic unit where urban development may be expected have a drainage pattern consisting primarily of overland flow directly to Quaas Creek. The configuration of the stormwater management system for such areas would, to a large extent, be dictated by future street layouts. Based on the density of the planned land uses in these areas and because runoff drains directly to Quaas Creek, stormwater drainage systems 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 developments. Detention storage could be considered at the time of development if the provision of such storage would achieve cost savings in the conveyance system through the reduction of peak flows within the hydrologic unit. Drainage improvements in these developments would have only a small impact on the City capital improvements budget since most facilities would be paid for by private developers.

Table 29

COMPARISON OF 100-YEAR RECURRENCE INTERVAL FLOOD FLOWS FOR QUAAS CREEK

Location	River Mile	Existing Land Use and Drainage System and Channel Conditions[a] (cfs)	Planned Land Use, Existing Drainage System, and Existing Channel Conditions[a] (cfs)	Planned Land Use and Recommended Drainage System and Existing Channel Conditions[a] (cfs)	1983 Federal Flood Insurance Study for Washington County (cfs)
Above Confluence with Unnamed Tributary in Subbasin QC7C	5.58	40	160	160	800
At Confluence with Unnamed Tributary in Subbasin QC7C	5.39	140	380	380	800
About 2,770 Feet Upstream of CTH P	5.11	210	400	400	800
Above Confluence with the South Branch of Quaas Creek	4.66	290	440	440	800
At Confluence with the South Branch of Quaas Creek Upstream of CTH P	4.534	760	770	770	800
About 2,820 Feet Downstream of CTH P	4.00	870	870	870	1,100
Progress Drive	3.31	910	920	920	1,100
Wisconsin Central Railway	2.85	910	920	920	1,100
CTH G	2.50	950	1,000	960	1,390
Upstream Side Paradise Drive	2.11	1,010	1,060	1,060	1,390
Downstream Side Paradise Drive	2.06	1,100	1,150	1,150	1,390
About 890 Feet Downstream of Paradise Drive	1.93	1,150	1,210	1,210	1,390
At Sand Drive	1.51	1,270	1,340	1,350	1,390
About 1,860 Feet Upstream of Decorah Road	0.91	1,300	1,380	1,380	1,390
Above Confluence with the Milwaukee River	0.07	1,310	1,400	1,390	1,390

[a]*No modifications are recommended for Quaas Creek or its tributaries. Thus, existing channel conditions apply to each of the scenarios presented in this table.*

Source: SEWRPC.

The recommended water quality management plan element presented in Chapter II of this volume calls for practices which promote infiltration of runoff in the areas of medium-density residential development. In addition, it is recommended that areas in subbasins QC28 which are tributary to industrial parking lots or storage areas be swept weekly in spring, summer, and fall. Primary environmental corridor lands are to be preserved and protected in their natural state to serve as riparian buffers.

The recommended water quality management plan element also calls for wet detention basin QCWD11 for the control of nonpoint source pollutants. The basin, which would have a permanent pond area of 0.76 acres and a permanent pond volume of 3.8 acre feet, would collect runoff from subbasin QC44, which includes the West Bend High School campuses.

The estimated nonpoint source pollutant removal effectiveness and costs of each of the stormwater quality management measures recommended for Hydrologic Unit QC-I are summarized in Table 9.

FLOODLAND MANAGEMENT PLAN ELEMENT

100-Year Recurrence Interval Flood Profile

Table 29 presents estimated 100-year recurrence interval flood flows at selected locations along

Quaas Creek under existing land use and drainage conditions, under planned land use and existing drainage conditions,[4] and under planned land use and recommended drainage system conditions. As shown in Table 29, in comparison to existing conditions, a maximum increase of 6 percent in the 100-year recurrence interval flood flow peak rate may be expected along the lower 4.66-mile reach of Quaas Creek under planned land use and recommended drainage conditions. A larger increase in peak flow rates may be expected in the 1.31-mile reach of Quaas Creek above its confluence with the South Branch of Quaas Creek.

The 100-year recurrence interval flood profile for Quaas Creek, computed using peak flow rates for planned land use and planned drainage system and existing channel conditions, was used to delineate the 100-year recurrence interval floodplain areas along Quaas Creek. That delineation is shown on Map 10. The floodplain delineation was accomplished using one-inch-equals-100-feet scale, two-foot contour interval topographic maps prepared to Regional Planning Commission standards. No buildings were located in the 100-year recurrence interval floodplain in 1990. It is recommended that the 100-year recurrence interval floodplain be preserved in open space uses and no structural flood control measures be undertaken.

Three structures over Quaas Creek were found to have inadequate hydraulic capacity to meet Commission standards.[5] Those structures are located at Sand Drive, which is a collector street; Paradise Drive, the pertinent section of which is currently a collector street, but which is recommended to be upgraded to an arterial street under the plan design year 2010 Regional transportation system plan;[6] and Main Street (CTH P), which is an arterial highway. It is recommended that the hydraulic capacities of these structures be increased to meet Commission standards at such time that bridge replacement is scheduled.[7] Table 30 presents a comparison of 100-year recurrence interval flood stages along Quaas Creek under planned land use and existing drainage conditions and under planned land use and recommended drainage conditions.

---

[4]*The determination of 100-year recurrence interval flood flows under "planned land use and existing drainage conditions" assumed that an engineered conveyance system would be provided in areas of future development. The calculated flood flows are suitable for floodland zoning and flood insurance purposes, representing a reasonable upper limit on 100-year recurrence interval flood flows in Quaas Creek during the interim period prior to implementation of the stormwater management recommendations. Because no flood hazard was identified along Quaas Creek, the recommended stormwater management measures are directed toward addressing local, off-channel conditions. Therefore, the 100-year recurrence interval flood flows are very similar under both planned land use and existing drainage system conditions and planned land use and recommended drainage system conditions.*

[5]*SEWRPC standards call for the following:*

1. *A hydraulic structure under a minor or collector street should convey the peak 10-year recurrence interval flood flow without overtopping the roadway.*
2. *A hydraulic structure under an arterial street or highway should convey the peak 50-year recurrence interval flood flow without overtopping the roadway.*
3. *A hydraulic structure under a freeway, expressway, or railroad should convey the peak 100-year recurrence interval flood flow without overtopping the roadway or railroad.*

[6]*The Paradise Drive crossing does not meet the 10-year recurrence interval flood overtopping standard which would be applied based on its current classification as a collector street.*

[7]*Because of high tailwater conditions, the recommended hydraulic capacity standards cannot be met for the Sand Drive and Paradise Drive crossings of Quaas Creek unless the associated roadway grades are raised. Under existing structure and roadway conditions at those two crossings there would be relatively large amounts of flow over the roadways during the flood frequencies associated with the recommended standards. Hydraulic studies would be required during the facilities design stage to determine whether provision of the capacities required by the standards is feasible and cost effective.*

Table 30

100-YEAR RECURRENCE INTERVAL FLOOD STAGES ALONG QUAAS CREEK

River Mile[a]	Location	100-Year Recurrence Interval Flood Stage Elevation in Feet NGVD		
		Planned Land Use, Existing Drainage System, and Existing Channel Conditions	Planned Land Use, Recommended Drainage System, and Existing Channel Conditions	1983 Federal Flood Insurance Study for Washington County[b]
0.070	Mouth	871.50[c]	871.50[c]	871.5[c]
0.330	--	871.50[c]	871.50[c]	871.5[c]
0.530	--	872.43	872.42	871.6
0.540	Decorah Road (downstream side)	872.52	872.50	871.8
0.550	Decorah Road (upstream side)	873.78	873.74	872.7
0.560	--	874.78	874.73	873.2
0.750	--	875.34	875.30	874.1
0.810	--	875.46	875.42	874.5
0.910	--	875.67	875.64	875.2
1.070	--	876.87	876.86	876.6
1.140	--	877.81	877.81	877.3
1.141	Private Drive (downstream side)	877.68	877.68	877.3
1.150	Private Drive (upstream side)	878.57	878.57	878.3
1.151	--	878.76	878.76	878.3
1.170	--	878.93	878.93	878.6
1.350	--	881.00	881.00	880.8
1.450	--	881.55	881.55	881.1
1.511	Sand Drive (downstream side)	881.67	881.67	881.4
1.520	Sand Drive (upstream side)	881.86	881.86	881.8
1.540	--	881.88	881.88	881.8
1.610	--	882.29	882.30	882.1
1.700	--	882.96	882.96	882.4
1.780	--	883.16	883.17	882.6
1.930	--	883.29	883.30	883.1
1.990	--	883.34	883.34	883.7
2.060	--	883.42	883.41	884.5
2.102	--	885.35	885.60	884.9
2.103	Paradise Drive (downstream side)	885.01	885.27	884.9
2.107	Paradise Drive (upstream side)	885.12	885.37	887.0
2.108	--	886.30	886.41	887.0
2.110	--	886.94	886.94	886.9
2.150	--	887.01	887.01	887.4
2.240	--	887.04	887.03	888.0
2.280	--	887.08	887.08	888.5
2.370	--	887.27	887.27	889.5
2.410	--	887.90	887.90	890.0
2.460	--	888.81	888.81	891.0
2.500	--	889.38	889.38	891.3
2.501	CTH G (downstream side)	889.40	889.31	891.3
2.513	CTH G (upstream side)	893.18	893.01	893.0
2.514	--	893.29	893.20	893.0
2.530	--	893.35	893.26	893.1
2.660	--	893.80	893.75	897.8
2.670	--	894.32	894.27	898.1
2.680	--	894.83	894.78	898.6
2.700	--	895.94	895.90	898.9
2.740	--	897.56	897.51	899.4
2.820	--	899.50	899.46	903.3
2.850	--	901.36	901.34	905.7
2.851	Wisconsin Central Railroad (downstream side)	901.37	901.37	905.7

Table 30 (continued)

River Mile[a]	Location	100-Year Recurrence Interval Flood Stage Elevation in Feet NGVD		
		Planned Land Use, Existing Drainage System, and Existing Channel Conditions	Planned Land Use, Recommended Drainage System, and Existing Channel Conditions	1983 Federal Flood Insurance Study for Washington County[b]
2.860	Wisconsin Central Railroad (upstream side)	903.94	903.94	906.6
2.861	--	904.17	904.17	906.6
2.890	--	905.68	905.68	907.8
3.020	--	906.87	906.87	909.0
3.110	--	909.20	909.20	910.5
3.210	--	911.00	911.00	912.0
3.300	--	912.44	912.44	913.1
3.310	--	912.77	912.77	913.2
3.311	Progress Drive (downstream side)	912.76	912.76	913.2
3.320	Progress Drive (upstream side)	912.93	912.93	913.4
3.321	--	912.94	912.94	913.4
3.330	--	913.30	913.30	913.7
3.360	--	913.73	913.73	914.0
3.440	--	914.12	914.12	914.3
3.550	--	914.79	914.79	916.2
3.700	--	917.53	917.53	919.2
3.850	--	922.17	922.17	922.5
3.890	--	923.50	923.50	923.8
4.000	--	927.25	927.25	927.0
4.220	--	933.13	933.13	933.6
4.290	--	935.24	935.24	934.4
4.400	--	937.44	937.44	938.8
4.460	--	940.20	940.20	941.0
4.510	--	941.11	941.11	943.3
4.534	CTH P (downstream side)	942.18	942.18	944.3
4.546	CTH P (upstream side)	946.94	946.94	947.2
4.550	--	946.94	946.94	947.2
4.560	--	946.97	946.97	947.7
4.660	--	947.04	947.04	950.7
4.680	--	947.08	947.08	951.3
4.710	--	947.25	947.25	952.2
4.770	Private Drive (downstream side)	952.38	952.38	954.0
4.790	Private Drive (upstream side)	953.67	953.67	954.6
4.850	--	954.76	954.76	956.4
4.940	--	957.47	957.47	958.9
4.980	--	958.18	958.18	960.0
5.110	--	961.67	961.67	963.6
5.190	--	964.45	964.45	966.0
5.210	Private Drive (downstream side)	965.07	965.07	966.6
5.220	Private Drive (upstream side)	965.32	965.32	966.9
5.240	--	965.80	965.80	967.5
5.270	--	966.51	966.51	968.4
5.280	--	967.59	967.59	968.7
5.330	--	969.42	969.42	970.2
5.390	--	970.70	970.70	971.6
5.470	--	972.50	972.50	973.6
5.580	--	973.60	973.60	976.3
5.620	--	973.89	973.89	977.3
5.670	--	974.66	974.66	978.0

Table 30 (continued)

River Mile[a]	Location	100-Year Recurrence Interval Flood Stage Elevation in Feet NGVD		
		Planned Land Use, Existing Drainage System, and Existing Channel Conditions	Planned Land Use, Recommended Drainage System, and Existing Channel Conditions	1983 Federal Flood Insurance Study for Washington County[b]
5.720	--	975.49	975.49	978.7
5.760	--	975.59	975.59	979.3
5.810	--	975.69	975.69	980.0
5.850	--	975.73	975.73	980.6
5.870	Mobil Mart Culvert (downstream side)	976.69	976.69	--
5.880	Mobil Mart Culvert (upstream side)	978.78	978.78	--
5.920	--	979.38	979.38	--
5.930	--	979.43	979.43	--

[a]*Stream distance in River Miles from confluence with the Milwaukee River.*

[b]*The hydraulic model developed for this stormwater management plan used more stream cross-sections and more accurate river mile stationing than did the Federal Flood Insurance Study (FIS). As a result, the river mile stations between the two studies do not agree and flood elevations at the same river mile cannot be directly compared. The flood stages in this column were determined using the flood profile published in the FIS and adjusting locations along that profile to correlate more closely with those based on the stormwater management plan river mile stationing.*

[c]*Backwater from the Milwaukee River determines the 100-Year Recurrence Interval Flood Stage at this location.*

Source: SEWRPC.

Comparison to the Federal Flood Insurance Study

The hydrologic and hydraulic analyses performed under this planning effort for the determination of 100-year recurrence interval flood stages along Quaas Creek are more detailed than the corresponding analyses performed under the March 1, 1983 Federal flood insurance study (FIS) for Washington County. Under the FIS, flood flows were determined for then-existing land use conditions using regional flood frequency equations developed by the U.S. Geological Survey. Such equations do not directly account for the effects of combining and routing subbasin flood hydrographs. Under the stormwater management planning effort, the 8.75-square-mile subwatershed was divided into 92 subbasins, ranging in area from 1.2 acres to 927 acres, and averaging 61 acres in area. The hydrographs for the subbasins were combined and routed through the stream and drainage system of the subwatershed using a U.S. Army Corps of Engineers HEC-1 flood hydrograph model developed by Commission staff. Using that model, flood flows were determined at 15 locations along Quaas Creek, as opposed to three locations under the FIS, thus providing a better definition of the flood profile. Also, the flood flows computed using the model reflect the effects of detention storage facilities constructed in the subwatershed subsequent to preparation of the FIS.

As may be seen from an examination of Table 29, the Commission flood flows developed for planned land use, existing drainage system, and existing channel conditions are similar to the FIS flood flows in the lower 1.93 miles of Quaas Creek. Upstream of that reach the differences between the two studies are more pronounced, with the largest difference occurring in the upper 0.92 mile of Quaas Creek where the greater detail of the Commission modeling enabled better definition of the changes in flood flows along the stream.

The U.S. Army Corps of Engineers HEC-2 water surface profiles computer model developed by Commission staff for computation of flood profiles along Quaas Creek under the stormwater management planning effort represents an improvement on the HEC-2 model developed and used under the FIS for the following reasons:

1. The Commission model more correctly represents the bridge geometry at Decorah Road.

Table 31

COMPARISON OF TWO-YEAR RECURRENCE INTERVAL FLOOD FLOWS FOR QUAAS CREEK

Location	River Mile	Existing Land Use and Drainage System and Channel Conditions (cfs)	Planned Land Use, Existing Drainage System, and Existing Channel Conditions[a] (cfs)	Planned Land Use and Recommended Drainage System and Existing Channel Conditions[a] (cfs)
Above Confluence with Unnamed Tributary in Subbasin QC7C	5.58	10	50	50
At Confluence with Unnamed Tributary in Subbasin QC7C	5.39	30	110	110
About 2,770 Feet Upstream of CTH P	5.11	50	110	110
Above Confluence with the South Branch of Quaas Creek	4.66	70	120	120
At Confluence with the South Branch of Quaas Creek Upstream of CTH P	4.534	220	220	220
About 2,820 Feet Downstream of CTH P	4.00	250	240	240
At Progress Drive	3.31	260	250	250
Wisconsin Central Railroad	2.85	260	260	260
At CTH G	2.50	270	280	260
Upstream Side Paradise Drive	2.11	280	280	280
Downstream Side Paradise Drive	2.06	310	310	320
About 890 Feet Downstream of Paradise Drive	1.93	330	330	340
At Sand Drive	1.51	350	360	370
About 1,860 Feet Upstream of Decorah Road	0.91	360	360	370
Above Confluence with Milwaukee River	0.07	360	360	370

[a]No modifications are recommended for Quaas Creek or its tributaries. Thus, existing channel conditions apply to each of the scenarios presented in this table.

Source: SEWRPC.

2. The Commission model accounts for modifications to the culvert under CTH P (Main Street) and for the new bridges and culverts which were constructed at Sand Drive, Progress Drive, and at the Mobil Mart south of Paradise Drive, all of which were completed since publication of the FIS.

3. The Commission model refines the modeling of the bridges at Paradise Drive and CTH G (River Road).

The Commission HEC-2 hydraulic model used 107 stream and overbank cross sections along the 5.93-mile length of Quaas Creek, while the FIS hydraulic model used 41 cross sections. The additional cross sections in the Commission model were determined using large-scale topographic mapping obtained in 1987 and 1988, following publication of the FIS. The 100-year recurrence interval flood stages computed by Commission staff for the stormwater management plan are compared to the stages computed under the FIS in Table 30.

STREAMBANK EROSION CONTROL CONSIDERATIONS

Table 31 sets forth peak flow rates for the two-year recurrence interval floods under existing land use and drainage conditions, planned land use and existing drainage conditions, and planned land use

and recommended drainage conditions at selected locations along Quaas Creek. As shown in Table 31, in comparison to existing conditions, no increase in the two-year recurrence interval flood flow peak rate is expected in the lower 4.66-mile reach of Quaas Creek under planned land use and recommended drainage conditions. This is consistent with the recommendations of the priority watershed plan for the control of nonpoint source pollution in the East and West Branches of the Milwaukee River watershed. The priority watershed plan calls for the two-year recurrence interval peak flood flow under planned land use conditions to be limited to no more than the two-year peak flow under existing land use conditions.

Increases in peak flow rates, ranging from about 70 to 400 percent, may be expected along the 1.31-mile upper reach of Quaas Creek. The largest increase in peak flow rates may be expected along the 2,060-foot extreme upper reach of the Creek upstream of River Mile 5.58. A 267 percent increase in peak rates of flow may be expected along the 1,000-foot-long reach of Quaas Creek above its confluence with an unnamed tributary in subbasin QC7C at River Mile 5.39. A 120 percent increase in peak rates of flow may be expected along the 1,480-foot-long reach of Quaas Creek between River Miles 5.11 and 5.39. A 70 percent increase in peak rates of flow may be expected along the 2,380-foot-long reach of Quaas Creek above its confluence with the South Branch at River Mile 4.53.

The provision of detention storage to reduce those peak two-year recurrence interval flood flows significantly would be limited by the following factors:

1. The impoundment of water through detention storage is generally not recommended in areas tributary to the upper reaches of Quaas Creek because of the need to maintain cool stream water temperatures in the stream reaches which are capable of supporting a trout fishery, and

2. There is a lack of adequate, undeveloped, off-stream sites for basins outside wetlands and primary environmental corridors.

Some reduction in peak two-year flood flows could be achieved through the recommendation to promote infiltration of runoff in areas of planned medium-density residential development tributary to the upper reach of the Creek. Such infiltration would be especially effective in reducing peak flows during the more frequent storms with recurrence intervals of two years and less. The degree of reduction of peak flows would be dependent on the extent to which infiltration measures are promoted by the City and implemented by developers and individual property owners.

Despite the anticipated increases in two-year recurrence interval flood flows under planned conditions, flow velocities would still generally be expected to be nonerosive. To mitigate the potential degradation of localized sites which may begin to experience erosion, it is recommended that streambank stabilization measures such as soil bioengineering, placement of riprap, or installation of gabions be considered on a site-by-site basis in this reach of Quaas Creek.

AUXILIARY PLAN RECOMMENDATIONS

Natural Resources and Open Space Preservation

The adopted land use plan for the City 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.[8] 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

As already noted, the 100-year recurrence interval flood profile determined for Quaas Creek under this study is based on more detailed analyses than were used in the 1983 Federal flood insurance study, and utilizes more current information on the hydraulic structures located along the Creek. Thus, upon adoption of this system plan, the City should amend its floodplain zoning ordinance to reflect the 100-year recurrence interval water surface profile set forth in this plan for Quaas Creek under planned land use and drainage system conditions. At that time, the City should also submit its proposed floodplain revisions and additions to the Wisconsin Department of Natural Resources, requesting revi-

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

sion of the Flood Insurance Rate Maps by the Federal Insurance Administration of the Federal Emergency Management Agency. Because portions of the 100-year recurrence interval floodplain of Quaas Creek lie within Washington County, it is recommended that the County also take similar steps to revise its zoning ordinance and Federal flood insurance maps. The City's currently-adopted 100-year recurrence interval flood profile for those portions of the Quaas Creek located within the City is based upon the 1983 Federal flood insurance study for Washington County as amended by the City. That profile must be used for zoning and regulatory purposes until such time that the 100-year recurrence interval flood profile determined under this stormwater management plan is formally approved by the State of Wisconsin and the Federal Emergency Management Agency and adopted by the City of West Bend.

Maintenance of Stormwater Management Facilities
The effectiveness of the stormwater management 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 procedures include the periodic repair of storm sewers, clearing sewer obstructions, maintenance of open channel vegetation lining, clearing debris and sediment from open channels, maintenance of detention facilities 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.

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 City staff review of and comment on preliminary findings and recommendations. Those refinements are described below.

Hydrologic Unit QC-G
Refinement of the Stormwater Drainage Plan Element: At the January 25, 1996 interagency staff meeting the City staff provided additional information pertaining to the existing roadside swale located along the north side of Paradise Drive, west of CTH G. The City staff also requested the evaluation of alternatives to conveying runoff from the Forest Highlands Subdivision in this roadside swale. The City staff suggested evaluating two alternatives: 1) conveying runoff in storm sewers located in Paradise Drive, and 2) conveying runoff to the south in the existing open channel located along the south side of Paradise Drive. Three alternatives which are refinements of the recommended plan were developed.

Alternative Refinement No. 1 to the Recommended Plan, Storm Sewer and Open Channel-Roadside Swale Conveyance with Centralized Detention and Runoff Conveyed in Roadside Swale along the North Side of Paradise Drive: Design drawings for the reconstruction of Paradise Drive, provided by City staff, show that the bed of the roadside swale located along the north side of Paradise Drive was raised. That increase in the bed elevation may impede runoff in the open channel located along the eastern edge of the Forest Highlands subdivision. To prevent the backup of runoff collected in that channel, this alternative refinement to the recommended plan calls for the deepening and modification of the cross-section of the roadside swale located along the north side of Paradise Drive. The modified roadside swale would have a triangular cross-section, with side slopes of generally one vertical on three horizontal, except for a 200-foot-long segment which would have side slopes varying between one vertical on two and one-half horizontal to one vertical on three horizontal. The roadside swale would be riprap-lined and would have an average depth of about three feet.

The present value cost of this refined alternative stormwater drainage plan for the entire hydrologic unit is $880,000, consisting of an estimated capital cost of $836,000, and an estimated annual operation and maintenance cost increase of $2,780.

Alternative Refinement No. 2 to the Recommended Plan, Storm Sewer and Open Channel-Roadside Swale Conveyance with Centralized Detention and Storm Sewers in Paradise Drive: This alternative refinement to the recommended plan proposes the installation of 1,780 lineal feet of 48-inch-diameter reinforced concrete storm sewer pipe to convey run-

off from the Forest Highlands Subdivision and other tributary areas located west of the subdivision during storms with recurrence intervals of 10 years or less. The proposed storm sewer would be installed in Paradise Drive, west of CTH G and in CTH G, north of Paradise Drive. This storm sewer would replace the existing roadside swale located along the north side of Paradise Drive and along the west side of CTH G.

The total present value cost of this refined alternative stormwater drainage plan for the entire hydrologic unit is $1,184,000, consisting of an estimated capital cost of $1,134,000, and an estimated annual operation and maintenance cost increase of $3,190.

Alternative Refinement No. 3 to the Recommended Plan, Storm Sewer and Open Channel-Roadside Swale Conveyance with Centralized Detention and Runoff Conveyed in Open Channel along the South Side of Paradise Drive: Under this alternative refinement to the recommended plan, during storms with recurrence intervals of 10 years or less, runoff from the Forest Highlands Subdivision and other tributary areas to the west, would be conveyed south under Paradise Drive through a proposed 60-inch-diameter reinforced concrete culvert, and east in the existing open channel located along the south side of Paradise Drive. The proposed culvert under Paradise Drive would be 70 feet long, and would be installed about 1,340 feet west of CTH G. To accommodate this proposed culvert, a 640-foot-long segment of the existing open channel along the south side of Paradise Drive would be modified. This segment of open channel, which is located between 700 and 1,340 feet west of CTH G, would be deepened by up to 3.5 feet. The upper 240 feet of this segment would have a triangular cross-section and side slopes of one vertical on three horizontal. The lower 400 feet would have a bottom width varying between three to 12 feet and side slopes of one vertical on four horizontal adjacent to the roadway and one vertical on three horizontal away from the roadway. This alternative refinement also calls for an additional 48-inch-diameter corrugated metal pipe to be installed under CTH G just south of Paradise Drive.

The total present value cost of refined alternative stormwater drainage plan for the entire hydrologic unit is $864,000, consisting of an estimated capital cost of $820,000, and an estimated annual operation and maintenance cost increase of $2,820.

Evaluation of Alternative Refinements to the Recommended Plan for Hydrologic Unit QC-G: Alternative Refinement No. 3 was eliminated from further consideration because, subsequent to the January 1996 interagency staff meeting, City staff expressed concern over increasing the runoff conveyed in the open channel located along the south side of Paradise Drive. Both alternative refinement plans No. 1 and No. 2 are considered equally implementable. Thus, the principal criterion for the comparative evaluation of these alternatives becomes cost.

Recommended Refined Stormwater Drainage Plan: Because Alternative Refinement No. 1 is less costly than Alternative Refinement No. 2, it is recommended for adoption in this hydrologic unit. The components and costs of the refined recommended plan are set forth in Table 28. The approximate location, alignment, and configuration of the refined recommended plan facilities are shown graphically on Map 10.

Refinement of the Water Quality Management Plan Element: At the January 25, 1996 interagency staff meeting the City staff questioned whether the recommended wet detention basin QCWD7, which would be located northeast of CTH G and Paradise Drive along a short reach of a minor tributary to Quaas Creek, could be constructed without expanding the limits of the shoreland jurisdictional boundary.[9] City staff requested that Wisconsin Department of Natural Resources Bureau of Water Regulation and Zoning staff be asked to comment on the shoreland zoning and permitting aspects related to the wet detention basins recommended under the plan. In a letter dated March 13, 1996, and addressed to Mr. John B. Capelle, Director of Community Development for the City of West Bend, Department staff indicated that, with the exception of basin QCWD7, the ponds which would be created would be classified as private, and therefore would not be attended by any changes in shoreland jurisdictional boundaries.

Because of the determination that, if it were constructed at the originally proposed site, basin QCWD7 would be likely to be classified as public and have associated with it a shoreland zone, an

---

[9]*Issues related to shoreland zoning in unincorporated lands which are annexed after May 7, 1982 are set forth in Chapter II of this volume.*

alternative location for the detention basin was considered. An alternative site would be located on planned park land at the location of proposed dry detention basin G-1. That site was rejected by City staff because a wet basin was considered inappropriate at a park location. Thus, consistent with the City policy that additional shorelands not be created in areas annexed after May 7, 1982 and in light of the rejection of the alternative upstream site by City staff, basin QCWD7 was eliminated from the water quality management plan element.

It is recommended that the decrease in the overall level of control of nonpoint source pollution within the subwatershed due to the elimination of QCWD7 be partially offset through the provision of on-site controls for about seven acres of planned industrial land in subbasin QC27. The recommended on-site controls include covering or berming industrial material storage areas and intensive weekly street, parking lot, and storage area sweeping along with periodic catch basin cleaning, where appropriate. It is also recommended that low-cost infiltration practices be promoted in those areas of planned medium-density residential development which would have been tributary to basin QCWD7.

The elimination of basin QCWD7 and the substitution of expanded industrial onsite controls would result in a net reduction in the level of control of nonpoint source pollution from the subwatershed in comparison to that envisioned under the water quality management plan element set forth in Chapter II of this report.[10] However, the refined recommended plan would still provide a level of control consistent with recommendations contained in the adopted regional water quality management plan and would still be in substantial conformance with the objectives of the priority watershed plan.

The refined recommended water quality management plan element would result in decreases in the capital and annual operation and maintenance costs of that element of $296,000 and $3,000, respectively. The components and costs of the refined recommended water quality management plan element are set forth in Table 28. The geographic area where the new recommended measures are to be applied is shown graphically on Map 10.

[10]*The following changes in the pollutant loads estimated under the original recommended plan would be anticipated due to the elimination of wet basin QCWD7 and the substitution of on-site practices to control industrial runoff: a 2 percent increase in sediment; a 1 percent increase in phosphorus, a 5 percent increase in lead; and a 3 percent increase in copper, zinc and cadmium.*

SUMMARY OF THE RECOMMENDED STORMWATER AND FLOODLAND MANAGEMENT PLAN

The recommended 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. The conveyance components include storm sewers, culverts, roadside swales, and open channels. The centralized detention components consist of both wet and dry detention basins.

The recommended major stormwater management system includes conveyance components and detention basins that have been designed to accommodate flows resulting from a 100-year recurrence interval storm. Conveyance components include street cross-sections, major open channels, drainageways, and receiving watercourses. The major system component of the recommended stormwater drainage plan element utilizes the existing natural floodwater storage along Quaas 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. In areas with existing urban streets, 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.

To accommodate anticipated runoff conditions within the Quaas Creek Subwatershed, the recommended stormwater drainage plan proposes the construction of about 22,820 lineal feet of new reinforced concrete storm sewers ranging in size from 12-inch-diameter circular pipe to 68-inch-wide by 43-inch-high HE RCP, the construction of about 790

Table 32

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

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 (acre-feet)	Peak Outflow from Detention Basin During a 10-Year Storm (cfs)	Incremental Peak Pond Volume During a 100-Year Storm[a] (acre-feet)	Peak Pond Volume During a 100-year Storm (acre-feet)	Peak Outflow from Detention Basin During a 100-Year Storm (cfs)
QC-B	QCWD13	3.37	2.3	2.42	2.42	32	2.58	2.58	57
QC-C	QCWD3	1.46	3.5	6.36	6.36	10	8.51	8.51	16
	QCWD4	0.30	0.6	1.80	1.80	17	2.06	2.06	34
	QCWD5	0.34	1.0	0.70	0.70	42	0.73	0.73	72
QC-D, QC-E	D-1[b]	--	--	2.23	2.23	11	4.00	4.00	13
	QCWD9	1.90	9.5	4.90	4.90	30	6.81	6.81	64
	QCWD12[c]	0.47	2.4	3.30	3.30	56	6.30	6.30	195
QC-F	F-1	--	--	2.04	2.04	16	3.40	3.40	25
	QCWD1	0.73	2.0	5.31	5.31	78	6.54	6.54	149
	QCWD2[d]	0.33	1.2	3.91[d]	3.91[d]	83, 74[d,e]	4.36[d]	4.36[d]	88, 228[d,e]
	QCWD8[f]	0.74	3.7	--[f]	--[f]	--[f]	--[f]	--[f]	--[f]
	QCWD10[c,d]	1.00	5.0	--[d]	--[d]	--[d,e]	--[d]	--[d]	--[d,e]
QC-G	G-1	--	--	0.96	0.96	12	1.4	1.4	31
QC-I	QCWD11[f]	0.76	3.8	--[f]	--[f]	--[f]	--[f]	--[f]	--[f]

[a]For wet detention basins, this is the incremental volume above the permanent pond volume.

[b]Dry detention basin proposed by the developer of a commercial warehouse development in subbasin QC24, south of Rusco Road and east of the Wisconsin Central Railroad.

[c]Expansions of Industrial Park-South dry detention basins "E" and "C", respectively, to include permanent ponds.

[d]During large storms, the divide between basins QCWD2 and QCWD10 (existing dry and wet basins "C" in the West Bend Industrial Park-South) would be submerged. The basins would act as a single basin with peak pond volume and peak outflow as shown above.

[e]During a 10-year recurrence interval storm, peak outflow from the combined basins QCWD2 and QCWD10 would consist of 83 cfs through the existing culvert under the Wisconsin Central Railroad northeast of the basins and of an overflow of 74 cfs to the south east into detention basin QCWD12 (existing dry basin "E" in the industrial park). During a 100-year recurrence interval storm, the peak outflow would consist of 88 cfs through the culvert under the railway and of an overflow of 228 cfs into detention basin QCWD12.

[f]Proposed wet basins designed for stormwater quality control and for which no stormwater quantity control is expected.

Source: SEWRPC.

lineal feet of replacement culverts ranging in size from 21-inch-diameter to 68-inch-wide by 43-inch-high HE RCP, the construction of about 1,200 feet of grass-lined channel at storm sewer outfalls, and the modification of about 1,780 feet of existing roadside swales and channels. The plan also calls for two centralized dry detention basins with storage volume of approximately 1.4 and 3.4 acre-feet.

The recommended water quality management plan element calls for the provision of 11 wet detention basins which would control runoff from about 652 acres of the planned urban area, the infiltration of runoff from parking lots serving commercial facilities with a total area of about 28 acres, the treatment of runoff from about 121 acres of land through the sweeping of selected industrial parking and storage areas and adjacent streets, the provision of low-cost measures to promote the infiltration of precipitation in areas of planned medium-density residential development, the preservation of the riparian buffer for natural infiltration and storage of runoff within the primary environmental corridor, and the continued enforcement of the City of West Bend construction erosion control ordinance.

Five of the 11 recommended wet basins have already been constructed in the West Bend Industrial Park-South. An additional recommended wet basin has been constructed on the west Bend Mutual Insurance Company property. It is also recommended that dry detention basins "C" and "E" in the West Bend Industrial Park-South be converted to wet basins to improve the pollutant removal effectiveness of the control system in the industrial park. The remaining three wet detention basins would be constructed on current open-space sites as urban development proceeds. One of these

three wet basins would be a dual-purpose detention basin and would provide both stormwater quantity and quality control. The hydrologic and hydraulic characteristics of the recommended dry and wet detention basins are presented in Table 32. The recommended stormwater management system plan is summarized graphically on Map 10.

It is recommended that the 100-year recurrence interval floodplain along Quaas Creek be preserved in open space uses and no structural flood control measures be constructed. It is also recommended that, where practical, the hydraulic capacities of the structures at Sand Drive, Paradise Drive, and Main Street (CTH P) be increased to meet Commission standards at such time that bridge replacement is scheduled.

The capital and operation and maintenance costs of the recommended stormwater management system plan are set forth in Table 33. The capital cost of the recommended plan is estimated to be $4.9 million. The annual operation and maintenance cost increase of the recommended plan is estimated to be $73,900, or $18,500 per square mile for the 4.0-square-mile portion of the Quaas Creek subwatershed within the planned urban service area.[11] Of the total capital cost of the recommended plan, about $3.88 million, or 79 percent, is for the stormwater drainage plan element; about $1.02 million, or 21 percent, is for the water quality management plan element. Of the total annual operation and maintenance cost, about $14,960, or 20 percent, is for the stormwater drainage plan element; about $58,900, or 80 percent, is for the water quality management plan element.

The estimated costs are based upon full development of the portion of the urban service area within the Quaas Creek subwatershed as recommended in the City land use plan and do not include the cost of minimum-diameter collector sewers, roadside swale collectors, roadway culverts that may be required to drain collector and land access roadways in areas of future development, or the cost of roadway sections in newly developed areas that have been designated to function as a component of the major drainage system. The cost of minimum-size collectors in 1995 dollars would be approximately $8,300 per acre of area served.

Table 33

COSTS OF THE RECOMMENDED STORMWATER MANAGEMENT PLAN FOR THE QUAAS CREEK SUBWATERSHED IN THE CITY OF WEST BEND STUDY AREA

Plan Element	Capital[a]	Annual Operation and Maintenance
Stormwater Drainage System	$3,885,000	$14,960
Water Quality Management Measures	1,016,000	58,900
Total	$4,901,000	$73,860

[a]Includes 35 percent for engineering, administration, and contingencies. Costs are for year 1995 with Engineering News-Record Construction Cost Index = 5,970.

Source: SEWRPC.

[11]*The planned urban service area limits used in the preparation of this volume of the report reflect some revisions to the limits of the planned urban service area as defined in Volume One of this report. Consequently, the area of the Quaas Creek subwatershed contained in the planned urban service area and shown above, differs somewhat from that shown in Table 1 in Volume One of this report.*

(This page intentionally left blank)

Chapter V

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 the 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.

The first section of this chapter describes the relationship of land development and redevelopment to the effectiveness of stormwater management measures. The second section addresses the importance of more detailed engineering design to implementation of the plan. The specific actions required to implement the plan are presented in the third section of this chapter. The fourth section sets forth an apportionment of costs between the City of West Bend, the State of Wisconsin, and the private sector and presents a preliminary plan implementation schedule. Regulatory considerations and the need for periodic reevaluation and updating of the plan are addressed in the fifth and sixth sections of this chapter, respectively.

RELATION TO FUTURE LAND USE DEVELOPMENT

Coordination with land use development and redevelopment is fundamental to successful implementation of a sound stormwater management plan. Design year 2010 planned land use conditions in the Quaas Creek subwatershed within the planned urban service area in the City of West Bend are presented in SEWRPC Community Assistance Planning Report (CAPR) 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 the aforereferenced SEWRPC CAPR 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.

Furthermore, the stormwater and floodland management plan identifies those areas in the subwatershed that should be preserved in open, natural uses. Such preservation would provide major economies in stormwater and floodland management, thus maximizing the use of natural stormwater conveyance and storage and allowing such conveyance and storage to be incorporated in the stormwater and floodland management plan. If the preservation of these areas is greatly compromised, stormwater management problems, such as localized flooding, poor drainage, and water pollution, may be expected to result.

As noted in Chapter II of this volume, the recommended water use objective for the Quaas Creek stream reaches upstream of CTH G is for recreational use and maintenance of a cold-water fishery and aquatic life. In order to meet that objective, the land use plan and the recommendations of the stormwater management plan regarding runoff infiltration practices should be carefully followed to minimize the effects of urban development on stream water temperatures.

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 future design and construction of stormwater management facilities. Detailed engineering design should begin as the systems-planning phase is completed. The detailed engineering design should examine in greater depth and detail potential 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 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 function as envisioned in the plan. Accordingly, Table 34 presents the design criteria and analytic procedures recommended to be followed in the detailed engineering design of the recommended plan components. Criteria and procedures presented in the table are for estimating stormwater flows, calculating hydraulic capacities of conveyance components, designing street cross-sections and related site grading, locating and designing storm sewer inlets, designing storm sewers, designing roadside swales, open channels, and culverts, designing detention facilities, and designing water quality control facilities. In this respect, it is recognized that over time new design stormwater procedures may be developed and become available for use in the design of stormwater management components. Before adoption, such techniques should, however, be carefully reviewed 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 Common Council of the City. 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 to making of 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

It is recommended that the plan 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 can 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 should 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. Implementation of the plan through the City zoning map and ordinance would be another means of ensuring that land use development takes place in accordance with the assumptions underlying the stormwater management plan.

Stormwater facility maintenance is an important part of plan implementation. It is recommended that the public works program of the City continue to provide for the maintenance, as well as the construction, of the stormwater management facilities. A detailed description of those procedures available to the City and recommended for use for implementation of the plan is presented in Chapter VI of Volume Three of this report.

Financing

Several means of financing stormwater management components are available to local government 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 is required. Therefore,

Table 34

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 the 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 Table 28 and on Map 10 of Chapter IV 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 grass-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 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 off-line 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 Table 28 and on Map 10 of Chapter IV 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 provided to permit fish passage
Storage Facilities	The size and design outflows of recommended storage facilities are set forth in Table 28 of Chapter IV 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
Water Quality Control Measures	The following references provide criteria for the design of water quality control measures: 1. SEWRPC Technical Report No. 31, Costs of Urban Nonpoint Source Water Pollution Control Measures, June 1991 2. Schueler, Thomas R., Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban BMPs, Metropolitan Washington Council of Governments, July 1987 3. The Wisconsin Municipal Stormwater Manual, Vol. 1, 1993, and Vol. 2, in preparation, Wisconsin Department of Natural Resources

NOTE: For a more detailed discussion of these design criteria, see Chapter IV of Volume One of this report.

Source: SEWRPC.

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 to 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 Natural Resources's Wisconsin Fund Nonpoint Source Pollution Abatement Program for the construction of many of the components of the water quality management plan element.[1]

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 developments which contain recommended stormwater management components to be financed entirely or in part, by the private sector, provision of the recommended facilities would ordinarily be a condition of plat approval by the City. Thus, the costs would ultimately be 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.

SCHEDULE FOR FINANCING AND IMPLEMENTATION OF THE PLAN

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 only 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 35. 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 serve specific, new urban development or to solve an isolated problem related to existing private 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 sweeping of industrial and commercial parking lots and storage areas were assumed to be borne by the private sector.

4. The capital costs of infiltration facilities were variously 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 funds provided under the Wisconsin Fund Nonpoint Source Pollution Abatement Program for nonpoint source pollution control measures undertaken by local units of government is presented in Chapter VI of Volume Three of this report. Tables 36 and 37 provide possible allocations of costs between the City, the State, and the private sector on the basis of current State cost-sharing policy.

---

[1]*The end date for implementing nonpoint source pollution control projects in the East and West Branches of the Milwaukee River priority watershed study is June 1997. Such projects can be proposed for State cost-sharing funds up to that end date. At the time of publication of this report, extension of the end date to December 31, 1999, was being considered.*

Table 35

RECOMMENDED APPORTIONMENT OF PUBLIC-SECTOR AND PRIVATE-SECTOR COSTS FOR COMPONENTS OF THE RECOMMENDED QUAAS CREEK SUBWATERSHED STORMWATER MANAGEMENT PLAN FOR THE CITY OF WEST BEND STUDY AREA

Hydrologic Unit Designation	Component Designation	Public Sector		Private Sector		Total	
		Capital[a]	Annual Operation and Maintenance	Capital[a]	Annual Operation and Maintenance	Capital[a]	Annual Operation and Maintenance
Recommended Stormwater Management Plan Components (refer to Table 28)							
QC-B	1		$ 80	$ 9,000		$ 9,000	$ 80
	2		80	13,000		13,000	80
	3		240	43,000		43,000	240
	4		190	40,000		40,000	190
	5		220	51,000		51,000	220
	6		160	42,000		42,000	160
	7		230	184,000		184,000	230
	8		140	145,000		145,000	140
	9		140	189,000		189,000	140
	10		10	5,000		5,000	10
	11		3,000	75,000		75,000	3,000
	12		1,800	0		0	1,800
	Subtotal	$ 0	$ 6,290	$ 796,000	$ 0	$ 796,000	$ 6,290
QC-C	1		$ 80	$ 11,000		$ 11,000	$ 80
	2		400	62,000		62,000	400
	3		120	22,000		22,000	120
	4		130	28,000		28,000	130
	5		520	121,000		121,000	520
	6		80	55,000		55,000	80
	7		140	117,000		117,000	140
	8		120	88,000		88,000	120
	9		10	18,000		18,000	10
	10	$ 6,000	0			6,000	0
	11		140	4,000		4,000	140
	12		220	3,000		3,000	220
	13		40	1,000		1,000	40
	14	36,000	4,000	54,000		90,000	4,000
	15			21,000	$23,100	21,000	23,100
	16		2,100			0	2,100
	17		1,400			0	1,400
	18		1,500			0	1,500
	Subtotal	$ 42,000	$11,000	$ 605,000	$23,100	$ 647,000	$34,100
QC-D and QC-E	1		$ 310	$ 49,000		$ 49,000	$ 310
	2		290	50,000		50,000	290
	3		210	44,000		44,000	210
	4		290	66,000		66,000	290
	5	$ 4,000	130	84,000		88,000	130
	6	7,000	180	141,000		148,000	180
	7	5,000	110	103,000		108,000	110
	8	4,000	70	85,000		89,000	70
	9		2,000	124,000		124,000	2,000
	10		20	14,000		14,000	20
	11	26,000	0			26,000	0
	12	12,000	10			12,000	10
	13	53,000	320			53,000	320
	14	2,000	0			2,000	0
	15	1,000	0			1,000	0
	16		80	3,000		3,000	80
	17	14,000	4,600	261,000		275,000	4,600
	18	89,000	1,900			89,000	1,900
	Subtotal	$217,000	$10,520	$1,024,000	$ 0	$1,241,000	$10,520

Table 35 (continued)

Hydrologic Unit Designation	Component Designation	Public Sector		Private Sector		Total	
		Capital[a]	Annual Operation and Maintenance	Capital[a]	Annual Operation and Maintenance	Capital[a]	Annual Operation and Maintenance
QC-F	1		$ 20	$ 15,000		$ 15,000	$ 20
	2	$ 9,000	-10			9,000	-10
	3	26,000	2,400			26,000	2,400
	4	0	1,700			0	1,700
	5	0	1,500			0	1,500
	6	146,000	2,200			146,000	2,200
	7	161,000	2,900			161,000	2,900
	Subtotal	$342,000	$10,710	$ 15,000	$ 0	$ 357,000	$10,710
QC-G	1		$ 110	$ 19,000		$ 19,000	$ 110
	2		470	97,000		97,000	470
	3		380	87,000		87,000	380
	4		140	105,000		105,000	140
	5		20	24,000		24,000	20
	6		120	114,000		114,000	120
	7		20	56,000		56,000	20
	8		0	38,000		38,000	0
	9		0	32,000		32,000	0
	10	$ 48,000	0			48,000	0
	11	65,000	0			65,000	0
	12		1,400	92,000		92,000	1,400
	13		60	51,000		51,000	60
	14		60	8,000		8,000	60
	15			2,000	$ 1,600	2,000	1,600
	Subtotal	$113,000	$ 2,780	$ 725,000	$ 1,600	$ 838,000	$ 4,380
QC-I	1		$ 280	$ 47,000		$ 47,000	$ 280
	2		160	33,000		33,000	160
	3		340	78,000		78,000	340
	4		840	222,000		222,000	840
	5		340	235,000		235,000	340
	6		300	248,000		248,000	300
	7		0	2,000		2,000	0
	8	$ 85,000	2,200	69,000		154,000	2,200
	9			3,000	$ 3,400	3,000	3,400
	Subtotal	$ 85,000	$ 4,460	$ 937,000	$ 3,400	$1,022,000	$ 7,860
- -	Total	$799,000	$45,760	$4,102,000	$28,100	$4,901,000	$73,860

[a]*Includes 35 percent for engineering, administration, and contingencies. Costs are for year 1995 with Engineering News-Record Construction Cost Index = 5,970.*

Source: SEWRPC.

All operation and maintenance costs, except those for sweeping of industrial and commercial parking and storage areas, were assumed to be funded 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 the 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 the operation and maintenance to execute a legal agreement which details both the responsibility of the private party for providing

Table 36

ASSIGNMENT OF CITY, STATE, AND PRIVATE-SECTOR COSTS OF THE RECOMMENDED QUAAS CREEK SUBWATERSHED WATER QUALITY MANAGEMENT PLAN ELEMENT

Hydrologic Unit Designation	Component Designation	Capital Cost[a] (dollars)			
		City of West Bend	State of Wisconsin	Private Sector	Total
Water Quality Management Plan Element (Refer to Table 28)					
QC-B	11	--	--	$ 75,000	$ 75,000
	12	--	--	--	--
	Subtotal	$ 0	$ 0	$ 75,000	$ 75,000
QC-C	14	$ 11,000	$ 25,000	$ 54,000	$ 90,000
	15	--	--	21,000	21,000
	16	--	--	--	--
	17	--	--	--	--
	18	--	--	--	--
	Subtotal	$ 11,000	$ 25,000	$ 75,000	$ 111,000
QC-D and E	17	$ 5,000	$ 9,000	$261,000	$ 275,000
	18	27,000	62,000	--	89,000
	Subtotal	$ 32,000	$ 71,000	$261,000	$ 364,000
QC-F	4	--	--	--	$ 0
	5	--	--	--	0
	6	$ 50,000	$ 96,000	--	146,000
	7	48,000	113,000	--	161,000
	Subtotal	$ 98,000	$209,000	$ 0	$ 307,000
QC-G	15	--	--	$ 2,000	$ 2,000
	Subtotal	$ 0	$ 0	$ 2,000	$ 2,000
QC-I	8	$ 29,000	$ 56,000	$ 69,000	$ 154,000
	9	--	--	3,000	$3,000
	Subtotal	$ 29,000	$ 56,000	$ 72,000	$ 157,000
--	Total	$170,000	$361,000	$485,000	$1,016,000

[a]*Includes 35 percent for engineering, administration, and contingencies. Costs are for year 1995 with Engineering News-Record Construction Cost Index = 5,970.*

Source: SEWRPC.

operation and maintenance and the degree of operation and maintenance to be provided. Those stormwater management facilities which are constructed by private funds, but maintained by the City, would be dedicated to the City following construction.

Prioritization of Capital Improvements

A preliminary prioritization of the recommended capital improvements is given in Table 38. 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 system of which it is a part.

The projects are classified as of high, intermediate, or low priority. The high-priority projects are those that address existing problems or those that are required to serve new development that is actually occurring. The intermediate-priority projects are those that are required to serve development anticipated to occur in the near future on the basis of development proposals which have been submitted to the City. The low-priority projects are those that are required to serve and promote development in the more distant future.

The sequence in which projects are actually implemented and the time at which they are implemented

Table 37

POSSIBLE APPORTIONMENT OF TOTAL CITY OF WEST BEND, STATE OF WISCONSIN, AND PRIVATE-SECTOR COSTS FOR THE RECOMMENDED QUAAS CREEK SUBWATERSHED STORMWATER MANAGEMENT PLAN

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	$268,000	$14,960	--	--	$3,617,000	$ 0	$3,885,000	$14,960
Water Quality Management Measures	$170,000	$30,800	$361,000	$0	$ 485,000	$28,100	$1,016,000	$58,900
Total	$438,000	$45,760	$361,000	$0	$4,102,000	$28,100	$4,901,000	$73,860

[a]*Includes 35 percent for engineering, administration, and contingencies. Costs are for year 1995 with Engineering News-Record Construction Cost Index = 5,970.*

Source: SEWRPC.

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.

Critical Implementation Sequences

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 a 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.

REGULATORY CONSIDERATIONS

Implementation of some of the drainage measures 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. The regulatory process involved is complex, therefore, the City should seek legal counsel prior to proceeding with any stormwater management measures that involve the construction or modification 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 relating to the disturbance of wetlands 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 modification 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, 30.195, 30.20, 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 Pro-

Table 38

PRIORITIZATION OF STORMWATER MANAGEMENT PLAN PROJECTS FOR THE QUAAS CREEK SUBWATERSHED

Project Number and Description	Hydrologic Unit	Project Components as Listed in Table 28	Capital Cost[a] (dollars)			
			City of West Bend	State of Wisconsin	Private Sector	Total
High-Priority Projects						
1. Culvert Replacements under Indiana Avenue and Crocus Court in the Forest Highlands Subdivision and roadside swale modifications at Paradise Drive	QC-G	Hydrologic Unit QC-G, items 8 through 11	113,000	--	70,000	183,000
2. Culvert Replacements and Roadside Swale Modifications at Rusco Road West of CTH G	QC-D	Hydrologic Units QC-D and QC-E, items 11 through 15	94,000	--	--	94,000
3. Wet Basin QCWD12 in the Industrial Park-South (City-Designated "E")[b]	QC-D	Hydrologic Units QC-D and QC-E, item 18	27,000	62,000	--	89,000
4. New Culvert, and Detention Basin in Subbasin QC13	QC-F	Hydrologic Unit QC-F, items 1 and 3	26,000	--	15,000	41,000
5. Wet Basins QCWD8 and QCWD10[b]	QC-F	Hydrologic Unit QC-F, items 6 and 7	98,000	209,000	--	307,000
6. Infiltration Systems in Existing Commercial Parking Lots[b]	QC-C	Hydrologic Unit QC-C, item 14 (partial)	11,000	25,000	--	36,000
7. Wet Basin QCWD11[b]	QC-I	Hydrologic Unit QC-I, item 8	29,000	56,000	69,000	154,000
Subtotal	--	--	398,000	352,000	154,000	904,000
Intermediate-Priority Projects						
8. New Culvert under 18th Avenue	QC-B	Hydrologic Unit QC-B, item 7 (partial)	--	--	11,000	11,000
9. Dual-Purpose Basin QCWD9	QC-D	Hydrologic Units QC-D and QC-E, items 9, 10 and 17	5,000	9,000	385,000	399,000
10. Infiltration Systems in Planned Commercial Parking Lots	QC-C	Hydrologic Unit QC-C, item 14 (partial)	--	--	54,000	54,000
11. Industrial Parking and Storage area Sweeping	QC-C	Hydrologic Unit QC-C, item 15	--	--	21,000	21,000
12. Culvert Replacement under CTH P	QC-F	Hydrologic Unit QC-F, item 2	9,000	--	--	9,000
Subtotal	--	--	14,000	9,000	471,000	494,000
Low-Priority Projects						
13. New Storm Sewers	QC-B	Hydrologic Unit QC-B, items 1 through 6, 8 through 10, and 7 (partial)	--	--	710,000	710,000
14. Infiltration Systems in Planned Commercial Parking Lots	QC-B	Hydrologic Unit QC-B, item 11	--	--	75,000	75,000
15. New Storm Sewers, Open Channels, and Culvert Replacements	QC-C	Hydrologic Unit QC-C, items 1 through 13	6,000	--	530,000	536,000
16. New Storm Sewers and Open Channel	QC-D and QC-E	Hydrologic Units QC-D and QC-E, items 1 through 8, and 16	20,000	--	639,000	659,000
17. New Storm Sewers and Detention Basin	QC-G	Hydrologic Unit QC-G, items 1 through 7, and 12 through 14	--	--	653,000	653,000
18. New Storm Sewers	QC-I	Hydrologic Unit QC-I, items 1 through 7	--	--	865,000	865,000
19. Industrial Parking and Storage Area Sweeping	QC-G and QC-I	Hydrologic Unit QC-G, item 15 Hydrologic Unit QC-I, item 9	--	--	5,000	5,000
Subtotal	--	--	26,000	--	3,477,000	3,503,000
Total	--	--	438,000	361,000	4,102,000	4,901,000

[a] *Includes 35 percent for engineering, administration, and contingencies. Costs are for year 1995 with Engineering News-Record Construction Cost Index = 5,970.*

[b] *These nonpoint source measures are 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.

gram." Under this planning effort, consideration was given to addressing the wetland water quality requirements of Chapter NR 103 of the Code. Specific information on wetland considerations related to the plan are presented in Chapter III of this volume.

As a result of the detailed hydrologic and hydraulic modeling conducted under the planning effort, an updated 100-year recurrence interval flood profile was computed for portions of Quaas Creek located in both the City of West Bend and Washington County. That profile and the substantiating analyses used in its development can be submitted by the City and the County to the Federal Emergency Management Agency with a request to revise the City and County floodplain boundary maps.[2]

PLAN REEVALUATION AND UPDATING

The recommended stormwater and floodland management 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 study 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, it was necessary in the initial plan development, 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 and reevaluation should be directed toward developing recommendations and updating inventories for smaller conveyance components as development plans are prepared and incorporating that information into the master stormwater management plan.

---

[2]*The City's currently adopted 100-year recurrence interval flood profile for those portions of the Quaas Creek floodplain located within the City is based on the 1983 Federal flood insurance study for Washington County as formally amended by the City. That profile must be used for zoning and regulatory purposes until the 100-year flood profile determined under this stormwater management plan is formally approved by the State of Wisconsin and the Federal Emergency Management Agency and adopted by the City of West Bend.*

Chapter VI

SUMMARY

The recommended stormwater management plan for that portion of the West Bend planned urban service area within the Quaas Creek subwatershed consists of a stormwater drainage plan element, a floodland management plan element, and a water quality management plan element. The recommended plan was selected following careful evaluation of several alternatives considered for each of the nine hydrologic units defined within the study area.

Based on the best alternative identified for each of the hydrologic units in the West Bend urban service area, a recommended stormwater drainage plan was developed consisting of minor system components and major system components. The minor system components were designed for a 10-year recurrence interval storm peak flow, while the major system components were designed for a 100-year recurrence interval storm peak flow. The recommended components consist of about 22,820 lineal feet of new storm sewers, 790 lineal feet of replacement culverts, 1,200 feet of grass-lined channel at storm sewer outfalls, modification of about 1,780 feet of existing roadside swales and channels, and two centralized dry detention basins for water quantity control.

The water quality management plan element calls for 11 wet detention basins for water quality control,[1] the infiltration of runoff from about 28 acres of parking lots serving commercial facilities, the treatment of runoff from about 121 acres of land through the sweeping of selected industrial parking and storage areas and adjacent streets, the provision of low-cost measures to promote the infiltration of precipitation in areas of planned medium-density residential development, preservation of a riparian buffer for natural infiltration and storage of runoff within the primary environmental corridor, continued enforcement of the City of West Bend construction erosion control ordinance, and public education programs. Five of the recommended wet basins have already been constructed in the West Bend Industrial Park-South. An additional recommended wet basin has been constructed on the West Bend Mutual Insurance Company property. It is also recommended that dry detention basins "C" and "E" in the West Bend Industrial Park-South be converted to wet basins to provide increased removal of nonpoint source pollutants contributed by lands in the industrial park and lands tributary to the industrial park. The remaining three wet detention basins would be constructed on current open-space sites as urban development proceeds.

In comparison to uncontrolled loadings under planned land use conditions, implementation of the recommended urban nonpoint source pollution control measures would reduce sediment loadings to Quaas Creek by 21 percent, phosphorus loadings by 11 percent, lead loadings by 42 percent, both copper and zinc loadings by 34 percent, and cadmium loadings by 35 percent.[2] The levels of control of nonpoint source pollutants in the recommended plan, when coupled with control of nonpoint source pollution from rural lands in the subwatershed as recommended under the regional water quality management plan, should meet or exceed the 25 percent reduction in nonpoint source pollution loadings from the subwatershed as recommended in the regional water quality management plan. In addition, the recommended stormwater management plan may be considered to be in substantial conformance with the goals of the priority watershed plan.

An updated 100-year recurrence interval flood profile for planned land use and existing channel conditions was developed for Quaas Creek based on the detailed hydrologic and hydraulic analyses performed as part of the floodland management plan element. The resulting 100-year recurrence interval floodplain area along Quaas Creek, shown on Map 10, lies in both the City of West Bend and Washington County. It is recommended that the

---

[1]*Nine of the 11 detention basins are dual-purpose basins for the control of both water quality and water quantity.*

[2]*These reductions account for the refinement to the recommended plan whereby detention basin QCWD7 was eliminated and onsite industrial controls were recommended for an additional seven-acre area. Thus the loading reductions differ slightly from those set forth in Chapter II of this volume.*

plain revisions to the Wisconsin Department of Natural Resources, requesting revision of the Flood Insurance Rate Maps by the Federal Insurance Administration of the Federal Emergency Management Agency.[3]

In general, it is recommended that the 100-year recurrence interval floodplain be preserved in open space uses and no structural flood control recommendations are made. It is also recommended that, where practical, the hydraulic capacities of the structures at Sand Drive, Paradise Drive, and Main Street (CTH P) be increased to meet Commission standards at such time that bridge replacement is scheduled.

Streambank stabilization measures are recommended to be considered on a site-by-site basis in the upper 1.31-mile reach of Quaas Creek where potential streambank degradation may occur as a result of increased peak-flow rates under planned land use conditions.

The total capital cost of the recommended plan is estimated to be $4.9 million. Of that cost, about $3.88 million, or 79 percent, is for the stormwater drainage plan element and about $1.02 million, or 21 percent, is for the water quality management plan element. Of the total capital cost of the plan, about $438,000, or 9 percent, is recommended to be borne by the City; about $361,000, or 7 percent, is recommended to be borne by the State of Wisconsin; and about $4.1 million, or 84 percent, is recommended to be financed by the private sector, primarily land developers. Of the total annual operation and maintenance cost increase of $73,900, about $14,960, or 20 percent, is for the stormwater drainage plan element; about $58,900, or 80 percent, is for the water quality management plan element. About $45,760, or 62 percent of the total annual operation and maintenance cost increase, is recommended to be borne by the City of West Bend and the remaining $28,100, or 38 percent, is recommended to be borne by private sector. The private sector annual operation and maintenance costs are for sweeping of industrial parking and storage areas, or both. The initial step in plan implementation is formal adoption of the plan by the Plan Commission, Board of Public Works, and Common Council of the City of West Bend. 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, continuous, and stable operation and maintenance of both the existing and new facilities. In order to facilitate implementation of 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 Quaas Creek subwatershed within the planned urban service area, thereby reducing the public costs attributable to improperly functioning drainage facilities. Implementation of the recommended plan would provide protection against substantial inconvenience to residents during minor storm events and against major property damage or significant hazard to human health and safety during major storm events. The plan seeks to protect or improve water quality and aquatic habitat conditions to the greatest degree practicable, thereby enhancing the use of surface waters. 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.

---

[3]*The City's currently-adopted 100-year recurrence interval flood profile for Quaas Creek is based on the 1983 Federal flood insurance study for Washington County as formally amended by the City. That profile must be used for zoning and regulatory purposes until the 100-year flood profile determined under this plan is approved by the State of Wisconsin and the Federal Emergency Management Agency and adopted by the City.*