City of
Oak Creek, WI

Stormwater Management Master Plan

R.A.SMITH
& ASSOCIATES, INC.

and

Hey & Associates, Inc.
Water Resources, Wetlands and Ecology

December 10, 2001

Acknowledgments

Involvement

The following have been a part in making this report possible and we thank them for their dedication, time, expertise, and perseverance:

Stormwater Master Plan Working Committee

Alderman Elizabeth J. Kopplin (Chairman)
Alderman Lawrence A. Prochnow
Alderman Merlyn J. Warner
Ervin J. Nowak
Mark Verhalen
Michael D. Rosen
Norb Theine, P.E.
Philip J. Beiermeister, P.E.

Agencies Involved in Development and Review of Master Plan

Milwaukee County Parks
Milwaukee Metropolitan Sewerage District
Southeastern Wisconsin Regional Planning Commission
Wisconsin Department of Natural Resources

Mayor and Common Council

Dale J. Richards (Mayor)
Elizabeth J. Kopplin (1st District Alderman)
Allan M. Foeckler (2nd District Alderman)
Ann M. Lampe (3rd District Alderman)
Merlyn J. Warner (4th District Alderman)
Lawrence A. Prochnow (5th District Alderman)
Alice A. Rudebusch (6th District Alderman)

Informational Meetings

Information Meetings regarding the floodplains were held on October 18, 25, and 26, 2000. A final Information Meeting on the overall plan was held on November 28, 2001.

CITY ADOPTION AND RESOLUTION

DECEMBER 10, 2001

RESOLUTION NO. 10032-121001

BY: Ald. Pradmore

RESOLUTION APPROVING THE STORM WATER MANAGEMENT MASTER PLAN

(PROJECT NO. 95025)

(CITY-WIDE)

WHEREAS, R.A. Smith and Associates prepared a Storm Water Management Master Plan for the City of Oak Creek; and

WHEREAS, the City's Storm Water Master Plan Committee oversaw the progress of the master plan and accepted the final draft report; and

WHEREAS, the Milwaukee Metropolitan Sewerage District adopted new storm water rules that apply to all governmental units within their sewer service area; and

WHEREAS, the tributary floodplain data developed under the master plan be amended to represent a uniform level of detail.

NOW, THEREFORE BE IT RESOLVED, by the Mayor and Common Council of the City of Oak Creek that the Storm Water Management Master Plan prepared by R.A. Smith and Associates be approved as recommended by the Storm Water Master Plan Committee amended to be in compliance with the chapter 13 Rules of the Milwaukee Metropolitan Sewerage District and amended to floodplains representing areas studied with a minimum tributary area of about 80 acres or previously adopted A zones; and

BE IT FURTHER RESOLVED, that staff is directed to begin the implementation process of the Master Plan.

RESOLVED, by the Common Council of the City of Oak Creek, Wisconsin:

Introduced at a regular meeting of the Common Council of the City of Oak Creek held on the 10th day of December, 2001.

Passed and adopted this 10th day of December, 2001.

Lawrence H. [signature]
President, Common Council

Approved this 10th day of December, 2001.

[signature]
Mayor

ATTEST:

Beverly A. Burotty
City Clerk

VOTE: Ayes 5 Noes 0
Ald. Koppler abstained

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Executive Summary

Introduction

The purpose of the City of Oak Creek Stormwater Management Master Plan is to develop alternatives, recommendations, and implementation strategies for correcting flooding and drainage problems and minimizing the impact of stormwater runoff from existing and future developments. The plan addresses water quality and quantity issues in the City of Oak Creek. Existing and future land uses in the City are evaluated as they influence the stormwater runoff characteristics.

As shown on Figure 1, the City of Oak Creek lies in three major watersheds: Oak Creek, Root River, and Lake Michigan. For planning purposes, the North Branch and Mitchell Field Drainage Ditch subwatersheds were identified within the Oak Creek watershed. The City of Oak Creek study area is approximately 28.8 square miles in size, not including tributary areas outside the City.

Stormwater Management Master Plan Goal

The goal of the City of Oak Creek Stormwater Management Master Plan is to protect, maintain, and enhance the public health, safety and general welfare by developing a plan to control the adverse impacts of increased stormwater runoff associated with existing and planned land use, and to recommend solutions to drainage problems. Proper management of stormwater runoff will minimize damage to public and private property, prevent inconvenience to local residents, protect water quality of surface and groundwater, maintain and enhance fish and wildlife habitat, protect public open space, and maintain the quality of life in the community.

Stormwater Management Objectives

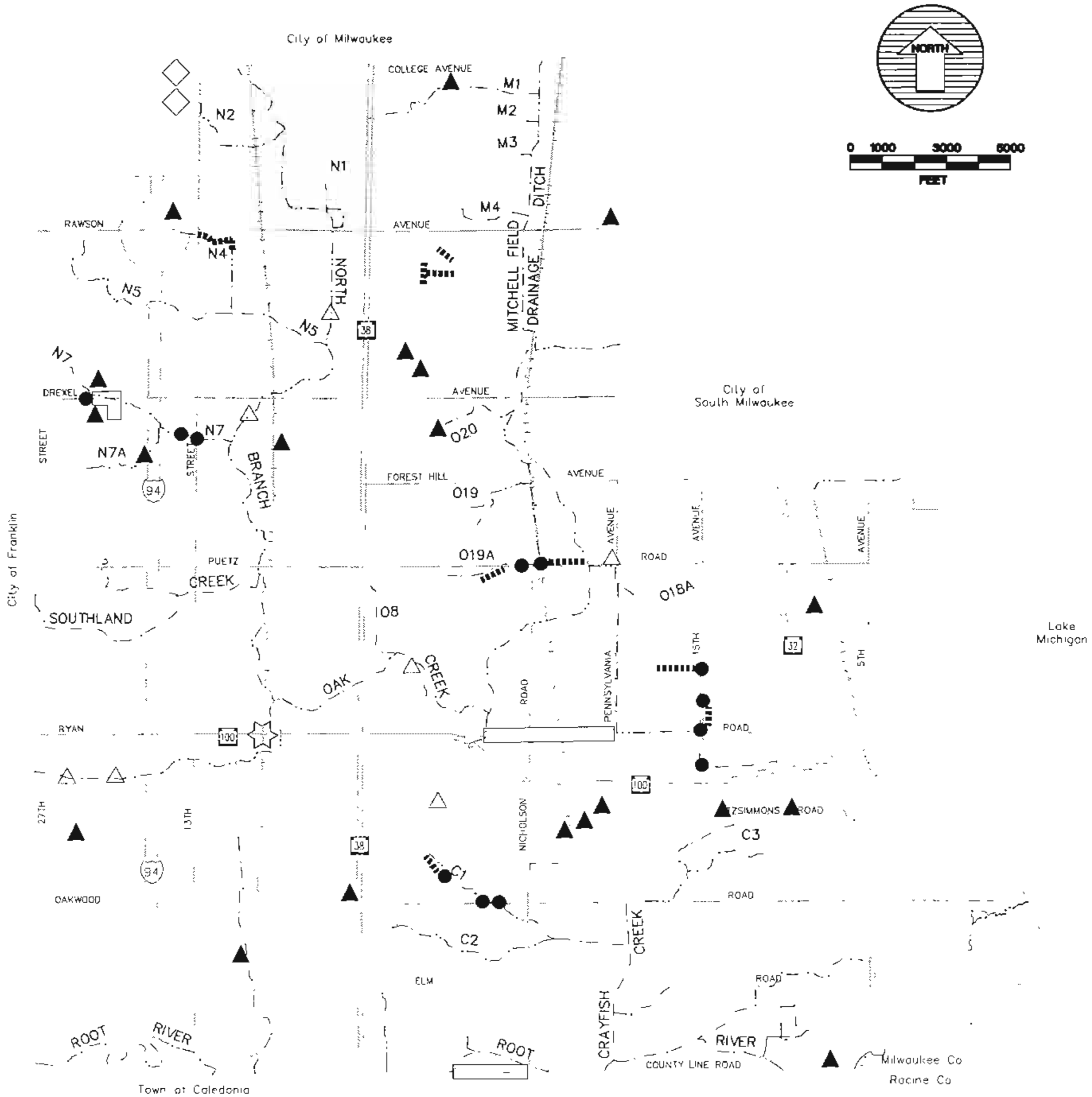
To achieve the above goal, the following objectives are established:

1) Develop a major and minor stormwater drainage system that will convey stormwater in a manner that reduces the public's exposure to drainage related inconveniences and protects public and private property from runoff related damages.

2) Develop a stormwater management system that prevents any adverse impacts of increases in flood elevations; where possible, reduces the floodplain to predeveloped conditions; and protects and preserves floodplain storage.

3) Develop a stormwater management system that evaluates stormwater storage versus stormwater conveyance.

Figure 1
Flood Control and Drainage Recommendations



Legend

- C3 — TRIBUTARY NAME
- ● — CULVERT
- ▮▮▮▮ — CHANNEL OR SWALE
- ▲ — PRESERVE NATURAL STORAGE
- ▭ — FLOOD PROTECTION
- ✡ — PUMPING STATION
- △ — STORM OUTLET MAINTENANCE
- ◇ — DETENTION BASIN

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4) Develop a stormwater management system which will abate nonpoint source water pollution, help achieve recommended water use objectives and supporting water quality standards for local streams, protect the quality of Lake Michigan as a drinking water source for the City, and protect local groundwater resources.

5) Establish a comprehensive hydrologic, hydraulic, existing and proposed land use, and cartographic data base using the best available and most appropriate technology to manage the stormwater, flood and water quality data needs of the program.

6) Develop a stormwater management system that controls runoff within a greenway system and maintains or enhances terrestrial, riparian, and aquatic biological communities including plants, fish and wildlife.

7) Develop a stormwater management system that is equitable and fair and effectively meets all of the other stated objectives while considering all benefits and cost.

8) Develop a stormwater management system that requires minimum maintenance and has maintenance requirements that can be implemented by available organizations or units of government.

9) Develop a stormwater management system that can be implemented under existing federal, state, regional and local regulations, and adopted management plans.

10) Establish a consistent, equitable and dedicated source of revenue in order to maintain the stormwater management program in the City of Oak Creek.

11) Development of an integrated stormwater management and flood control system, which effectively serves existing, and future land use.

Inventory

The inventory conducted under the stormwater management plan included a number of items that are very important to the City staff, including:

- Identification and digital mapping of storm sewers 15 inches and larger
- Identification, survey, and digital mapping of culverts 24 inches and larger
- Identification of industries and their permitting requirements
- Mapping of wetlands and classification for potential stormwater control and water quality treatment
- Identification of waste disposal facilities
- Evaluation of the streams in the City and identification of areas of active channel erosion, sediment deposition, and channel blockage
- Identification of flooding and drainage problems

Improvement Priorities and Responsibilities

Due to fiscal constraints, not all of the recommendations can be implemented at one time. Therefore, a prioritization of the improvements is necessary. The priorities are presented in Table 1.

It should be noted that the recommendations and priorities might change if conditions change. The ranking of the recommendations is only a guide for planning purposes. Actual placement of projects into the City's capital improvement or maintenance budget will be based on available funds and ranking against other competing priorities.

Summary of Stormwater Management Recommendations

Flood Control and Drainage Recommendations

Management of stormwater runoff is a complicated issue in Oak Creek because much of the City is already developed. Also, rapid release of stormwater without storage may benefit some sections of Oak Creek, while hurting others and downstream communities. The model studies performed for Oak Creek suggest that for many specific areas storage alone cannot relieve existing drainage problems. However, it is equally clear that storage for new development can reduce the cost of some of these drainage improvements by maintaining the rate of design flows after development takes place.

Recommended solutions for the flooding and drainage problem areas are summarized in Table 1. These recommendations are, in general, the least cost alternatives unless there are overriding considerations such as adverse ecological impacts, implementation barriers, or safety concerns. The recommended priority and implementing agency are identified for each recommendation in Table 1.

TABLE 1 Flood Control and Drainage Projects

Priority	Project	District	Capital Improvement Cost (1)	Annual O&M Cost	Comments
1	Pumping Station at 700 W. Ryan Rd.	6	$733,000	$40,000	Construction in progress
2	Rebuild storm sewer outlet and clean channel downstream of Darlene Ln.	5	$65,000	$1,000	Channel cleaning scheduled for summer 2000
3	Install storm sewer S. 11th Ave. (south of E. Puetz Rd.)to Madeira Dr.	4	$500,000		
4	Overflow grading south of Puetz Rd. east of Shepard Ave.; add culverts at Nicholson Rd. (O19A)	3	$304,000		These two projects should be constructed at the same time
4	Culvert under railroad north of Puetz Rd. and channel to the east to Oak Creek (O19A)	3	$406,000		
5	Culverts at S. Shepard Ave. north of Oakwood Rd. (C1)	5	$80,000		These two projects should be constructed at the same time
5	Culverts at E. Oakwood Rd. east of McGraw (C1)	5	$181,000		
6	Additional culverts and swales at S. 15th Ave., north of E. Ryan Rd. (O15)	3,4	$218,000		
7	Channel modifications downstream of S. 13th St. to box culvert S. 10th St. (N4)	1	$689,000		Add box culvert with road reconstruction (2001)
8	Raise road and additional culvert at S. 20th St. & W. Drexel Ave. (N7)	2	$201,000		
9	Detention west of S. 13th St. & additional culvert going in at Pelton Dr. (N2)	1	$940,000	$2,000	Add culvert at time of road resurfacing (2000)
10	Additional culvert at S. 15th Ave., south of E. Ryan Rd. (O16)	4,5	$75,000		Completed in May 2000
11	Swale along north property line at 7152 S. Taylor Ave.	1	$14,000		Do at time of road resurfacing (2001)
12	Diversion berm and overflow swale at 7289 S. Quincy Ave.	1	$21,000		Do at time of road resurfacing (2001)
13	Culverts at Willow Dr. and S. 13th St.	2	$300,000		
14	Reconstruct road and add culverts at 9000 S. Pennsylvania Ave.	3			Do at time of road resurfacing (2001)
15	Raise E. Ryan Rd. – Pennsylvania Ave. to west of Nicholson Rd.	3,5	$622,000		
16	Control development flows upstream of S. 11th Ave. (C3 Trib.)	5			
17	Revise easement at 7538 S. 13th St.	1			
18	Raise E. County Line Rd. west of Nicholson Rd.	5	$384,000		
19	Evaluate raising E. Oakwood Rd.	5			
20	Evaluate raising E. Elm Rd.	5			
	Maintain storm sewer outfalls -Marquette Ave. -Drexel Ave. and Wildwood Dr. -Puetz Ave. and Pennsylvania Ave. -Parkway Estates and Oak Lane -Southbranch Blvd. And Reinhart Dr. -Arthur Dr.	 1 2 3 3 6 5		 $1,000 $1,000 $1,000 $1,000 $1,000 $1,000	These outfalls need to be inspected annually Possible to reroute storm with prop. subdivision
	Total		$5,911,500	$49,000	

(1) Easement and land acquisition costs are not included.

Water Quality Recommendations

The suspended sediment loading from the study area, from all sources, is estimated at 8,570,000 pounds per year. Implementation of the water quality recommendations, outlined in Table 3 and illustrated in Figure 2, will result in an annual reduction of more than 3,620,000 pounds per year of suspended sediment, or 42% of the total loading. Combined with the housekeeping practices outlined in Table 2, the plan recommendations should reach the 50% total suspended solids reduction goal. Implementation of the High Priority recommendations results in a 27% reduction in suspended sediment loading. Implementation of the Medium Priority recommendations in addition to the High Priority items would raise the sediment reduction level to 32%.

TABLE 2 Water Quality Recommendations on a City Wide Basis

Recommendation	Annual Cost	Implementing Agency	Priority
Enforcement of construction site erosion control ordinances.	$30,000 to $40,000	City of Oak Creek	High
Adoption and enforcement of a City stormwater management ordinance.	$15,000	City of Oak Creek	High
Continued support for the Milwaukee County Hazardous Response Team.	NA	City of Oak Creek	High
Conduct an information and education program on proper lawn fertilization and pesticide use, proper disposal of lawn clippings, leaf composting, proper pet waste disposal, and the need to control dumping of waste down storm sewers.	$5,000	City of Oak Creek	High
Conduct a storm sewer-stenciling program informing residents to not dump waste into storm sewers. Conduct an annual program of inspections and replace faded and worn stencils.	$2,000	City of Oak Creek School District	High
Enter discussions with the City of Franklin and South Milwaukee to explore options for coordinating their stormwater management efforts.	NA	City of Oak Creek	High
Sweep all City streets with curbs spring and fall.	$25,000	City of Oak Creek	High
Implement a program of catch basin cleaning twice per year or when sumps are 30-40% full.	$24,000 to $45,000/yr	City of Oak Creek	High
Develop a "Business Partnership Program for Clean Water"	$5,000	City of Oak Creek	High
Total Annual Cost	**$81,000 to 112,000**		

[1] NA means "Not Available"

TABLE 3 Water Quality Recommendations for Targeted Subbasins

Number on Figure 2	Recommendation	TSS Reductions (lbs/year)	Capital Cost[1]	Annual Operation and Maintenance Cost[2]	Implementing Agency	Priority
WQ-1[4]	Street sweeping on major highways including, I-94, Ryan Rd., Howell Ave., 27th St., College Ave., Rawson Ave., Drexel Ave., Puetz Rd., and Forest Hill Ave.	334,247	$150,000	$34,800 to $92,250/yr	Milwaukee County and City of Oak Creek	Medium
WQ-2[4]	Use conservation tillage practices on agricultural fields	194,630	NA[3]	$152,320/yr	Private Landowners	Medium
WQ-3[4]	Install streambank erosion control on sites surveyed with heavy erosion. Streambank stabilization practices of rock riprap and/or soil bioengineering should be installed on approximately 9,500 feet of streambank	142,500	$427,500	$25,000/yr	City of Oak Creek	Medium
WQ-4	Install 3.24-acre wet detention basin in subbasin L1-6	90,102	$286,500	$10,740	City of Oak Creek	Medium
WQ-5	Install 1.19-acre wet detention basin in subbasin L2-7	37,653	$105,000	$4,200	City of Oak Creek	Medium
WQ-6	Install 2.07-acre wet detention basin in subbasin L5-3	106,199	$175,180	$7,030	Private	Medium
WQ-7	Install 0.82-acre wet detention basin in subbasin LG-8	67,789	$75,500	$3,020	Private	Medium
WQ-8	Install 1.17-acre wet detention basin in subbasin LG-11 (north)	73,425	$103,500	$4,140	Private	Medium
WQ-9	Install 1.22-acre wet detention basin in subbasin LG-11 (south)	78,844	$107,400	$4,300	Private	Medium
WQ-10	Install 2.99-acre wet detention basin in subbasin LG-17	283,457	$248,600	$10,000	Private	Medium
WQ-11	Install 11-acre wetland treatment system in subbasin M1-4	51,983	$49,000	$2,000	City of Oak Creek	Medium
WQ-12	Install 5.23-acre wetland treatment system in subbasin N1-2	170,268	$26,000	$1,000	City of Oak Creek	Medium
WQ-13	Install 3.58-acre wet detention basin in subbasin N2-5G	109,273	$295,900	$11,900	City of Milwaukee, City of Oak Creek & WDOT	Medium

[1] Unless noted, capital cost includes construction, engineering, and contingencies. Costs do not include acquisition of land.
[2] Costs are for annual operation and maintenance for a one-year period. O& M cost include annual cost of street sweeping and 4% of capital cost for O&M on detention ponds.
[3] NA means "Not Available"
[4] Not shown on Figure 2-1

TABLE 3 Water Quality Recommendations for Targeted Subbasins (continued)

Number on Figure 2	Recommendation	TSS Reductions (lbs/year)	Capital Cost[1]	Annual Operation and Maintenance Cost[2]	Implementing Agency	Priority
WQ-14	Install 1.77-acre wetland treatment system in subbasin N6-1	4,679	$19,000	$1,000	City of Oak Creek	Medium
WQ-15	Install 1.00-acre wet detention basin in subbasin O3-2	47,688	$89,900	$3,600	City of Oak Creek	Medium
WQ-16	Install 1.90-acre wet detention basin in subbasin O5-13	103,593	$161,700	$6,470	City of Oak Creek & WDOT	Medium
WQ-17	Install 3.35-acre wet detention basin in subbasin O8-13	204,032	$277,300	$11,100	City of Oak Creek	Medium
WQ-18	Install 0.82-acre wet detention basin in subbasin O18-5	27,071	$75,500	$3.020	City of Oak Creek	Medium
WQ-19	Install 1.85-acre wet detention basin in subbasin O24-6	53,062	$157,700	$6,300	City of Oak Creek	Medium
WQ-20	Install 0.67-acre wet detention basin in subbasin O25-4	34,955	$63,600	$2,550	City of Oak Creek	Medium
WQ-21	Install 17.87-acre wetland treatment system in subbasin R2-8	89,858	$76,000	$3,000	City of Oak Creek	Medium
WQ-22	Install 0.39-acre wet detention basin in subbasin RR-2	31,376	$41,300	$1,650	WDOT	Medium
WQ-23	Install 0.47-acre wet detention basin in subbasin M2-2	20,404	$47,600	$1,900	City of Oak Creek	Medium
WQ-24	Install 0.52-acre wet detention basin in subbasin M3-2	16,301	$51,600	$2,070	City of Oak Creek	Medium
WQ-25	Install 1.02-acre wet detention basin in subbasin M5-7	32,981	$91,500	$3,660	City of Oak Creek	Medium
WQ-26	Install 0.39-acre wet detention basin in subbasin MF-10	20,680	$41,300	$1,650	City of Oak Creek	Medium
WQ-27	Install 0.40-acre wet detention basin in subbasin MF-20	16,788	$41,000	$1,640	City of Oak Creek	Medium
WQ-28	Install 0.39-acre wet detention basin in subbasin MF-21	51,737	$40,900	$1,640	City of Oak Creek	Medium
WQ-29	Install 5.96-acre wetland treatment system in subbasin O11-3	25,708	$29,000	$1,200	City of Oak Creek	Medium

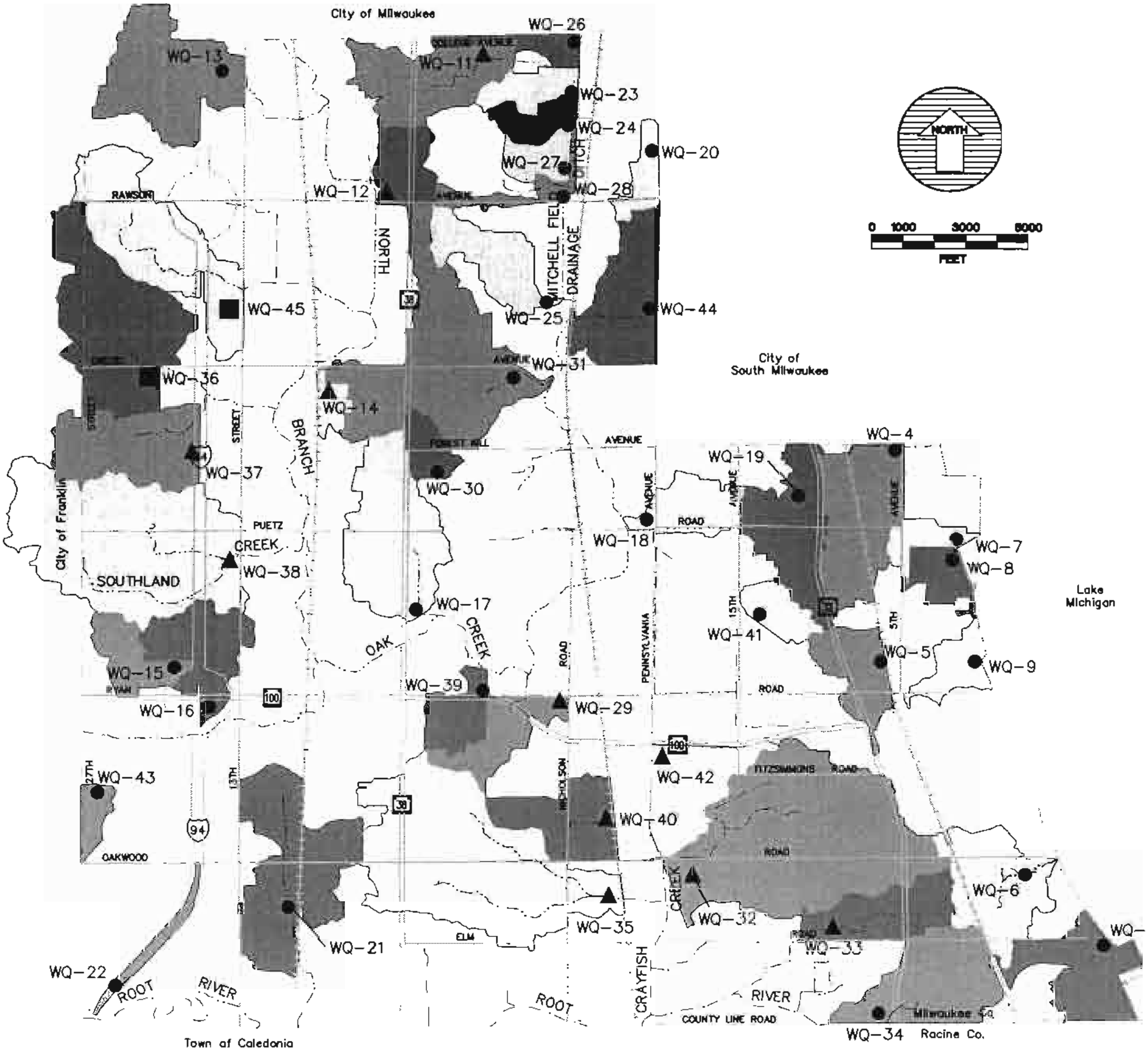
[1] Unless noted, capital cost includes construction, engineering, and contingencies. Costs do not include acquisition of land.
[2] Costs are for annual operation and maintenance for a one-year period. O& M cost include annual cost of street sweeping and 4% of capital cost for O&M on detention ponds.
[3] NA means "Not Available"

TABLE 3 Water Quality Recommendations for Targeted Subbasins (continued)

Number on Figure 2	Recommendation	TSS Reductions (lbs/year)	Capital Cost[1]	Annual Operation and Maintenance Cost[2]	Implementing Agency	Priority
WQ-30	Install 0.48-acre wet detention basin in subbasin O19-6	14,798	$48,400	$1,940	City of Oak Creek	Medium
WQ-31	Install 4.8-acre wet detention basin in subbasins O20-14&15	179,454	$392,900	$15,700	City of Oak Creek	Medium
WQ-32	Install 36.35-acre wetland treatment system in subbasin C3-14	151,447	$150,000	$6,000	City of Oak Creek	Low
WQ-33	Install 8.09-acre wetland treatment system in subbasin CB1-4	38,359	$37,000	$1,500	City of Oak Creek	Low
WQ-34	Install 1.69-acre wet detention basin in subbasin CB3-6	50,115	$144,900	$6,000	City of Oak Creek	Low
WQ-35	Install 32.71-acre wetland treatment system in subbasin CC-2	210,687	$136,000	$5,500	City of Oak Creek	Low
WQ-36	Install 19.93-acre wetland treatment system in subbasin N7-6	100,147	$85,000	$3,400	City of Oak Creek	Low
WQ-37	Install 12.13-acre wetland treatment system in subbasin N7-13	48,801	$54,000	$2,000	City of Oak Creek	Low
WQ-38	Install 31.87-acre wetland treatment system in subbasin N10-15	132,622	$136,000	$5,500	City of Oak Creek	Low
WQ-39	Install 0.83-acre wet detention basin in subbasin O10-5	27,279	$76,300	$3,050	City of Oak Creek	Low
WQ-40	Install 8.29-acre wetland treatment system in subbasin O15-4	27,371	$38,000	$1,500	City of Oak Creek	Low
WQ-41	Install 0.26-acre wet detention basin in subbasin O17-2	4,746	$30,900	$1,250	City of Oak Creek	Low
WQ-42	Install 13.17-acre wetland treatment system in subbasin O17-9	58,222	$58,000	$2,300	City of Oak Creek	Low
WQ-43	Install 0.42-acre wet detention basin in subbasin OC-447	34,236	$43,600	$1,750	City of Oak Creek	Low
WQ-44	Install 0.77-acre wet detention basin in subbasin OC-500	21,623	$71,900	$2,900	City of Oak Creek	Low
WQ-45	Install 17.89-acre wetland treatment system in subbasin N5-6	106,261	$77,300	$3,100	City of Oak Creek	Medium
Total		3,727,451	$4,935,000	$383,000 to 441,000		

[1] Unless noted, capital cost includes construction, engineering, and contingencies. Costs do not include acquisition of land.
[2] Costs are for annual operation and maintenance for a one-year period. O& M cost include annual cost of street sweeping and 4% of capital cost for O&M on detention ponds.
[3] NA means "Not Available"

Figure 2
Recommended Detention Pond and Wetland Locations



Legend

● PROPOSED NEW OR RETROFIT WET DETENTION POND

▲ PROPOSED NEW OR RETROFIT WETLAND TREATMENT SYSTEM

■ POTENTIAL REGIONAL WATER QUALITY POND FOR NEW DEVELOPMENT

WQ-34 RECOMMENDATION NO. IN TABLE 3

Plan Adoption and Regulatory Approval

An important first step in the plan implementation is the formal adoption of the plan by the City of Oak Creek and acceptance by Wisconsin Department of Natural Resources, Milwaukee County, and Milwaukee Metropolitan Sewerage District. The steps in the approval process are as follows:

1. Review of plan by the City's Stormwater Management Committee (SMC).

2. Review and adoption of plan by City Council.

3. Public informational meeting.

4. Submit plan to the Wisconsin Department of Natural Resources for acceptance as a refinement to A Regional Water Quality Management Plan for Southeastern Wisconsin: An Update and Status Report (SEWRPC, Memorandum Report 93, 1995)

5. Submit plan to Milwaukee County and the Milwaukee Metropolitan Sewerage District for acceptance.

Chapter 1

Introduction

The purpose of the City of Oak Creek Stormwater Management Master Plan is to develop alternatives, recommendations, and implementation strategies for correcting flooding and drainage problems and minimizing the impact of stormwater runoff from existing and future developments. The plan addresses water quality and quantity issues in the City of Oak Creek. Existing and future land uses in the City are evaluated as they influence the stormwater runoff characteristics.

As shown on Figure 1-1, the City of Oak Creek lies in three major watersheds: Oak Creek, Root River, and Lake Michigan. For planning purposes, the North Branch and Mitchell Field Drainage Ditch subwatersheds were identified within the Oak Creek watershed. The City of Oak Creek study area is approximately 28.8 square miles in size, not including tributary areas outside the City.

Organization of the Plan

The plan discusses an overview of the project area, types of existing problems, alternatives for management and a recommended plan of action. The report is laid out in two volumes. Volume I contains the report text and general appendices with supporting information suitable for most plan users. Volume II contains detailed reference data for use primarily by city staff members. Volume I is organized in the following format:

Chapter 1 – Introduction

Chapter 2 – Management Goals and Objectives

Chapter 3 – Inventory

Chapter 4 – Hydrologic Hydraulic Analysis

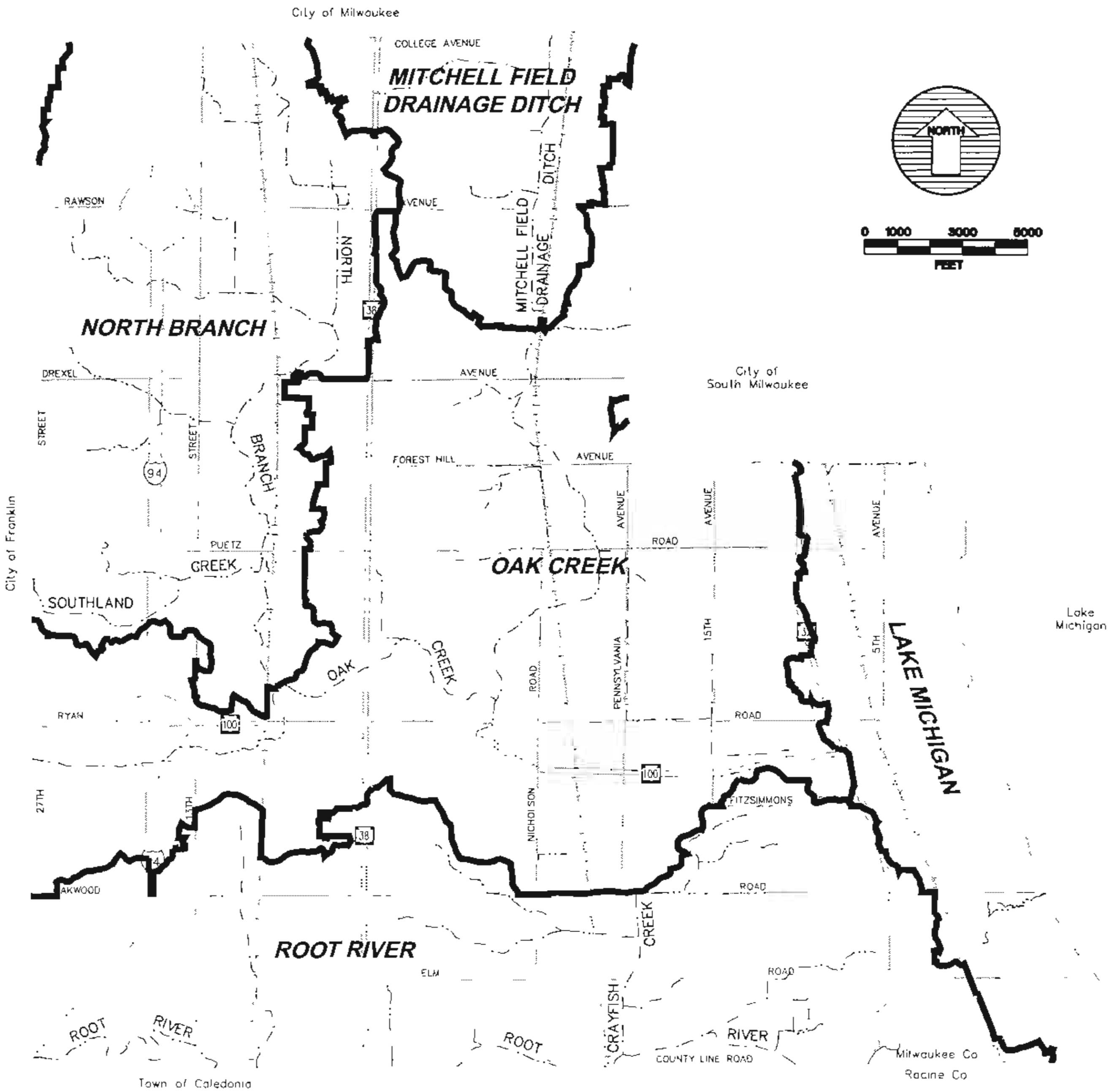
Chapter 5 – Water Quality Analysis

Chapter 6 – Flooding and Drainage Alternatives and Recommendations

Chapter 7 – Water Quality Alternatives and Recommendations

Chapter 8 – Implementation Recommendations

Figure 1-1
Major Watersheds in the City of Oak Creek



Planning Process

The consulting team of R. A. Smith & Associates, and Hey and Associates, Inc developed the City of Oak Creek Stormwater Management Master Plan. AquaNova International assisted in the formulation of policies and review of the report.

To provide guidance to the planning team the City of Oak Creek formed a Stormwater Management Committee (SMC). Committee members included:

- Elizabeth Kopplin, Alderman (Chair)
- Lawrence Prochnow, Alderman
- Merlyn Warner, Alderman
- Phillip Beiermeister, City Environmental Engineer
- Erv Nowak, Greendale, Developer
- Michael Rosen, West Bend, Developer
- Mark Verhalen, Resident
- Norb Theine, South Milwaukee, Developer

The SMC met frequently to review the ongoing findings and provide direction to the planning process. In addition to the formal SMC members, related agencies were invited to attend the meetings as adhoc members. Invitees included the following:

- Wisconsin Department of Natural Resources representative
- Southeastern Wisconsin Regional Planning Commission representative
- Milwaukee County Parks Department representative
- Milwaukee Metropolitan Sewerage District

The City of Oak Creek held a public information meeting early in the project to receive comments from residents. The public informational meeting was held on October 28, 1995.

Relationship to Other Plans

The following Stormwater Management Plan is a refinement to several existing water resource plans addressing the study area. The related plans include:

- A Comprehensive Plan for the Oak Creek Watershed (SEWRPC, Planning Report 36, 1986)

- A Stormwater Drainage and Flood Control Plan for the Metropolitan Sewerage District (SEWRPC, Community Assistance Planning Report No. 152, 1990)

- A Regional Water Quality Management Plan for Southeastem Wisconsin: An Update and Status Report (SEWRPC, Memorandum Report 93, 1995)

A Comprehensive Plan for the Oak Creek Watershed (SEWRPC, 1986) was the first detailed planning report for the City of Oak Creek addressing the natural resources base, land use, and pollutant sources. The plan included mapping of the floodplains, recommendations for flood control, and general recommendations for the abatement of nonpoint sources of pollution. The City of Oak Creek did not adopt the recommendations of the plan. The plan was adopted by the Wisconsin Department of Natural Resources, Wisconsin Department of Transportation, Milwaukee Metropolitan Sewerage District, and the Cities of Milwaukee, Franklin, Cudahy, and South Milwaukee.(1986 and 1987)

A Stormwater Drainage and Flood Control Plan for the Metropolitan Sewerage District (SEWRPC, 1990) is a master plan for the implementation of flood control projects within the Milwaukee Metropolitan Sewerage District. For Oak Creek the plan recommended minor channel deeping and shaping of 1.4 miles of stream on the main channel of Oak Creek and 1.0 mile on the North Branch, replacement of two bridges, structural flood proofing of 21 buildings, and removal of two buildings. The plan is currently being updated by the Sewerage District. The update is planned for completion in spring of1999.

A Regional Water Quality Management Plan for Southeastem Wisconsin: An Update and Status Report (SEWRPC, 1980) was developed under section 208 of the Clean Water Act. The plan identified the significant impacts of nonpoint source pollution on Oak Creek and the Root River. As part of the plan, SEWRPC recommended that nonpoint source pollution from existing urban development in the City of Oak Creek be reduced by 50% and that runoff from agricultural lands be reduced by 25%.

Regulatory Permits

In the 1987 revision of the Clean Water Act, Congress redefined runoff from urban areas as an activity that would be regulated by federal pollution law. In the State of Wisconsin, the federal government delegates the enforcement of the Clean Water Act to the Wisconsin Department of Natural Resource (WDNR). To enforce the federal requirements the WDNR adopted administrative code NR 216 in October of 1994. The WDNR has designated the City of Oak Creek under NR 216 as a municipality that is required to apply for a stormwater discharge permit. In January of 1997, the City submitted a pre-application as required under NR 216.05. A final application was submitted on February 11, 1999. A permit was issued on June 29, 2000 (Appendix G.)

Permit requirements under the NR 216 program are currently being developed by WDNR. At this time, WDNR is anticipating that during the first three years of the permit they will require communities to implement the following activities:

- Enforcement of erosion control ordinances.
- Enforcement of a stormwater management ordinance that meets the criteria of the state model.
- Enforcement of ordinances that prohibit illicit discharges to the stormwater drainage system.
- Implementation of housekeeping practices, such as street sweeping and catch basin cleaning.
- Conduct public education programs on lawn care, car washing, pet waste, and dumping of waste into the local drainage system.
- Water quality monitoring.

During the second issuance of the NR 216 permit, WDNR may require the installation of management practices to control existing sources of pollution. Implementation of the water quality recommendation outlined in this plan will help the City comply with the requirements of NR 216.

Chapter 2

Management Goals and Objectives

The City of Oak Creek Stormwater Management Committee worked with the consultant team to develop goals and objectives to guide the stormwater management planning. The committee reviewed past procedures and policies, learned about current practices, and envisioned future needs in the City It should be noted that not all of the objectives can be met under all circumstances. At times, conflicts between competing objectives may exist. The goals and objectives outlined here should be viewed as a guidance for stormwater planning. Implementation of the goals and objectives will be through city ordinance and the City's Engineering Handbook.

Stormwater Management Master Plan Goal

The goal of the City of Oak Creek Stormwater Management Master Plan is to protect, maintain, and enhance the public health, safety and general welfare by developing a plan to control the adverse impacts of increased stormwater runoff associated with existing and planned land use, and to recommend solutions to drainage problems. Proper management of stormwater runoff will minimize damage to public and private property, prevent inconvenience to local residents, protect water quality of surface and groundwater, maintain and enhance fish and wildlife habitat, protect public open space, and maintain the quality of life in the community.

Stormwater Management Objectives

To achieve the above goal, the following objectives are established:

1. Develop a major and minor stormwater drainage system that will convey stormwater in a manner that reduces the public's exposure to drainage related inconveniences and protects public and private property from runoff related damages.
2. Develop a stormwater management system that prevents any adverse impacts of increases in flood elevations; where possible, reduces the floodplain to predeveloped conditions; and protects and preserves floodplain storage.
3. Develop a stormwater management system that evaluates stormwater storage versus stormwater conveyance.
4. Develop a stormwater management system which will abate nonpoint source water pollution, help achieve recommended water use objectives and supporting water quality standards for local streams, protect the quality of Lake Michigan as a drinking water source for the City, and protect local groundwater resources.

3. All stormwater infiltration systems shall pre-treat the runoff to prevent surface water pollutants from contaminating the local groundwater.

4. Stormwater management facilities shall be designed to minimize any off-site impacts of construction site erosion.

5. Control existing sources of nonpoint sources pollution through use of best management practices to the levels outlined in Table 2-1 as established in A Regional Water Quality Management Plan for Southeastern Wisconsin: An Update and Status Report (SEWRPC, Memorandum Report 93, 1995) and discussions with the Wisconsin Department of Natural Resources.

TABLE 2-1 Pollutant Reduction Goals in the City of Oak Creek

Pollutant by Source	Pollutant Reduction
Suspended solids (existing urban development)	50%
Suspended solids (existing rural development)	25%
Suspended solids (future urban development)	90%
Phosphorus (existing urban development)	50%
Lead (existing urban development)	45%
Copper (existing urban development)	40%
Zinc (existing urban development)	40%

Source: SEWRPC, 1995 and WDNR, 1999

Objective 5

Establish a comprehensive hydrologic, hydraulic, existing and proposed land use, and cartographic database using the best available and most appropriate technology to manage the stormwater, flood, and water quality data needs of the program.

Guidelines

1. City of Oak Creek will establish an electronic database repository to record existing information on the performance of the stormwater drainage system. Information that will be recorded in the database will include land use zoning, major stream networks, major drainage areas, existing storm sewer networks, storm sewer capacities, cross street culvert and bridge elevations, flow capacities, drainage easements, and regulatory floodplains.

2. All new development plans will be provided to the City of Oak Creek in both paper and electronic formats. Grading and storm sewer plans will be provided in AutoCAD format for integration into the City's database. Changes to the regulatory floodplain shall be provided in the form of HEC-2 or HEC-RAS files.

3. Information in the City's database will be provided to the public at the cost of duplication.

4. The City of Oak should establish a monitoring network of stream gauges to record peak annual flood heights.

Objective 6

Develop a stormwater management system that controls runoff within a greenway system and maintains or enhances terrestrial, riparian, and aquatic biological communities including plants, fish, and wildlife.

Guidelines

1. Stormwater management systems shall be designed to avoid significant negative impacts to primary and secondary environmental corridors.
2 Stormwater management systems shall be designed to avoid significant negative impacts to the Milwaukee County Park System (i.e.: Bender Park, Michael F. Cudahy Nature Preserve, Falk Park, Oak Creek and Root River Parkways). Work on Milwaukee County Park property can only take place with the permission of Milwaukee County.
3. To protect the quality of wetlands within the City of Oak Creek, untreated stormwater shall not be discharged to high quality wetlands (Category III)[1]. Discharge of untreated stormwater is allowed to flow to wetlands that have been identified in the City of Oak Creek Stormwater Master Plan as having plant and wildlife communities that will not be degraded by stormwater runoff.
4. Stormwater and flood control facilities should be designed to avoid enclosure of tributary streams identified as having significant and valuable biological and recreational use.
5. Bridges and culverts shall be designed to facilitate fish passage through elimination of hydraulic drops, maintenance of lowflow channels, and minimization of excess stream enclosures.
6. In the future, modifications and disturbance shall avoid significant negative impacts to existing natural resources. Any significant disturbances to natural channels shall be appropriately mitigated—preferably with native vegetation as described in the Oak Creek Stormwater Management Master Plan.

Objective 7

Develop a stormwater management system that is equitable, fair, and effectively meets all of the other stated objectives while considering all benefits in light of cost.

Guidelines

1. To minimize new costs, maximum feasibility should be made of all existing stormwater system components, as well as natural stormwater storage.
2. Stormwater management facilities should be designed for staged or phased construction so as to limit the required investment in such facilities at any one time and to permit maximum flexibility to accommodate changes in development patterns, economic growth, objectives or guidelines of this plan, or technology of stormwater management or flood control.

---

[1] There are no high quality wetlands in the City of Oak Creek

3. To the maximum extent possible, the location and alignment of new storm sewers, engineered channels, and storage facilities should coincide with existing public rights-of-way to minimize land acquisition or easement costs.

4. Stormwater storage facilities—consisting of both centralized and on-site detention basins—should be used, where hydraulically feasible and economic, to reduce the size and resultant cost of the required stormwater conveyance system downstream of the storage site.

Objective 8

Develop a stormwater management system that requires minimum maintenance and has maintenance requirements that can be implemented by available organizations or units of government.

Guidelines

1. Local developments and streets shall be designed and graded to provide overland gravity flow routes to major drainageways so that drainage will not be affected in the event of failure of the local storm sewer network.

2. Major drainageways should be designed with low flow pilot channels to maintain increased stream velocity to reduce sedimentation in the stream channels and accompanying nuisance vegetation.

3. Stormwater storage pond outlets shall be designed to minimize clogging and downstream erosion.

4. Where feasible, streambanks and edges of detention ponds should be landscaped with native vegetation to prevent bank erosion.

5. The City engineering department shall establish a routine inspection program of stormwater facilities. The purpose of the inspection program is to facilitate implementation of a program of minor repairs, with the intent of reducing the need for more extensive major maintenance.

Objective 9

Develop a stormwater management system that can be implemented under existing federal, state, regional and local regulations, and adopted management plans.

Guidelines

1. The City of Oak Creek Stormwater Management Master Plan will identify all stream courses that fall under the jurisdiction of state and federal regulations. Within the plan, all activities that require regulatory permits will be identified.

2. Prior to the design of major projects requiring regulatory permits, the City engineering staff will contact the affected regulatory agencies to identify any regulatory constraints.

3. Any projects involving the modification of navigable waters will include in-kind replacement of the stream functional values. Functional values include such items as fish and wildlife habitat, recreational opportunities, and aesthetic values.

Objective 10

Establish a consistent, equitable, and dedicated source of revenue in order to maintain the stormwater management program in the City of Oak Creek.

Guidelines

1. To provide equitability, all user and impact fees used to fund stormwater management will be based on the volume of runoff generated from the property.
2. The City of Oak Creek will establish a segregated fund to maintain revenue for implementation of the City's Stormwater Management Program.
3. City staff will work with the State of Wisconsin and Metropolitan Sewerage District to identify on an annual basis, potential opportunities for outside funding and grants.

Objective 11

Development of an integrated stormwater management and flood control system, which effectively serves existing, and future land use.

Guidelines

1. The stormwater drainage system shall be designed to safely carry the runoff from existing and proposed development as established in the most recently adopted City Land Use Master Plan.
2. Stormwater drainage systems should be designed assuming that collector and land access streets can, during major storm events, serve as open runoff channels supplementary to the minor drainage system without flooding adjoining building sites. The stormwater drainage system design should avoid mid-block sags in street grades; street grades should generally parallel swale, channel and storm sewer gradients.

Chapter 3

Inventory

Introduction

The study area is the City of Oak Creek. This chapter provides an overview of the physical features of the study area, including drainage facilities, land use, climate, soils, groundwater resources, wetland resources and stream classifications. The City of Oak Creek has experienced stormwater drainage and water quality problems. These problems are identified in this chapter.

Drainage System

The City of Oak Creek drains to three major drainage systems: Oak Creek, Root River, and direct tributaries to Lake Michigan. Table 3-1 summarizes the areas for each of the major watershed systems within the City boundaries.

Table 3-1 Watershed Areas

Watershed	Area (acres)
Oak Creek	11,993
Root River	4,567
Direct Tributaries to Lake Michigan	1,877
Total	18,437

The City of Oak Creek also receives drainage from outside its borders from the cities of Cudahy, Franklin, Greenfield, and Milwaukee and the Town of Caledonia. Table 3-2 summarizes the aerial extent of bordering communities that drain into City of Oak Creek.

Table 3-2 Areas Tributary to the City of Oak Creek

Community	Area (acres)
City of Cudahy	108
City of Franklin	1,626
City of Greenfield	141
City of Milwaukee	1,830
Town of Caledonia	682
Total	4,387

Source: SEWRPC, 1986

Water Courses and Tributary Streams

The three major watershed systems include numerous tributary streams as shown in Figure 3-1. The streams are categorized as watercourses or tributary streams. The watercourses have been addressed in previous and ongoing studies by the Southeastern Wisconsin Regional Planning Commission and the Milwaukee Metropolitan Sewerage District. Further hydrologic and hydraulic analysis of these watercourses was not part of this stormwater management planning study.

This study focused on the 32 tributary streams. Hydrologic and hydraulic analyses were conducted to determine flood flows as discussed in Chapter 4. Floodplains for 100-year recurrence interval storm events were mapped along each of these tributary streams.

Storm Sewers and Culverts

Stormwater runoff drainage facilities in the study area are a mixture of open grass swales and storm sewer. As part of the stormwater management plan, an inventory was conducted of City owned storm sewers 15-inches and larger and culverts 24-inches and larger. Storm sewer information was compiled from as-built information in the files of the City of Oak Creek Engineering Department. Figure 3-2 illustrates the storm sewer locations in the City. The locations of the surveyed culverts are shown on Figure 3-3. The length and elevation of each culvert was measured in the field. Information on storm sewer and culvert location, size, and elevations was provided to the City of Oak Creek in AutoCAD files and large scale maps.

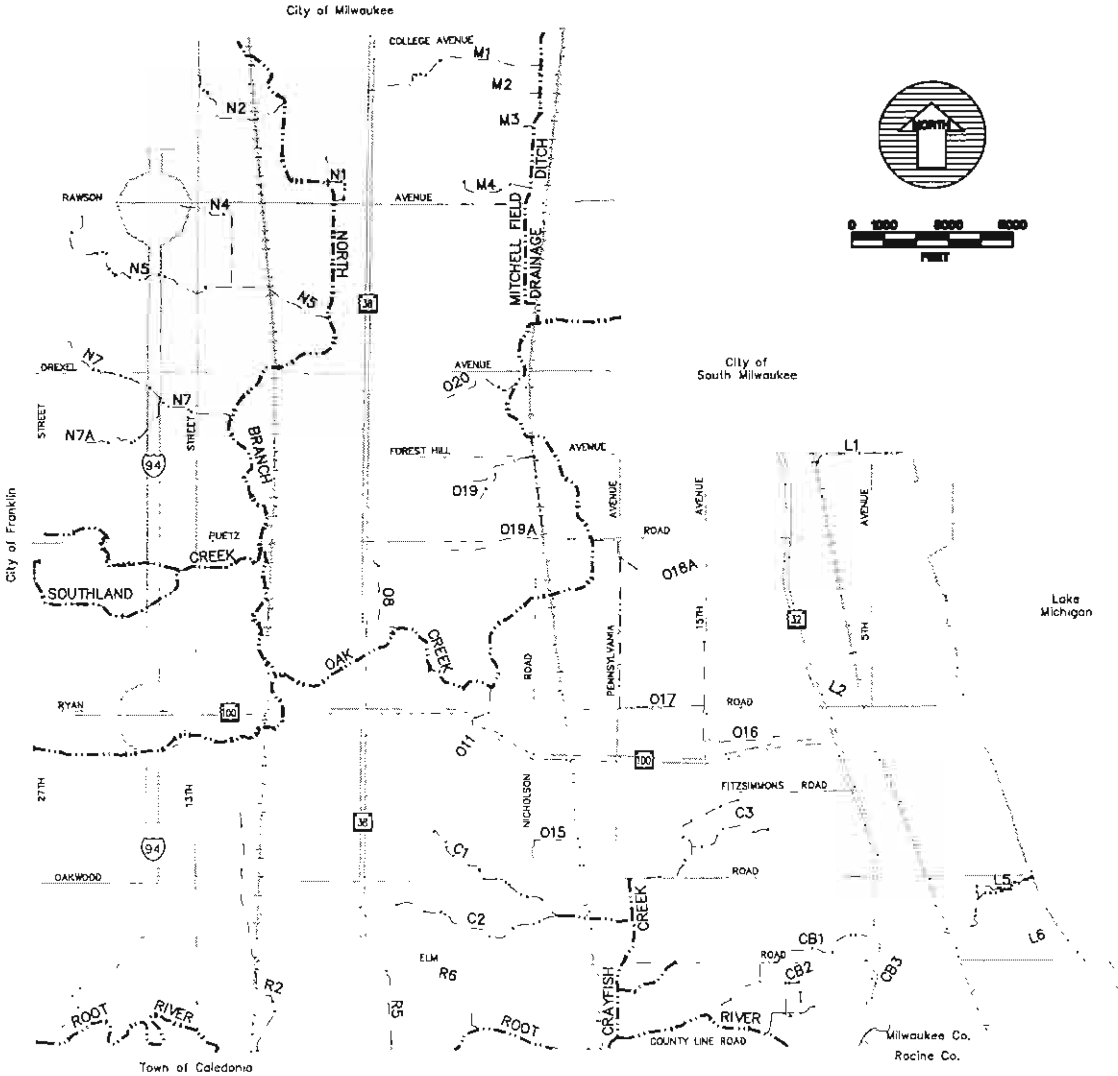
Within the City of Oak Creek, a number of detention basins have been built to control stormwater runoff. Most of the basins have been designed to control peak rates of runoff. Existing detention basins within the City were analyzed as part of the hydrologic analysis summarized in Chapter 4. The locations of the detention basins are discussed in Chapter 4 of this report.

Land Use

The City of Oak Creek population in 1998 was 25,842 (Wisconsin Dept. of Administration). The City is in a period of rapid growth. In 1985, 6,352 acres of the City were in urban development (SEWRPC, 1992). In 1995, urban land uses increased to 8,300 acres, a 23% increase in ten years. As the City develops, stormwater runoff and related issues will increase. To better understand how land uses affect stormwater runoff, an inventory of land use and land covers was conducted.

The existing land use condition is defined as the development in place as of April 1995. Aerial photographs provided by the Southeastern Wisconsin Regional Planning Commission (SEWRPC) and topographic maps provided by the City were used to delineate the existing development. The future land use condition was determined from the City of Oak Creek zoning map.

Figure 3-1
Watercourses and Tributary Streams In City of Oak Creek



Legend

ROOT RIVER — WATERCOURSES

R6 — TRIBUTARY STREAMS

Hey and Associates, Inc.

R. A. SMITH & ASSOCIATES, INC.

Figure 3-2
Storm Sewer Systems

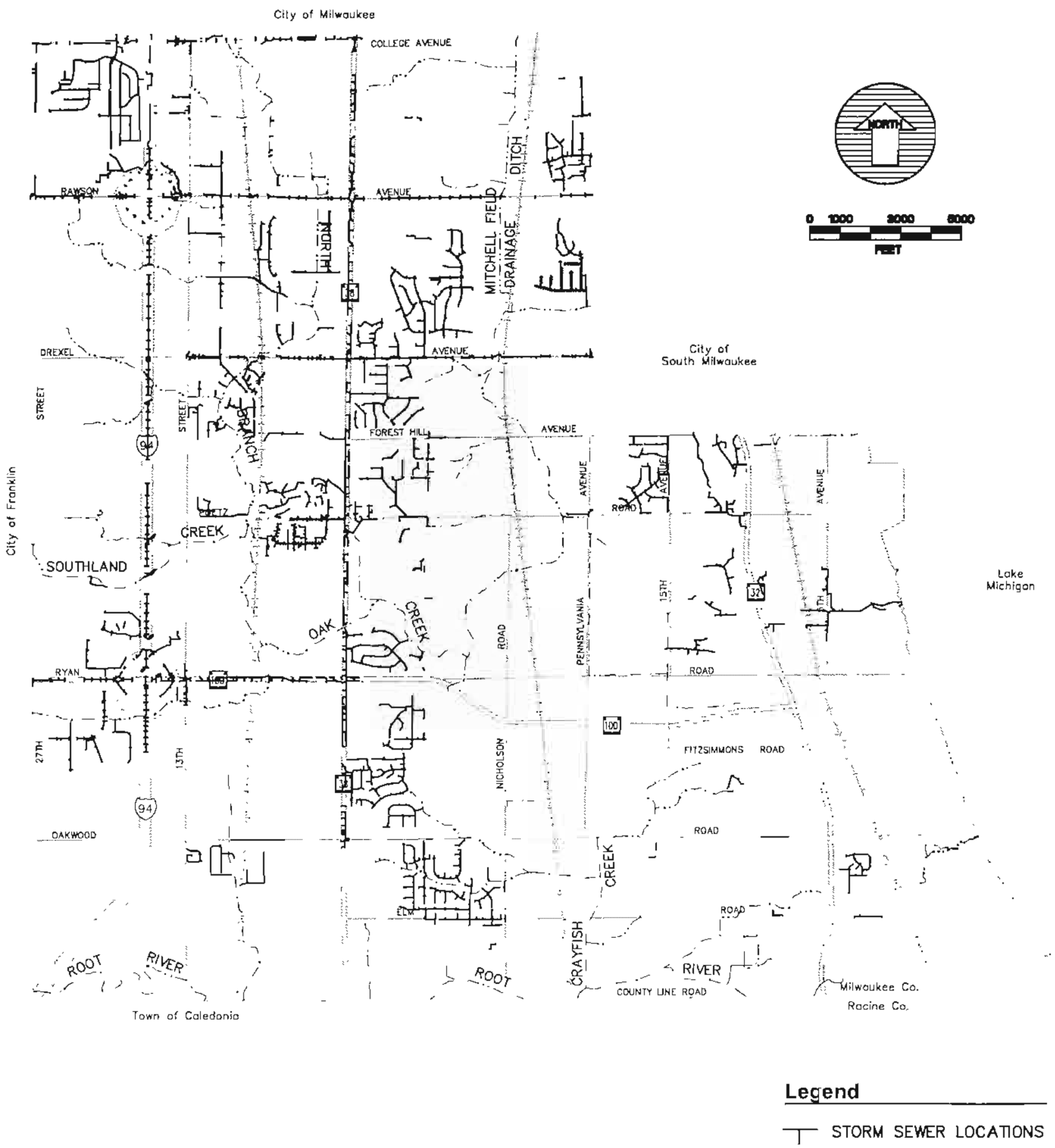
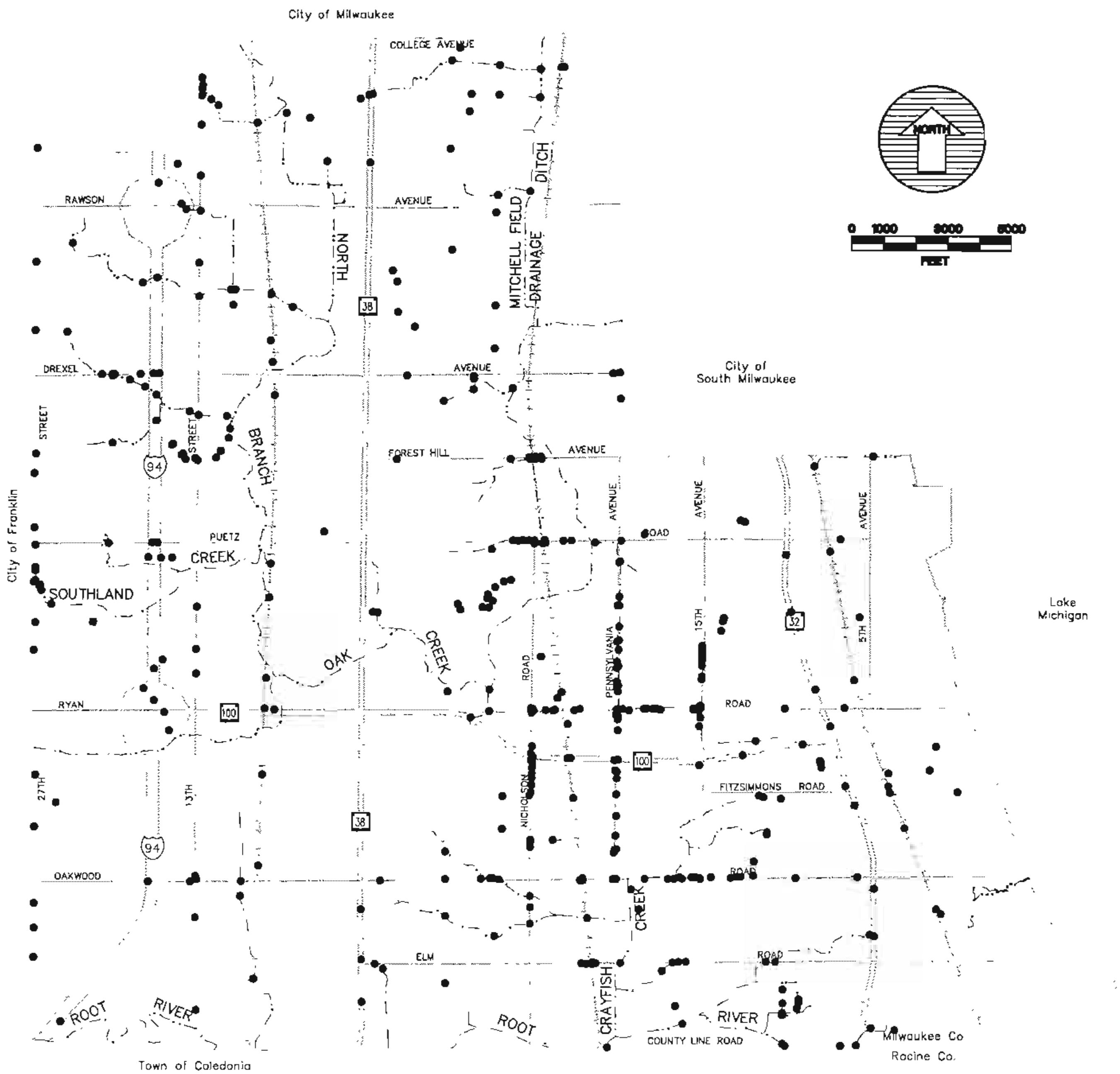


Figure 3-3
Surveyed Culverts



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- CULVERT LOCATIONS (24" OR LARGER)

Hey and Associates, Inc.

R. A. SMITH & ASSOCIATES, INC.

The existing land use within the study area is a mixture of residential, institutional, commercial, industrial, open space, and freeway. Residential areas are a mixture of single family with lot sizes ranging from 1/3 acre to several acre estates, and multi-family including duplexes, and large apartment and condominium complexes. Commercial areas within the study area are located along several major roadways including: S. 27th Street, S. 13th Street, Rawson Avenue, Howell Avenue, Puetz Road, and Ryan Road. Within the City, there are more than 35 park and open space sites. Together these sites make up more than 2,000 acres. Milwaukee County Parks Department is a major landowner with parkway corridors along Oak Creek and the Root River, and several isolated parks including Bender Park, Falk Park, and the Michael F. Cudahy Nature Preserve. Other open space land includes agricultural fields and wetlands. Table 3-3 summarizes the land use in the study area.

Table 3-3 1995 Land Use Areas

Land Use	Acres	Percent
Residential	5,057	27.4%
Institutional	241	1.3%
Commercial	591	3.2%
Industrial	2,350	12.6%
Open Space	10,112	54.5%
Freeway	86	0.5%
Total	18,437	100%

Source: Hey and Associates, Inc.

Industries

There are numerous industries in the City of Oak Creek that have regulated discharges to local streams. Table 3-4 lists the industries in the City of Oak Creek that have received stormwater discharge permits under Wisconsin Administrative Code NR 216. The table includes their Standard Industry Code (SIC) and regulatory status under NR 216. Tier 1 includes heavy manufacturing companies and Tier 2 includes light manufacturing operations. Each industry is required to prepare a pollution prevention plan as a condition of the permit. The pollution prevention plan addresses ways the facility will minimize the potential discharge of pollutants from storage areas on the property.

Table 3-5 identifies the industries that have general and specific wastewater discharge permits from WDNR. These permits are for direct discharges to the streams, and include cooling water and treated process water.

Table 3-4 Industries with NR 216 Stormwater Permits

Company	Standard Industry Code (SIC)	Regulatory Ranking Under NR 216
Wisconsin Electric Power Company	5607	Tier 2
PPG Industries	6269	Tier 2
PH Orth Company	1669	Tier 2
Hynite Corporation	8278	Tier 1
Wabash Alloys	8225	Tier 1
Cemedine USA Incorporated	3338	Tier 1
General Motor AC Rochester Delco Electric Division	1367	Tier 2
General Thermodynamics Incorporated	2117, 2118	Tier 2
Air Products & Chemical Incorporated	3453	Tier 2
Zenar Crane Corporation	419	Tier 2
Zierden Company	177	Tier 2
Harnischfeger Corporation	1880	Tier 2
Tews Concrete Company	8005	Tier 2
Henkel Surface Technologies Incorporated	6917	Tier 1
Bordens Incorporated	3477	Tier 1
Outlook Packaging	8583	Tier 2
Oak Creek Pallet Company	8302	Tier 2
Behrens Moving Company	2075	Tier 2
Mid America Steel Drum Company Incorporated	1458	Tier 1

Source: Wisconsin Department of Natural Resources, 1997

Table 3-5 Industries with General and Specific WPDES Wastewater Discharge Permits

Industry	Permit Type	Permit Number
Air Products & Chemical Incorporated	General	0046531-1
Bel-Aire Enterprises	General	0046566-2
Hodgson Process Chemicals Incorporated	General	0044938-3
Hynite Corporation	General	0044939-3
Milwaukee Travel Center, Incorporated	General	0046531-1
Oak Creek Water & Sewer Utility	General	0057681-1
PH Orth Company	General	0044938-3
PPG Industries	General	0044938-4
Svedala Industries	General	0044938-3
Tews Concrete Company	General	0046507-2
Wisconsin Electric Gas Operations, LNG Plant	General	0044938-3
Americas Best Fabricated Metals Incorporated	Specific	0046493
Henkel Surface Technologies Incorporated	Specific	0047643
PPG Industries	Specific	0029149
Wisconsin Electric Power Company	Specific	0000914

Source: Wisconsin Department of Natural Resources, 1997

Climate

The frequency, duration, and amount of precipitation influences surface and groundwater quality and quantity, soil moisture content, runoff characteristics, and the physical condition of surface waters. Precipitation events throughout the watershed are most frequently moderate in duration and quantity. An event is defined as a distinct period when precipitation is equal to or greater than 0.1 inch. Approximately 50 events per year occur in the watershed.

Table 3-6 summarizes the average annual temperature and precipitation from the National Weather Service station for the City of Milwaukee located at General Mitchell International Airport. Table 3-7 summarizes the nominal frost depth in Southeastern Wisconsin for November through April.

Table 3-6 Average Temperature and Precipitation

	Temperature			Precipitation	
Month	Average Daily Maximum (^{0}F)	Average Daily Minimum (^{0}F)	Mean (^{0}F)	Normal Total Precipitation (in)	Average Total Precipitation (in)
January	26.1	11.6	18.9	1.60	1.30
February	30.1	15.9	22.3	1.45	1.25
March	40.4	26.2	33.5	2.67	2.79
April	52.9	35.8	44.2	3.50	3.64
May	64.3	44.8	54.9	2.84	2.73
June	74.9	55.0	65.3	3.24	2.75
July	79.9	62.0	71.3	3.47	3.35
August	77.8	60.8	69.3	3.53	3.26
September	70.6	52.8	61.9	3.38	2.65
October	58.7	41.8	50.5	2.41	2.45
November	44.7	30.7	37.7	2.51	2.23
December	31.2	17.5	24.8	2.33	2.39
Average/ Total	54.3	37.9	46.0	32.93	33.23

Source: NOAA, 1992 (Averages for 1961 – 1990)

Table 3-7 Average Frost Depth

Month and Day	Nominal Frost Depth (inches)
November 30	1
December 15	3
December 31	4
January 15	9
January 31	12
February 15	14
February 28	15
March 15	13
March 31	7
April 7	3

Source: Wisconsin Agricultural Reporting Service, Snow and Frost in Wisconsin, October 1978 (Based on 1961-1977)

Soils

Soils play an important role in determining surface water runoff. Permeable soils allow infiltration of rainwater; water runs off tight clay soils. The City of Oak Creek is primarily underlain by three soil associations: The Houghton-Palm-Adrian association, Boyer-Oshtemo association, and the Ozaukee- Morley-Mequon association. All three are classified as very poorly drained organic soils, poorly drained, and somewhat poorly drained soils, respectively.

Soils are classified into four hydrological soil groups (HSG) (A, B, C, and D) according to their minimum infiltration rate. The soils range from Group A, which has high permeability in well-drained soil with less runoff produced, to Group D which has low permeability and more anticipated runoff. Table 3-8 summarizes the predominant soil groups in the City of Oak Creek and their associated HSG. The predominant soils in the City are the Morley silt loam, and Blount silt loam, both Group C soils.

Table 3-8 Predominate Soil Groups

Soil Name	Symbol	Hydrological Soil Group
Ashkum silty clay loam	AsA	B
Casco loam	CeB	B
Fox loam	FoB	B
Grays silt loam	GrB	B
Hebron loam	HeA, HeB	B
Juneau silt loam	JuA	B
Matherton silt loam	MnA	B
Aztalan loam	AzA, AzB	C
Blount silt loam	BiA	C
Martinton silt loam	MgA	C
Montgomery silt loam	MzB	C
Morley silt loam	MzdB, MzdC	C
Mundelein silt loam	MzfA	C
Saylesville silt loam	ShB	C
Navin silt loam	Na	D
Houghton muck	HtA	A/D

Source: USDA, 1971

Wetlands

Wetlands in the study area provide a variety of beneficial uses, including flood storage, water quality treatment, and fish and wildlife habitat. Uncontrolled stormwater runoff can adversely affect wetlands causing degradation in their beneficial use. The potential impacts to a wetland from uncontrolled runoff will vary depending on the type of wetland plant community. For example, wetlands such as sedge meadows are sensitive to stormwater pollutants and water level changes, while reed canary grass or cattail wetlands are tolerant of stormwater pollutants and water level changes. To protect the wetlands in the City of Oak Creek, an inventory of the wetlands was conducted and their sensitivity to stormwater runoff was classified. The wetlands were classified into the following three categories:

Category I wetlands have vegetation that are not impacted by the discharge of pollutants or impacted by changing water levels. Category I wetlands can be used for stormwater storage provided the water is pretreated for sediment removal, and that no dredging takes place in the wetland.

Category II wetlands have vegetation and wildlife communities that cannot tolerate discharges of sediment or pollutants without becoming degraded. Discharges of treated stormwater to Category II wetlands should only be allowed if inundation of the vegetation is for periods of less than one week.

Category III wetlands have vegetation and wildlife communities that cannot tolerate any discharge of sediment or pollutants, and cannot tolerate any changes in water levels. There are no Category III wetlands in the City of Oak Creek.

Figure 3-4 illustrates the classification of wetlands 2 acres and larger in size in the City of Oak Creek. Wetlands with the characteristics of one or more classification should be protected to the highest classification level. Wetland locations are based on Wisconsin Wetland Inventory and data summarized by the Southeastern Wisconsin Regional Planning Commission in 1987.

Groundwater Resources

The sources of groundwater are, in general order of depth below land surface, the sand and gravel, the Niagara Dolomite, and the St. Peter sandstone aquifers (USGS, 1980). The sand and gravel aquifer consists of unconsolidated sand and gravel deposits of outwash, glacial-lake deposits, or alluvium. Groundwater occurs and moves in the void spaces among the grains of sand and gravel. The potential for contamination of this aquifer is high because of the shallow depth to groundwater. Due to high clay content in this aquifer in the City of Oak Creek, it does not produce enough water to be used for drinking water wells.

The Niagara aquifer includes the entire Silurian and Devonian dolomite section overlying the Maquoketa Shale and is not restricted to rocks of Middle Silurian (Niagaran age). Dolomite is a brittle rock similar to limestone, which contains groundwater in interconnected cracks. The potential for contamination of this aquifer is moderate to low.

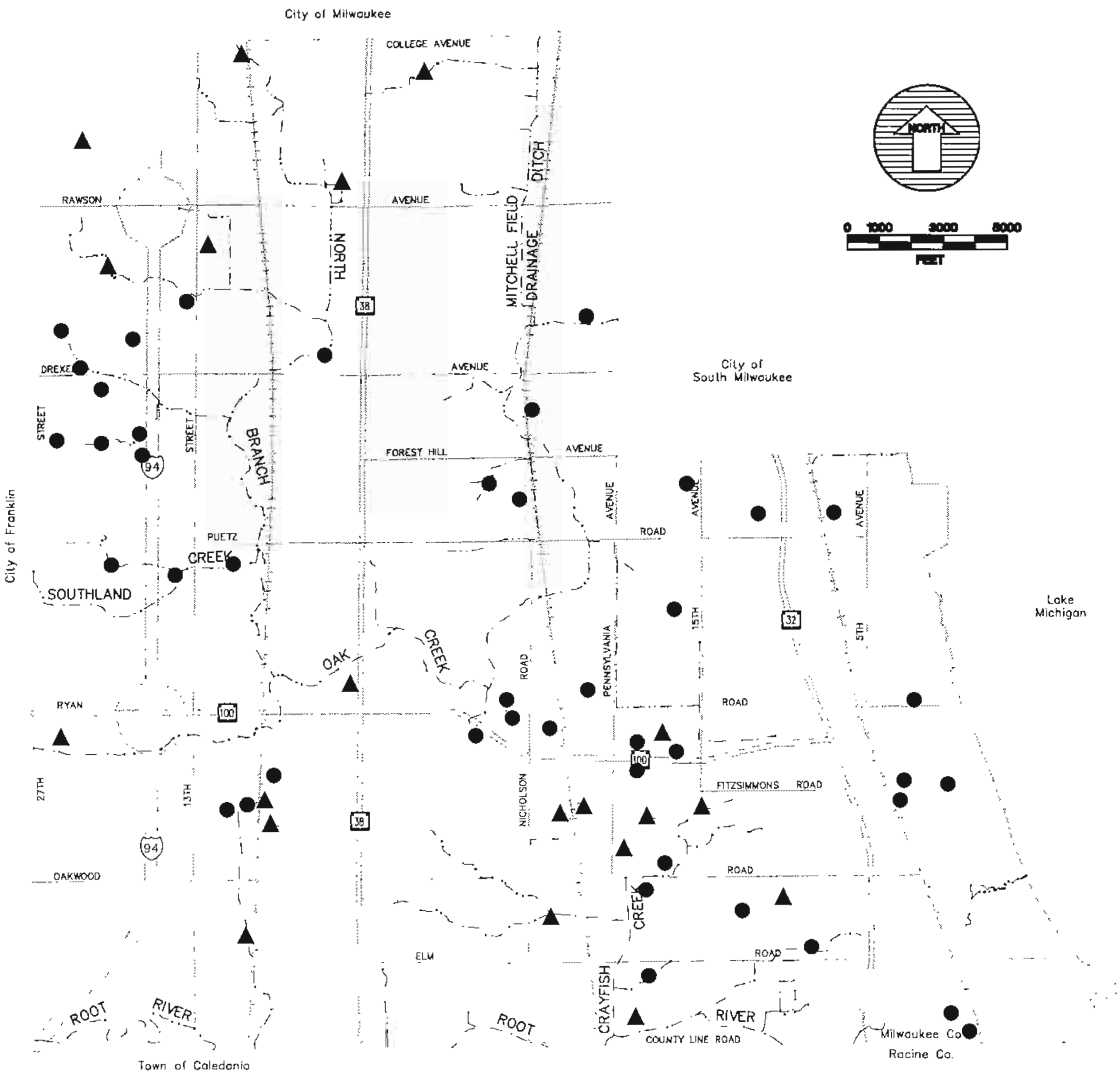
The sandstone aquifer includes all Ordovician and Cambrian rocks older than the Maquoketa Shale and lies on relatively impermeable Precambrian rocks. The Maquoketa Shale separates the Niagara and sandstone aquifers. Because of its low permeability, the shale restricts the vertical movement of water and confines water in the sandstone aquifer. The potential for contamination in the sandstone aquifer is low.

Figure 3-5 illustrates the areas within the Oak Creek watershed that have seasonally high groundwater (SEWRPC, 1986). Areas of the City that have public water receive their water from Lake Michigan.

Waste Disposal Sites

When siting stormwater facilities such as detention basins or infiltration systems, waste disposal sites should be avoided to prevent the potential for groundwater contamination or expensive environmental clean up cost. Table 3-9 summarizes the locations of known waste disposal sites in the study area.

Figure 3-4
Major Wetlands



Legend

- CATEGORY I WETLANDS
- CATEGORY II WETLANDS
- CATEGORY I RIPARIAN WETLANDS

WETLANDS LESS THAN 2 ACRES IN SIZE ARE NOT SHOWN

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Figure 3-5
Seasonal High Groundwater In The Oak Creek Watershed

SOURCE: SEWRPC

Legend

DEPTH OF WATER TABLE, IN FEET BELOW LAND SURFACE

LESS THAN 10

10 TO 30

Hey and Associates, Inc.

R. A. SMITH & ASSOCIATES, INC.

Table 3-9 Waste Disposal Facilities

Facility Name	Location		
	Quarter/Quarter Section or Address	Section	Township/Range
Allis Chalmers	SW	24	T5N, R22E
City of Oak Creek	SW, SW	10	T5N, T22E
City of South Milwaukee	NW, SE	14	T5N, T22E
Derosso Landfill	NE, NW	27	T5N, T22E
Dump	NE, NE	8	T5N, T22E
Dump	NE, NW	5	T5N, T22E
Dump	NE, NW	8	T5N, T22E
Dump	SW,NE	8	T5N, T22E
Frank Guiffe	9770 S. Ridgeview Dr.		T5N, T22E
Harry Troka	1200 W. Elm Ave.		T5N, T22E
James Jacobs	SW,SE	34	T5N, T22E
Interstate Erecting	3925 E. American Ave.		T5N, T22E
John Verdev	7621 S. Pennsylvania Ave.		T5N, T22E
Lake City Disposal	6524 S. 13th St.		T5N, T22E
Milwaukee Metropolitan Sewerage District	8500 S 5th Ave.		T5N, T22E
Milwaukee Metropolitan Sewerage District	SW, SW	13	T5N, T22E
Oak Creek DIS	9781 S. Pennsylvania Ave.		T5N, T22E
Peter Cooper Site	9006 S 5th Ave.		T5N, T22E
Vulcan Materials Company	9100 S. 5th Ave.		T5N, T22E
Wisconsin Electric Power Company	SW	36	T5N, T22E
Wisconsin Electric Power Company	N, NE	36	T5N, T22E
Wisconsin Electric Power Company	SE, SE	36	T5N, T22E

Source: Registry of Waste Disposal Sites in Wisconsin, SW-108-93 (WDNR, 1993)

Environmental Corridors

Environmental corridors are defined by SEWRPC as linear areas in the landscape containing concentrations of natural resource and resource-related amenities. These corridors generally lie along the major stream valleys, around major lakes, and in the Kettle Moraine area of Southeastern Wisconsin. Almost all the remaining high-value wetlands, woodlands, wildlife habitat areas, major bodies of surface water, and delineated floodlands and shorelands are contained within these corridors. In addition, significant groundwater recharge and discharge areas, many of the most important recreational and scenic areas, and the best remaining potential park sites are located within the environmental corridors. Such environmental corridors are, in effect, a composite of the most important individual elements of the natural resource base in Southeastern Wisconsin and have immeasurable environmental, ecological, and recreational value (SEWRPC, 1992). SEWRPC has divided environmental corridors into primary and secondary categories based on their size and significance.

In the study area, primary environmental corridor exists predominately in the southeast corner of the City in Section 34. Along the stream channels of the Oak Creek and Root River, SEWRPC has identified the entire stream course and associated wetlands as secondary environmental corridor.

Stream Classification and Surface Water Quality Conditions

As part of the preparation of a water quality standards review of the Oak Creek and Root River, the Wisconsin Department of Natural Resources prepared an appraisal of the instream water quality. Table 3-10 summarizes the classification of the stream channels in the study area.

Based on the WDNR inventories of the streams in the City of Oak Creek, the following were identified to be the major water quality problems:

- Excess sediment from construction site erosion.
- Loss of aquatic habitat due to sediment deposits in the stream channels.
- Lack of in-stream fish habitat due to a lack of overhanging vegetation and instream structures.
- Potential toxicity from heavy metals and organic compounds washed off of commercial and industrial areas.

Table 3-10 Water Resource Conditions

	Oak Creek, North Branch of Oak Creek, and Mitchell Drainage Ditch [1]	Root River and Crayfish Creek [1]
Potential Biological Use[1]	Warm water sport fish community	Warm water sport fish community
Current Condition	Not meeting potential biological use	Not meeting potential biological use
Problems or Threats to Potential Use	Loss of fish and invertebrate habitat Trophic /community imbalance: nuisance vegetation Stream flow fluctuation or low flow Embedded substrate Turbidity Temperature extremes Toxicity (potential) Size and depth Bacteria	Loss of fish and invertebrate habitat Trophic /community imbalance: nuisance vegetation Embedded substrate Toxicity (potential) Turbidity Bacteria
Pollutants or Limiting Factors Causing Problems or Threats	Channelization; bank debrushing; drainage of wetlands; ponding Nutrients Low flow and flashy flow Sediment Metals; pesticides	Channelization; bank debrushing; drainage of wetlands; construction site erosion; streambank erosion Nutrients Sediment Metals; pesticides

Source: Wisc.Adm.Code NR104 and Hey and Associates, Inc.

1 Other Tributaries of the Oak Creek and Root River have not been classified by the State of Wisconsin

Stream Maintenance Conditions

As part of the preparation of this project, R. A. Smith and Associates, Inc. conducted a stream inventory to identify areas of active channel erosion, sediment deposition, and channel blockage. The inventory was conducted in summer of 1996. The inventory involved walking the entire reaches of every mapped stream in the City of Oak Creek. Each reach was photographed for permanent documentation.

The results of the inventory were summarized on a 1-inch equals 1000-foot map that has been provided to the City Engineering staff.

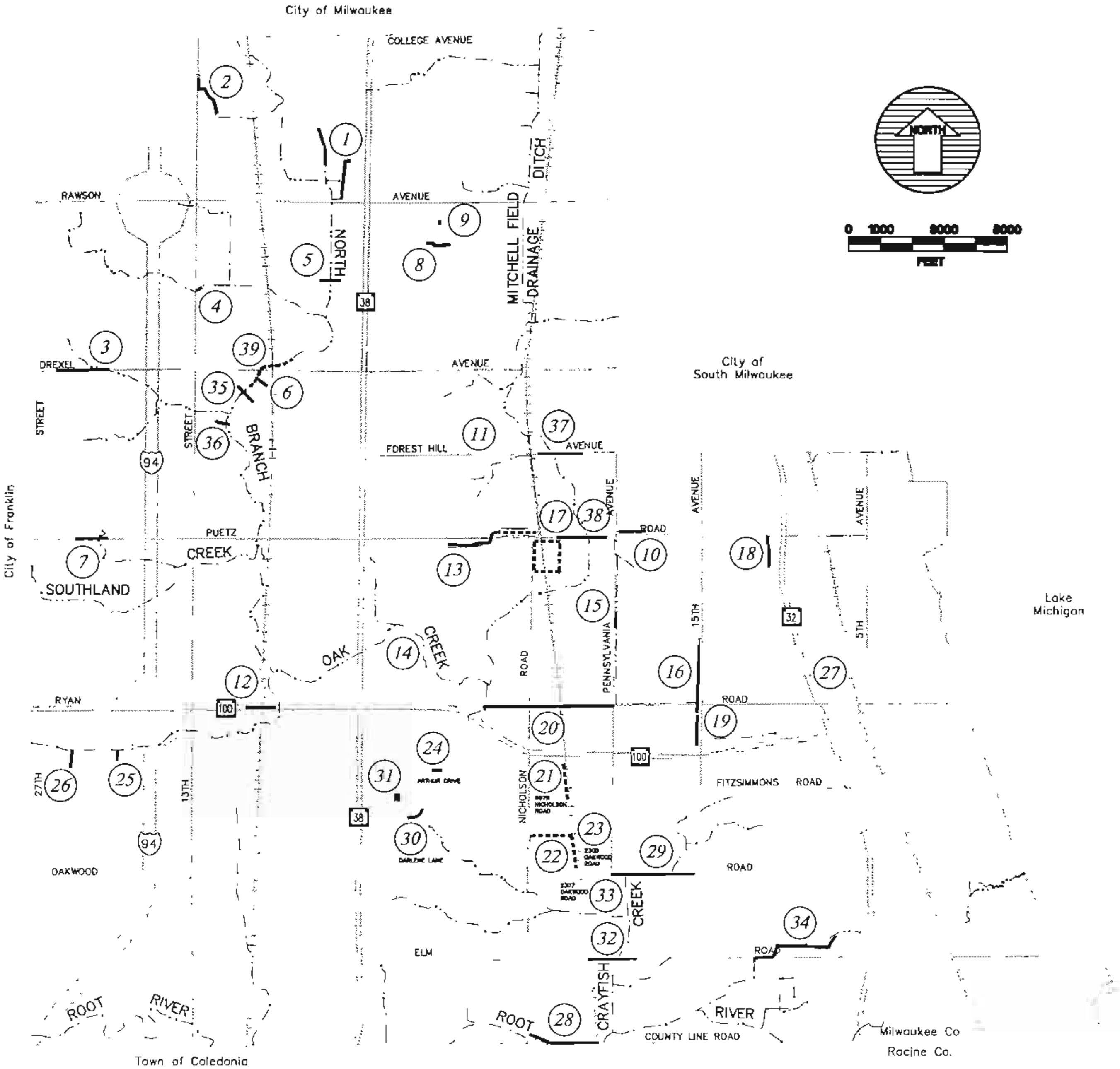
Reported Flooding and Drainage Problems

City staff and residents were asked to report flooding and drainage problems in the study area. Early in the project, city staff compiled a list of 14 areas that have had ongoing flooding and drainage problems. An open house meeting was held on Saturday October 29, 1995 to solicit comments and problem reports from residents of the City. At this meeting, maps of the City were used to discuss various drainage and flooding situations and 23 problem areas were identified. Several additional problem areas were identified by the City in October 1998. These reported problems were reviewed with the Stormwater Management Committee and categorized into three groups. The first group was the problems to be addressed in this study, as shown in Table 3-11 and on Figure 3-6.

Table 3-11 Reported Flooding and Drainage Problems within Project Scope

ID No.	Location	Reported Problem	Section	Qtr Sec.
1	6931 S. Howell Ave.	drainage blocked	5	SE
2	S. 13th St. & Pelton Dr.	street and adjacent area flooding	5	NW
3	S. 20th St. and Drexel Ave.	street flooding	7	SW
4	7538 S. 13th St.	easement not consistent with stream location	8	SW
5	Marquette Ave.	storm sewer outlet below channel	8	NE
6	Between Drexel Ave. and Wildwood Dr.	storm sewer outlet below channel	17	NW
7	2000 block W. Puetz Rd.	street flooding	18	SW
8	7289 S. Quincy Ave.	sewer surcharge from field upstream	9	NW
9	7152 S. Taylor Ave.	basement flooding	9	NW
10	E. Puetz Rd. & Pennsylvania Ave. - Sharon Dr.	storm sewer outlet below channel	15	SW
11	1020 E. Forest Hill Ave.	drainage blocked	16	NE
12	700 W. Ryan Rd.	frequent underpass flooding	20	SW
13	Stonegate Drainageway	houses at risk of flooding	21	NE
14	Parkway Estates & Oak View Ln.	storm sewer outlet below channel	21	SW
15	9000 S. Pennsylvania Ave.	street flooding	22	NE
16	S. 15th Ave. north of E. Ryan Rd.	street flooding and poor drainage	22	SE
17	8768 Nicholson Rd	poor drainage	22	NW
18	S. 11th Ave.-Madeira Dr. to E. Puetz Rd.	local flooding	23	NW
19	15th Ave. - STH 100 to E. Ryan Rd.	street flooding	26	NW
20	E. Ryan Rd. – Pennsylvania Ave. to west of Nicholson Rd.	street flooding	27	NW
21	9978 S. Nicholson Rd.	drainage blocked	27	NW
22	10016 S. Nicholson Rd. and 1834 E. Oakwood Rd.	drainage blocked	27	SW
23	2300 E. Oakwood Rd.	poor drainage	27	SW
24	Arthur Dr.	street flooding	28	NW
25	Ridgeview Dr.	storm sewer outlet below channel	30	NW
26	Southbranch Blvd. & Reinhart Dr.	storm sewer outlet below channel	30	NW
27	9310 S. 8th Ave.	street flooding	23	SE
28	2200 E. County Line Rd. to Nicholson Rd.	street flooding	34	SW
29	2400 to 3200 E. Oakwood Rd.	street flooding	27	SE
30	Darlene Ln.	street flooding	28	SW
31	410 E. Robert Rd.	poor drainage	28	SW
32	2200 to 2600 E. Elm Rd.	street flooding	34	SE
33	2307 E. Oakwood Rd.	poor drainage	34	NW
34	E. Elm Rd.-Chicago Rd. to Shangri La Ct.	poor drainage	35	NE-NW

Figure 3-6
Reported Flooding and Drainage Problems



Legend

— PROBLEM AREA IDENTIFIED BY CITY

---- PROBLEM AREA IDENTIFIED AT OPEN HOUSE

(31) PROBLEM I.D. NUMBER

Alternatives and recommendations for the problem areas in Table 3-11 are discussed in Chapter 6.

The second group of reported problems consisted of problems related to flooding on the main stem of Oak Creek, as shown in Table 3-12 and on Figure 3-6. These problems were referred to the Metropolitan Sewerage District to be addressed in the update of the Watercourse System Plan.

Table 3-12 Reported Flooding and Drainage Problems to Be Addressed by MMSD

ID No.	Location	Problem	Section	Qtr Sec.
35	Wildwood Bridge	street flooding	17	NW
36	W. Weatherly Dr.	street flooding	17	NW
37	1600 block E. Forest Hill Ave.	street flooding	15	NW
38	2000 block E. Puetz Rd.	street flooding	15	NW
39	S. Wildwood and S. 6th St.	channel blocked	17	NW

The third category consisted of problems already addressed by the City and minor drainage problems being addressed by the City. These problems are listed in Table 3-13.

Table 3-13 Reported Flooding and Drainage Problems Addressed by City

Location	Problem	Section	Qtr Sec.
2330-34 E. Chestnut Dr.	drainage	3	SW
7463 S. Highfield Ct.	drainage	10	NW
3675 E. Ryan Rd.	drainage	26	N
10181 S. Nicholson Rd.	drainage & easement	27	SW
3443 E. Puetz Rd.	drainage	23	NW
10730 S. Howell Ave.	drainage	33	SW
McGraw Dr.	street flooding	33	NE
S. 4th Ave. and E. Studio Ln.	drainage	36	NW
10570 S. Chicago Rd.	drainage	36	NW
10585 S. Chicago Rd.	drainage	36	NW
drainage map correction	None	5	SE

Chapter 4

Hydrologic – Hydraulic Analysis

Introduction

This chapter describes the approach used to determine flows, flood stages, and storm sewer capacities. The methods and computer programs are described, and the parameters used in the computations are discussed. Results from the analyses are presented.

The hydrologic analysis determined peak flood flows and volumes at numerous locations in the City for a range of storm recurrence intervals. Both existing (1995) and ultimate future (2020) land use conditions in the watershed were addressed in the hydrologic analysis. Flood flows for 2-, 10-, and 100-year recurrence interval storm events were determined at all stream confluences, municipal boundaries, railroad crossings, and road crossings with 24-inch or larger culverts. Flows for 2-, and 10-year recurrence interval storm events were determined at each manhole in storm sewer systems 15-inch and greater in diameter.

The hydraulic analysis determined flood stage profiles along tributary streams for all flow conditions addressed in the hydrologic analysis. Floodplain boundaries for existing land use conditions were delineated along the tributary streams and flood stage elevations were computed at road crossings. Floodplain boundaries and flood stages on Oak Creek, North Branch of Oak Creek, Mitchell Field Drainage Ditch, Southland Creek, Root River, and Crayfish Creek were evaluated by SEWRPC and mapped independently from this plan.

Methodology

Three computer programs were used to conduct the hydrologic-hydraulic analysis for the City of Oak Creek. The specific programs identified in the scope of services were used, except that a replacement version of the floodplain hydraulic analysis program was used.

The flood flow and floodplain mapping analysis was done using U.S. Army Corps of Engineers programs HEC-1 and HEC-RAS. The programs are in the public domain, well-documented, widely accepted, and essentially standard tools for floodplain studies. WDNR and FEMA require these programs for floodplain evaluations submitted for review and approval. The storm sewer systems were evaluated using a proprietary version of the SWMM program developed by the U.S. Environmental Protection Agency.

The application of each of these programs required assumptions to fit the specific watershed situation. Typical procedures were developed and followed to create models that are uniform for each tributary stream or sewer system. The following sections discuss the application of these computer programs for the hydrologic and hydraulic analyses.

Watershed Hydrology

The rainfall/runoff relationships for all subbasins were developed using the U.S. Army Corps of Engineers hydrologic computer program HEC-1: Flood Hydrograph Package (USCOE, 1990). HEC-1 is widely used for hydrologic analysis of urban and rural watersheds where flow routing and reservoir storage must be addressed. The primary function of the HEC-1 model is to develop surface runoff hydrographs for each subbasin and route the runoff through the stream system to produce peak discharge values at various locations within the watershed.

HEC-1 models were prepared for each tributary stream. Flow hydrographs for storm events with recurrence intervals of 2-, 10-, and 100-years were computed for each subbasin. HEC-1 was used to simulate flows at the outlet of each subbasin and at major road crossing culverts. Flow hydrographs were routed through detention facilities and natural storage areas for peak flow reduction in HEC-1. Detention outlet analyses accounted for tailwater conditions at the outlets and downstream flood elevations.

Floodplain Hydraulics

Flood stage profiles were computed using the U.S. Army Corps of Engineers hydraulic backwater computer program HEC-RAS: River Analysis System (USCOE, 1997). This software replaces the HEC-2 program previously used for water surface profile computations. HEC-RAS calculates water surface profiles for steady gradually varied flow and is capable of modeling subcritical, supercritical, and mixed flow regime water surface profiles. HEC-RAS determines the flood elevations associated with the peak flows occurring in the stream system. Flood stages are largely a function of the flow and the geometric characteristics of the stream. These characteristics include cross-sectional shape, longitudinal slope, roughness, and restrictions caused by culverts, bridges, and other hydraulic structures.

Hydraulic models were developed with HEC-RAS for each tributary stream in the study area. Geometric data collected to describe the channel and floodplain included: reach length and slope, roughness coefficients, cross-section geometry, and bridge and culvert geometry and elevations. Much of the data were obtained from the 1993 large-scale topographic mapping from the City. Locations of hydraulic cross sections were recorded in an AutoCAD file provided to the City. Master grading plans were used for topographic data in areas developed since the mapping. Bridge and culvert geometry and elevations were obtained by field survey of the structures. Roughness coefficients were determined from field reconnaissance and aerial photographs. Where historic highwater marks were available, the hydraulic models were calibrated to be consistent with the historic data.

In the hydraulic analysis of tributary streams, backwater from the receiving stream was assumed to not effect the outlet of each stream. This assumption is consistent with the approach used by WDNR and FEMA. This approach examines the probability of high flows on the tributary independent of high stages on the receiving stream. The joint probability of high stages on the receiving stream occurring coincidentally with high tributary flows is a lesser probability than the occurrence of either independent event.

Storm Sewer Analysis

The storm sewer systems were analyzed using a hydrologic/hydraulic computer program entitled XP-SWMM™ (XP Software, Inc., 1997). The XP-SWMM model represents the storm sewer system with a series of links and nodes. A node represents a manhole or a place where a change in the geometric shape, size, or type of a channel or pipe takes place. In addition, a node can represent a storage area or boundary condition (such as a downstream river). The links represent the pipes or channels between the nodes.

XP-SWMM evaluates the capacity of the sewer system as the flow hydrographs are routed through the system. The effects of the pipe size, slope, and downstream water elevations are accounted for in determining the peak flows and maximum water levels. The model allows deficiencies in the storm sewer to be evaluated by determining the depth of water in the storm sewers and locations where the water levels exceed the ground elevation. Storm sewers were evaluated for 2- and 10-year recurrence interval storm events. For storm sewer systems subject to river backwater, the tailwater was based on the 10-year river flood elevations.

Hydrologic Parameters

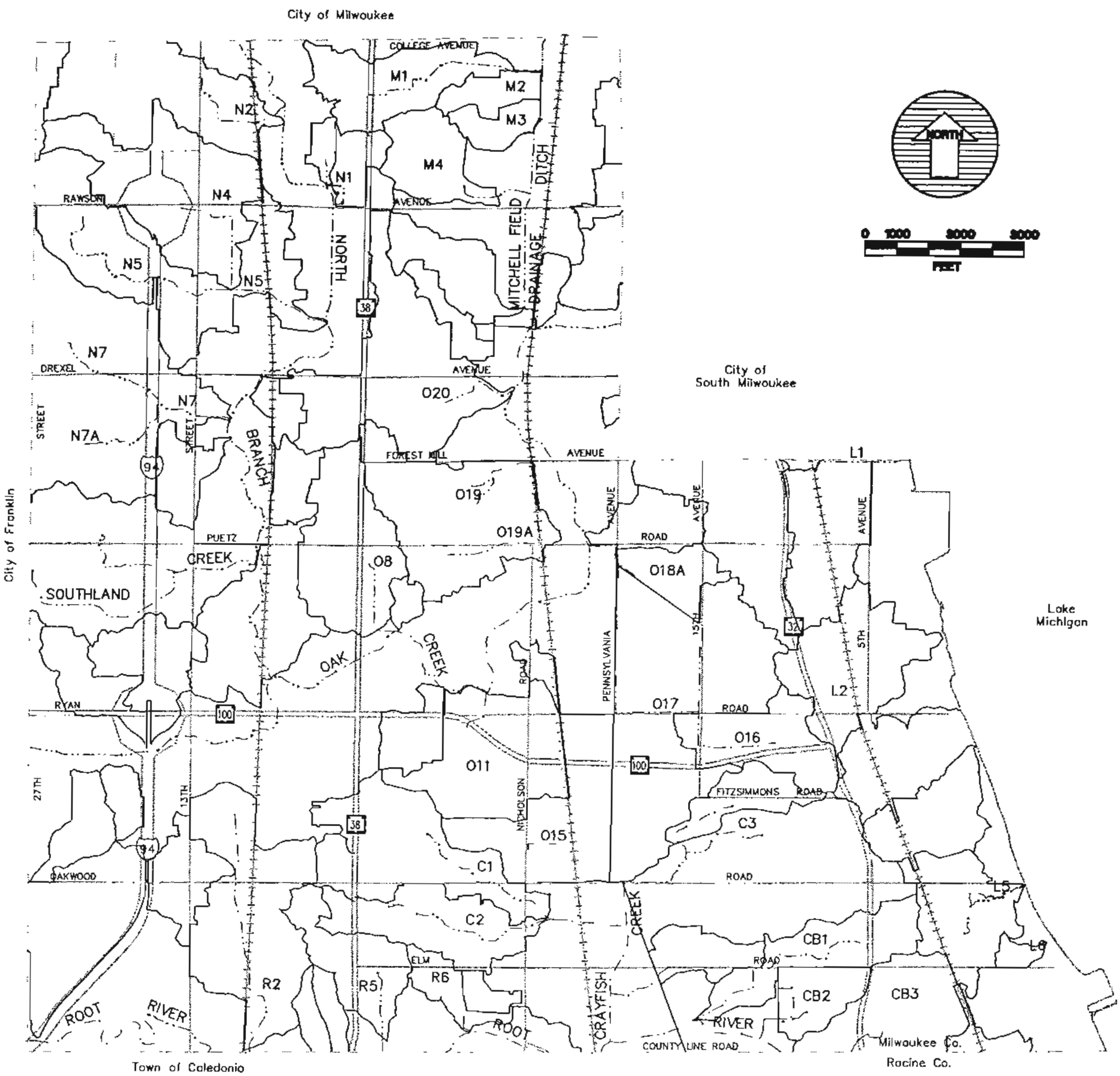
The data needed to perform the runoff analyses using HEC-1 and XP-SWMM were compiled for the study area. The data parameters include precipitation, subbasin size, soil type, land use, and the timing associated with surface runoff reaching the stream system. A summary of the hydrologic parameters necessary for the analysis is described below.

Subbasins

The major watersheds in the City of Oak Creek were divided into 60 subwatersheds for each tributary to the major streams. The boundaries were determined by the topography and location of the tributary streams. These subwatershed boundaries are shown in Figure 4-1. The hydrologic analysis addressed each subwatershed, with specific hydrologic models describing the unique runoff, conveyance, and storage characteristics of each tributary stream system.

Each of the subwatersheds and the areas directly tributary to major streams were divided into subbasins. Subbasins are the basic building blocks used to evaluate the hydrologic behavior of the watersheds under existing and projected future land use conditions. The subbasin boundaries are shown in Figure 4-2 and were documented in an AutoCAD file and on large-scale maps provided to the City. The boundaries were based on topographic mapping and visual observations during field reconnaissance. The subbasins ranged from less than 1 acre to 255 acres in size. For the analysis of storm sewer systems, the subbasin areas were apportioned to individual pipe segments within the subbasin.

Figure 4-1
Subwatershed Boundaries



Legend

——	BOUNDARY
CB3	SUBWATERSHED NAME

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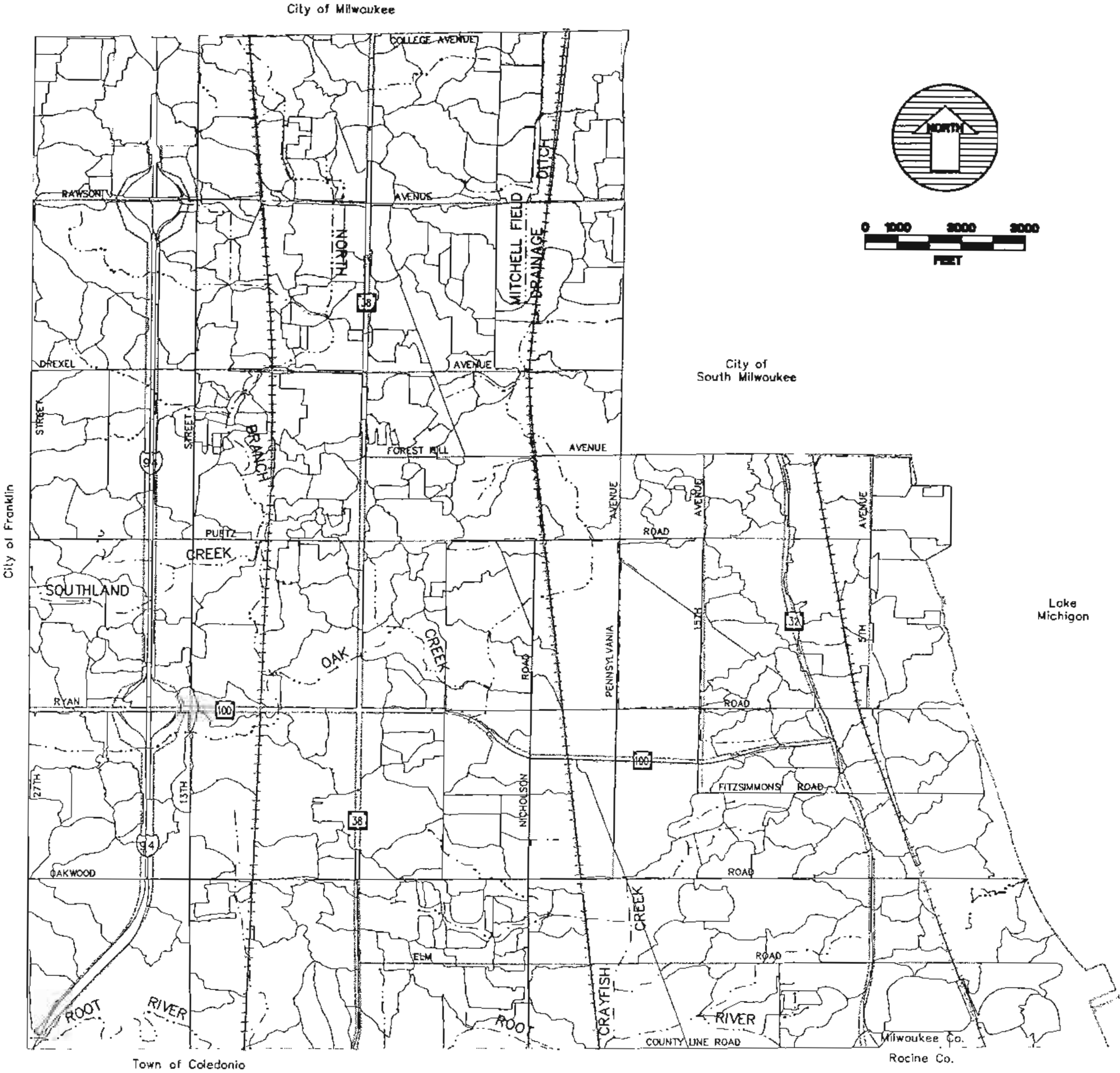
Figure 4-2
Drainage Subbasins



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Precipitation

Rainfall depths were obtained from the Midwestern Climate Center Bulletin 71, Rainfall Frequency Atlas of the Midwest. The rainfall volumes were disaggregated according to the first quartile Huff distribution. To determine the proper storm duration for the analysis, a sensitivity analysis was conducted. Storm durations ranging from 30 minutes to 24 hours were simulated in different size subbasins. The 2-hour rainfall was found to produce the largest peak discharges. Based on this evaluation, the hydrologic analysis used the 2-, 10-, and 100-year recurrence interval storm events with 2-hour rainfall amounts of 1.6, 2.2, and 3.6 inches, respectively. Table 4-1 presents the depth and duration data for various storm events.

Table 4-1 Rainfall Data

	Rainfall Volume (inches)				
	Storm Duration (hours)				
Recurrence Interval	0.5	1.0	2.0	3.0	6.0
2-year	1.0	1.3	1.6	1.7	2.0
10-year	1.4	1.8	2.2	2.5	2.9
100-year	2.3	2.9	3.6	4.0	4.7

Soil Type

The predominant soil types in all subbasins are in hydrologic soil group C based on the Soil Conservation Service Soil Survey, Milwaukee and Waukesha Counties, Wisconsin (USDA, 1971). These soils are chiefly clay and have low infiltration rates, poor drainage, and high runoff potential. The hydrologic soil type is used in determining the runoff curve number.

Land Cover – Runoff Curve Number

Existing land cover was determined using Geographic Information System (GIS) analysis of 1993 digital land use mapping provided by SEWRPC. The area of each of twenty categories of land cover was measured in each subbasin. Some areas showed as developed on the 1995 aerial photographs, but were not on the 1993 mapping. Those areas were included in the GIS analysis by delineating the development area and assigning an area-wide curve number. Each land cover type was assigned a runoff curve number as shown in Table 4-2. An area-weighted average curve number was computed for each subbasin.

Future land use was determined from the City zoning map, as amended in 1998. Future watershed conditions were characterized by adjusting the areas of each land cover category to reflect the future land use and re-computing the area-weighted average curve number for each subbasin.

Table 4-2 Runoff Curve Numbers

Land Use	Curve Number
Agriculture	88
Driveway – paved	98
Driveway – unpaved	89
Marsh	95
Meadow	71
Mowed	74
Open	71
Open Water	95
Park	74
Patio	98
Parking – paved	98
Parking – unpaved	89
Roof	98
Sidewalk	98
Street – paved	98
Street – unpaved	89
Wooded	70
Yard	74
Developed – 1/3 acre residential	81
Developed – 1/4 acre residential	83
Developed – multifamily residential	90
Developed – commercial and business	94
Developed – parking areas	97

Time of Concentration

XP-SWMM uses Time of Concentration (T_C) to account for the delay in time between when the rainfall occurs and when the runoff occurs. T_C is the time it takes for the surface water runoff to travel from the hydraulically most distant point of the subbasin to the discharge location. The T_C was calculated based on a combination of sheet flow, shallow concentrated flow, and open channel flow. Travel paths were determined from the available topographic mapping.

HEC-1 uses Lag Time to account for the delay in time between when the rainfall occurs and when the runoff occurs. The lag time is equal to the time (hours) between the center of mass of the rainfall hyetograph and the peak of the unit runoff hydrograph. Lag times were computed as 0.6 times the Time of Concentration.

Storm Sewer Systems

To compute flows tributary to the storm sewers, the subbasins were divided into smaller catchments tributary to nodes, or manholes on the sewer system. Topographic mapping and the sewer system layout were used to define the catchment boundaries. The boundaries were documented in an AutoCAD file provided to the City. Each catchment was described in the model by its area, time of concentration, and percentage of impervious surface. Parameter values were determined from the subbasin parameters and 1995 aerial photographs.

Detention Storage

Detention storage facilities were represented in the HEC-1 and XP-SWMM models using data available from the City. Other areas of potential runoff storage such as wetlands or significant ponding areas upstream of culverts, referred to as natural storage, were also included in the hydrologic models. The detention storage facilities and natural storage areas are identified in Figure 4-3.

Elevation-area relationships were prepared from the topographic mapping to define the storage function of natural and constructed detention areas. Elevation-discharge relationships were prepared from the hydraulic analysis to define the outlet flow rates from the detention facilities and natural storage areas.

Hydrologic-Hydraulic Results

The results of the hydrologic and hydraulic analyses indicate that overall the drainage systems in the City of Oak Creek perform well, with few problem areas other than those reported by City staff and citizens. The findings of the storm sewer system analysis are presented below, followed by discussion of the flood flows and floodplains.

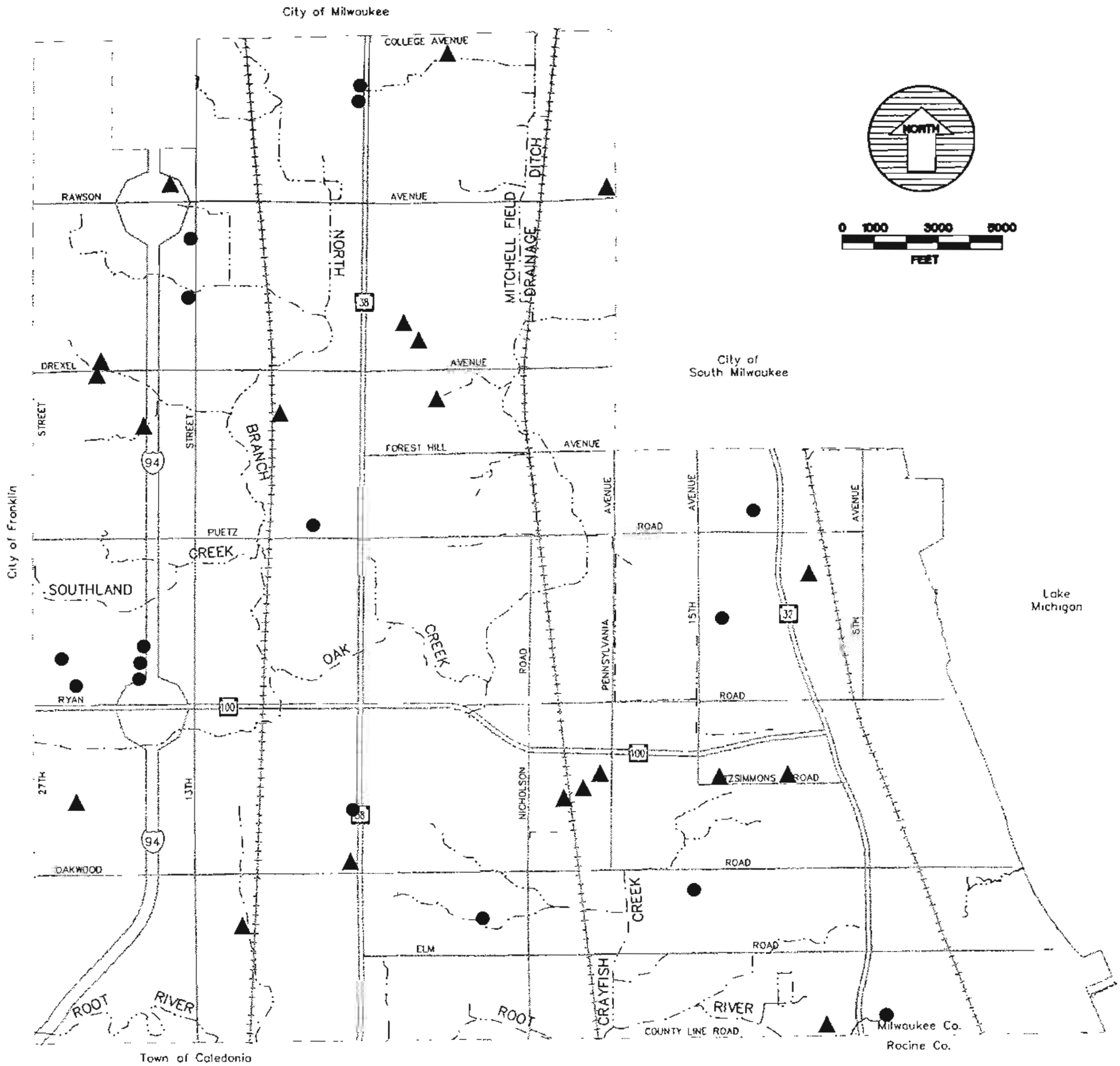
Storm Sewer Systems

Storm sewers 15-inch or larger in diameter were evaluated to determine their capacity for 2- and 10-year recurrence interval storm events occurring with existing land use conditions. The evaluation included three elements. First, peak flows for 2- and 10-year recurrence interval storms were compared to the pipe capacity. Second, water levels in the storm sewers for a 10-year frequency storm were compared to the manhole rim elevations. Finally, overland flow routes were examined where surcharging occurred above the manhole rim.

The adequacy of storm sewer systems was evaluated by their ability to handle a 10-year recurrence interval storm event without surcharging above the manhole rim. Surcharging occurs when the water level rises above the top of the sewer pipe. Although this is not the preferred design arrangement, surcharging occurs in many storm systems and is acceptable from an engineering and maintenance perspective. However, when surcharge levels exceed the manhole rim or road elevation, stormwater may displace the manhole lid and may discharge from the manhole. Overflow may cause flooding problems depending on the topography and the overland flow route available to handle the excess stormwater.

The capacity analysis results are tabulated in Appendix H (Volume 2). The results indicate that most sewer systems have sufficient capacity for the peak 10-year storm flows. There were 145 systems identified in the City of Oak Creek, of which 11 were not analyzed due to insufficient data. Of the 134 analyzed systems, 107 have capacities greater than the peak flows. In 20 of the systems, there are one or two pipe segments under capacity, which do not affect the overall system capacity. Only seven entire systems were found to have capacities less than the peak 10-year flows. The systems with deficient capacities are shown on Figure 4-4.

Figure 4-3
Existing Detention Storage Locations

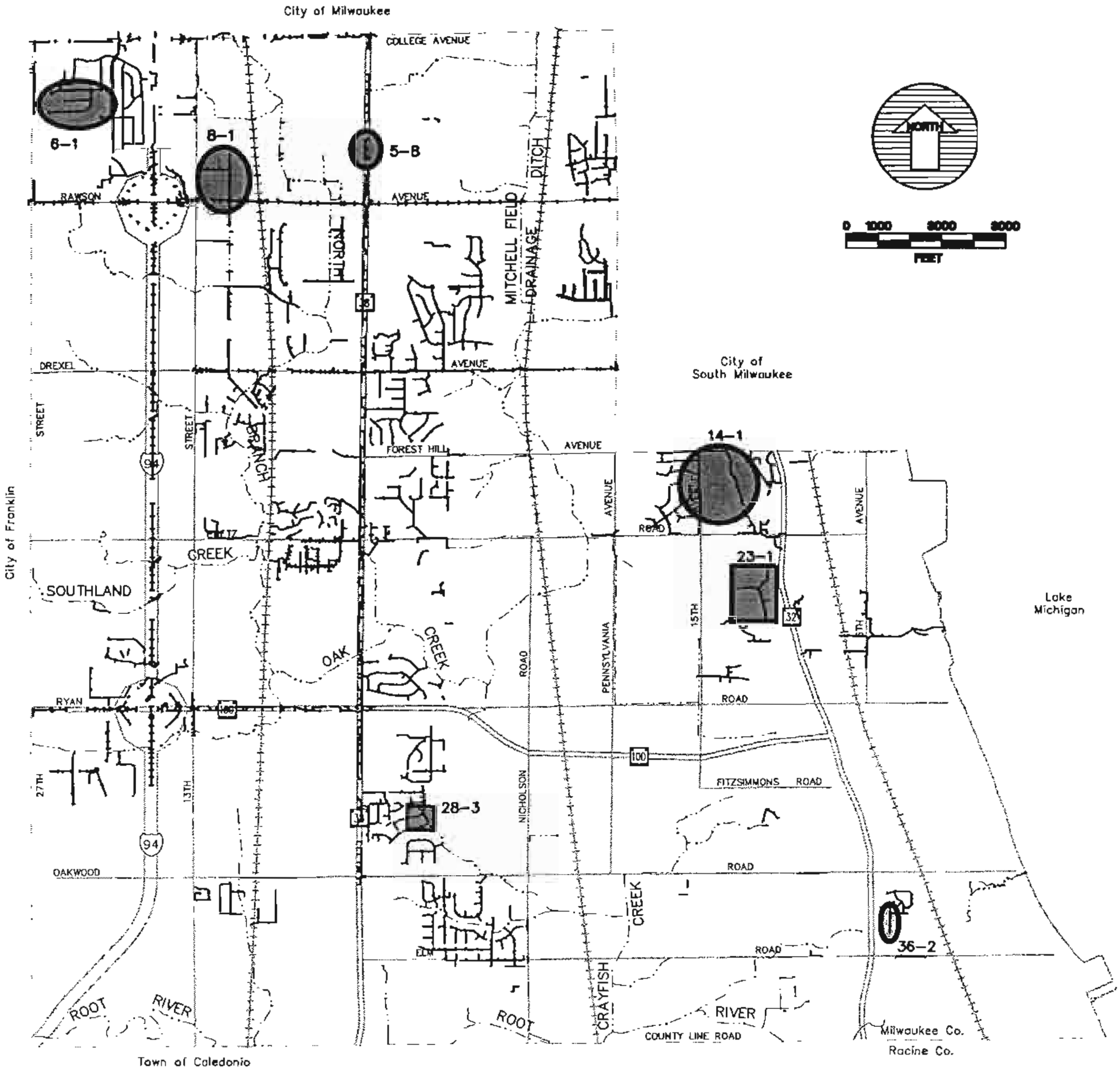


Legend

● DETENTION POND LOCATIONS AS OF 1995

▲ NATURAL HEADWATER STORAGE LOCATIONS

Figure 4-4
Deficient Storm Sewer Systems



Legend

STORM SEWER LOCATIONS

8-1 STORM SEWER SYSTEM NUMBER

CAPACITY LESS THAN PEAK 10-YEAR FREQUENCY STORM FLOW

FLOODING PROBLEM DUE TO INADEQUATE CAPACITY

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Most storm sewer systems have capacity for the 2- and 10-year recurrence interval storms without surcharging above the top of the pipe. Of the sewer systems that surcharge with a 10-year frequency storm, only 2 systems were found to surcharge above the manhole rim and cause flooding because of insufficient capacity or inadequate overland flow routes. The locations of these systems are shown on Figure 4-4.

The analysis indicates that the storm sewer system at Darlene Lane (ID No. 28-3) is inadequate and causes flooding. This system was reported as a problem area. The existing storm sewer system along S. 11th Avenue from Madeira Drive to E. Puetz Road (ID No. 23-1) is inadequate and surcharges above the road. The City has designed a replacement system for construction in 1999. The replacement system was evaluated and found adequate.

Flood Flows

Flood flows were computed for storm events with recurrence intervals of 2-, 10-, and 100-years on each tributary stream. The flows were determined at confluences with the major streams and at culverts and bridges crossing the tributary. The detailed flow results for existing and future development conditions are presented in Appendix I (Volume 2). The flows were used in the hydraulic analysis to determine flood stages and the extent of the floodplains.

The existing and future condition flows at the outlet of primary tributaries are summarized and compared in Table 4-3. The flow increases due to future development range from 0 to 89 percent of the existing flows. The 2-year recurrence interval flows increase by 0 to 89 percent and the 100-year recurrence interval flows increase by 0 to 39 percent. The future condition flows assume that future development occurs without new regional or on-site detention facilities. Existing detention facilities and natural floodwater storage areas are assumed to remain in existence.

Table 4-3 Summary of Tributary Flood Flows (cfs) (without new detention)

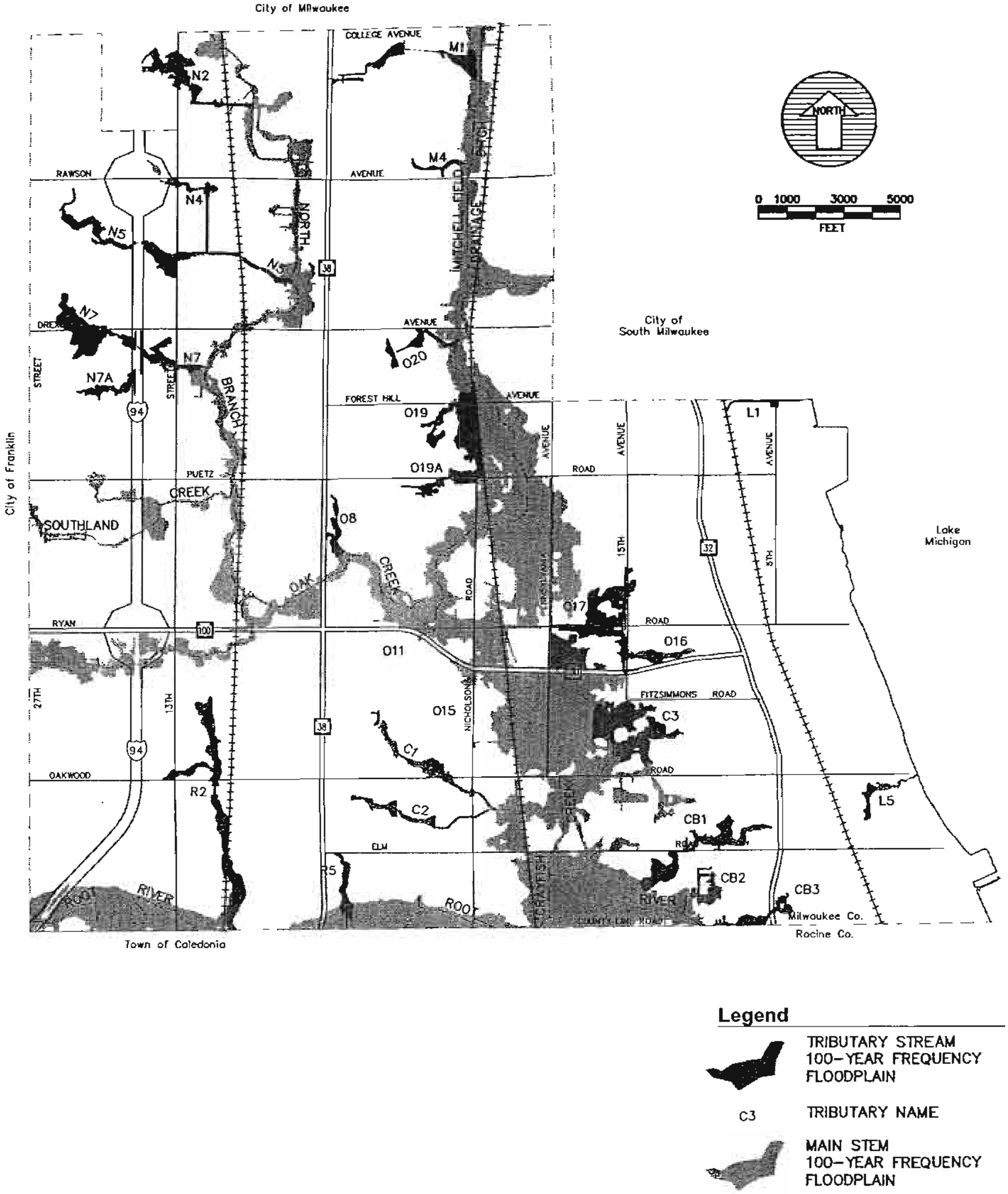
Tributary	Drainage Area (mi²)	Existing Conditions			Future Conditions			Percent Increase		
		2-year	10-year	100-year	2-year	10-year	100-year	2-year	10-year	100-yr
C1	1.02	130	285	700	140	300	725	8	5	4
C2	0.49	60	135	330	65	145	355	8	7	8
C3	1.14	110	230	545	110	230	545	0	0	0
CB1	0.34	50	100	240	50	100	240	0	0	0
CB2	0.17	25	55	140	25	55	140	0	0	0
CB3	0.40	20	40	140	20	40	140	0	0	0
L1	0.41	40	80	185	45	95	210	12	19	14
L2	0.48	45	115	310	85	175	420	89	52	35
L5	0.36	30	80	230	40	100	265	33	25	15
L6	0.04	5	10	25	5	10	25	0	0	0
M1	0.37	45	95	130	55	110	135	22	16	4
M2	0.11	30	60	135	30	60	135	0	0	0
M3	0.10	15	35	90	15	35	90	0	0	0
M4	0.25	60	120	285	75	150	335	25	25	18
N1& N3	0.16	15	30	50	25	40	60	67	33	20
N2	0.71	130	280	660	175	330	720	35	18	9
N4	0.68	115	245	560	130	275	610	13	12	9
N5	1.52	185	375	820	210	420	900	14	12	10
N7	1.27	130	245	495	140	270	510	8	10	3
O8	0.50	90	190	445	170	305	620	89	61	39
O11	0.56	70	150	350	80	165	375	14	10	7
O15	0.51	50	90	165	50	90	165	0	0	0
O16	0.33	35	85	225	45	100	245	29	18	9
O17	1.40	95	170	365	105	190	405	10	12	11
O18A	0.16	25	60	140	25	60	140	0	0	0
O19	0.69	90	205	510	95	205	510	6	0	0
O20	0.75	150	290	610	155	295	610	3	2	0
R2	0.94	115	195	395	140	215	430	22	10	9
R5	0.29	45	100	235	55	115	270	22	15	13
R6	0.17	25	60	145	35	75	180	40	25	24

Floodplains

Flood stage profiles were computed for each tributary stream using the existing and future land use condition flood flows for 2-, 10-, and 100-year recurrence interval storm events. The existing and future land use condition 100-year recurrence interval flood stages were used to map the 100-year recurrence interval floodplain boundaries. The floodplain mapping on the tributary streams was amended to reflect reaches that drain an aggregate area of at least 80 acres. This provides for a uniform designation throughout the City. Typically, these upper reaches draining less than 80 acres have not had historical flooding problems. The City's topography is such that drainage subbasins either combine around 80 acres, or feeder streams draining less than 80 acres merge together forming larger drainage basins over 80 acres. Drainage in these upper reaches with less than 80 acres is thought of as local drainage issues and is best managed by local regulations. Development in these areas will be subject to stormwater management planning through the proposed stormwater ordinance, Milwaukee Metropolitan Sewerage District's stormwater rules, and the City's NR 216 permit requirements. The future condition floodplain boundaries are shown on Figure 4-5 for the entire City and on Figure 4-6 for individual streams. The boundaries were also recorded in an AutoCAD file and on large-scale maps provided to the City. Floodplains along the major watercourses in the City of Oak Creek were prepared by the Southeastem Regional Planning Commission. Flood stage profile data are presented for each stream in Appendix J (Volume 2).

The floodplain boundaries identified areas where existing buildings and streets are subject to flooding from the tributary streams. The locations of these potential problem areas are shown on Figure 4-7.

Figure 4-5
Mapped Floodplains of Tributary Streams



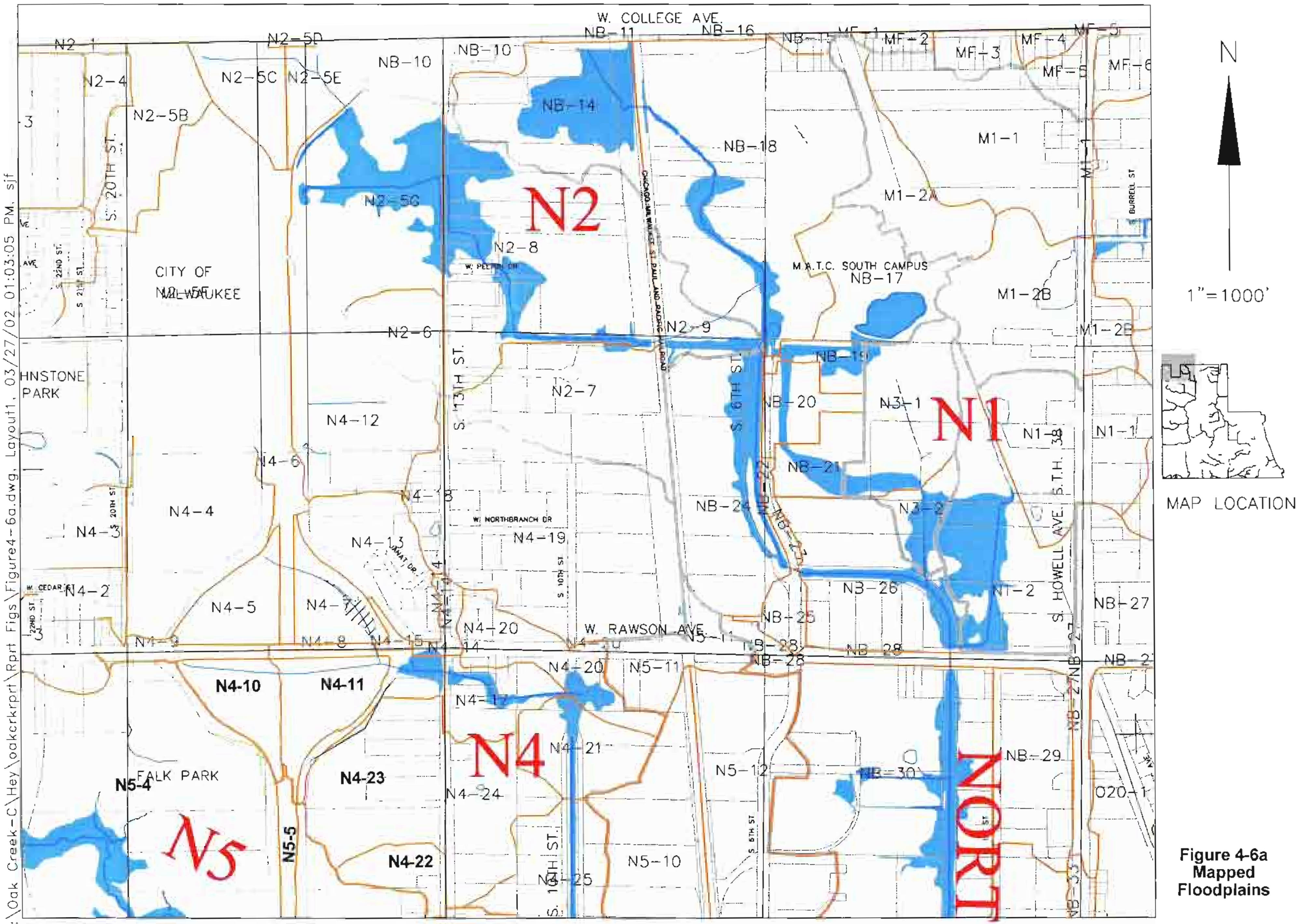


Figure 4-6a
Mapped
Floodplains

H:\Oak Creek-C\Hey\oakcrkrprt\Rprt Figs\Figure4-6a.dwg, Layout1, 03/27/02 01:03:05 PM, sjf

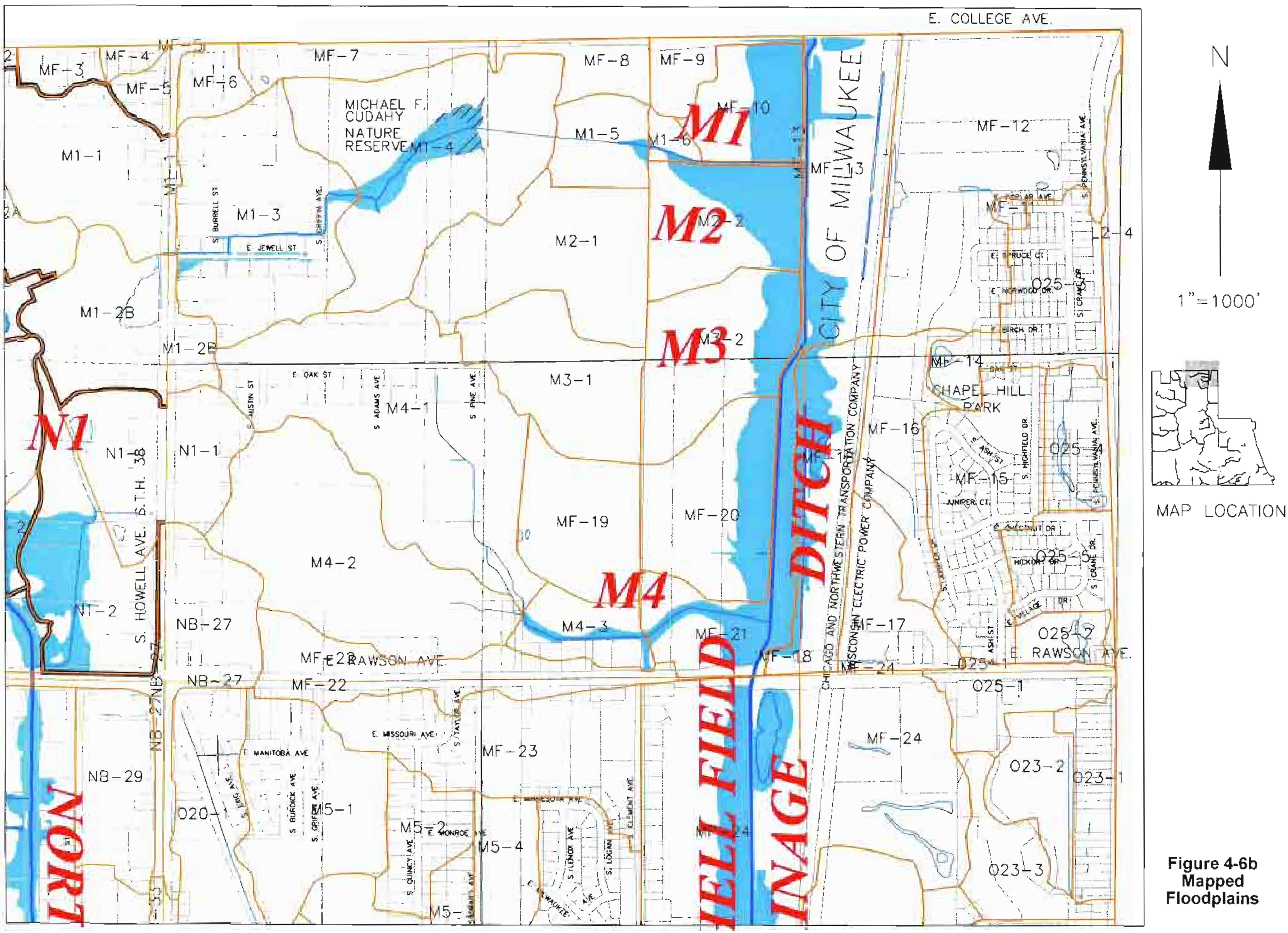


Figure 4-6b
Mapped
Floodplains

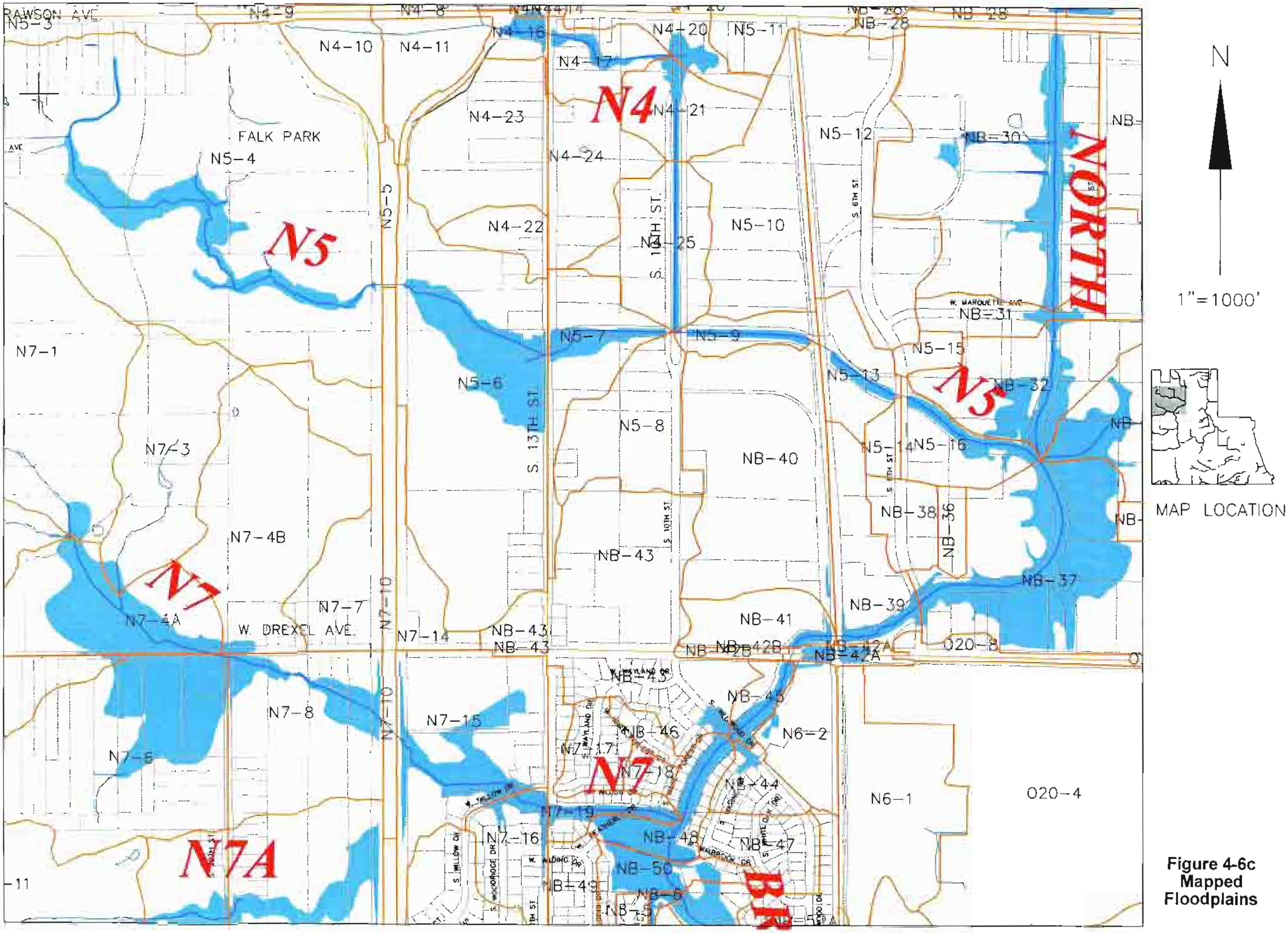


Figure 4-6c
Mapped
Floodplains

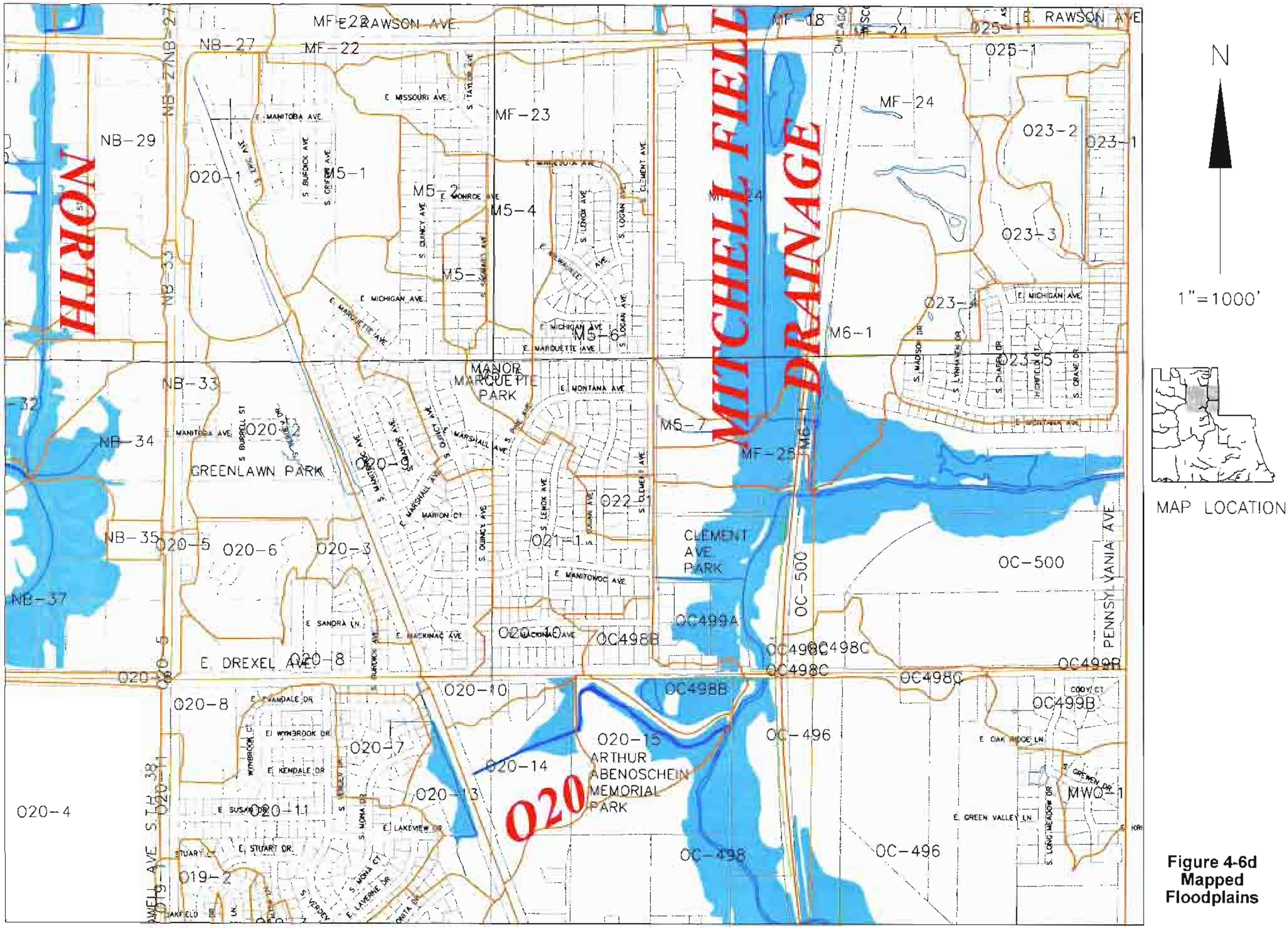


Figure 4-6d Mapped Floodplains

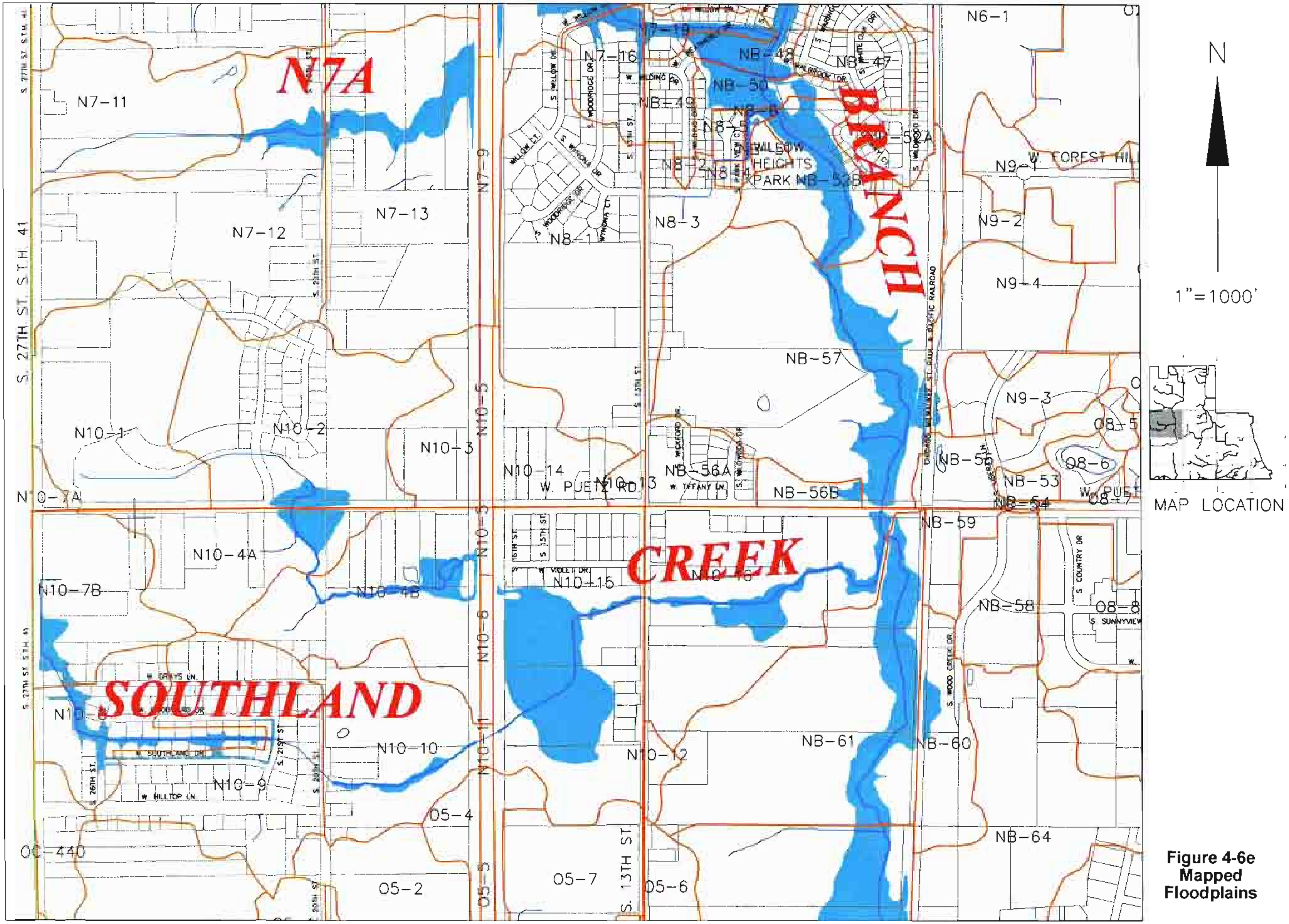


Figure 4-6e
Mapped
Floodplains

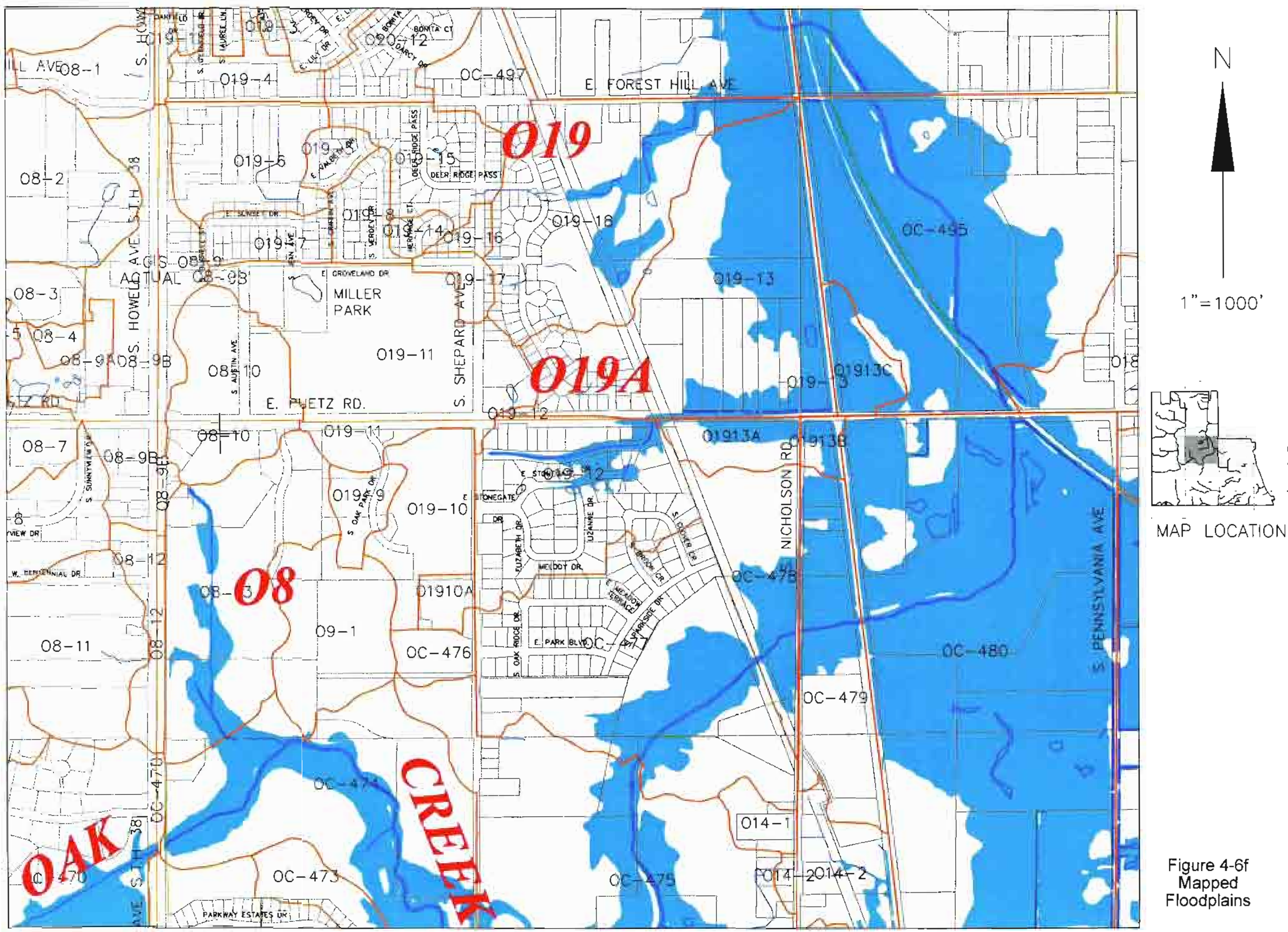


Figure 4-6f
Mapped
Floodplains

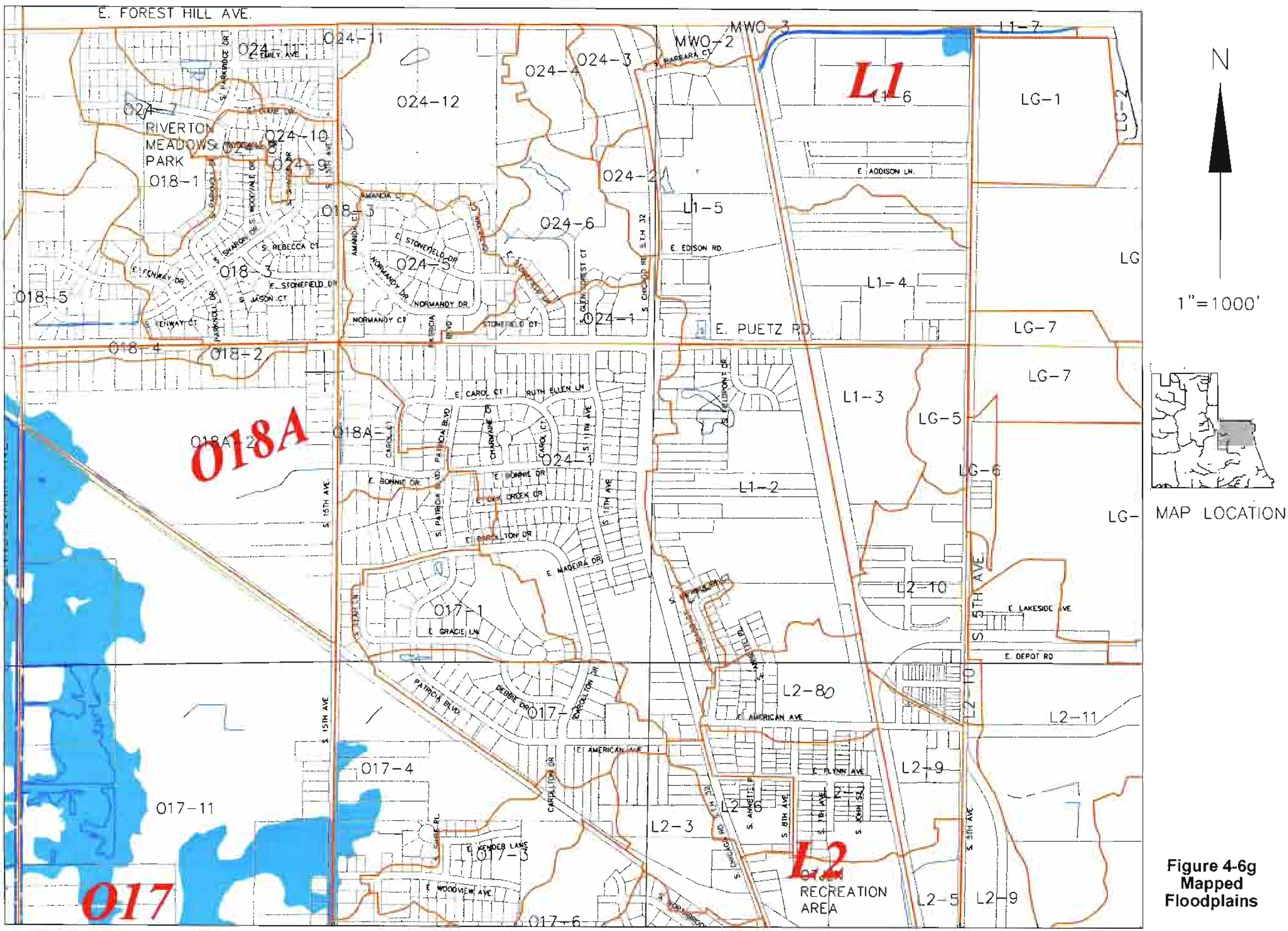


Figure 4-6g
Mapped Floodplains

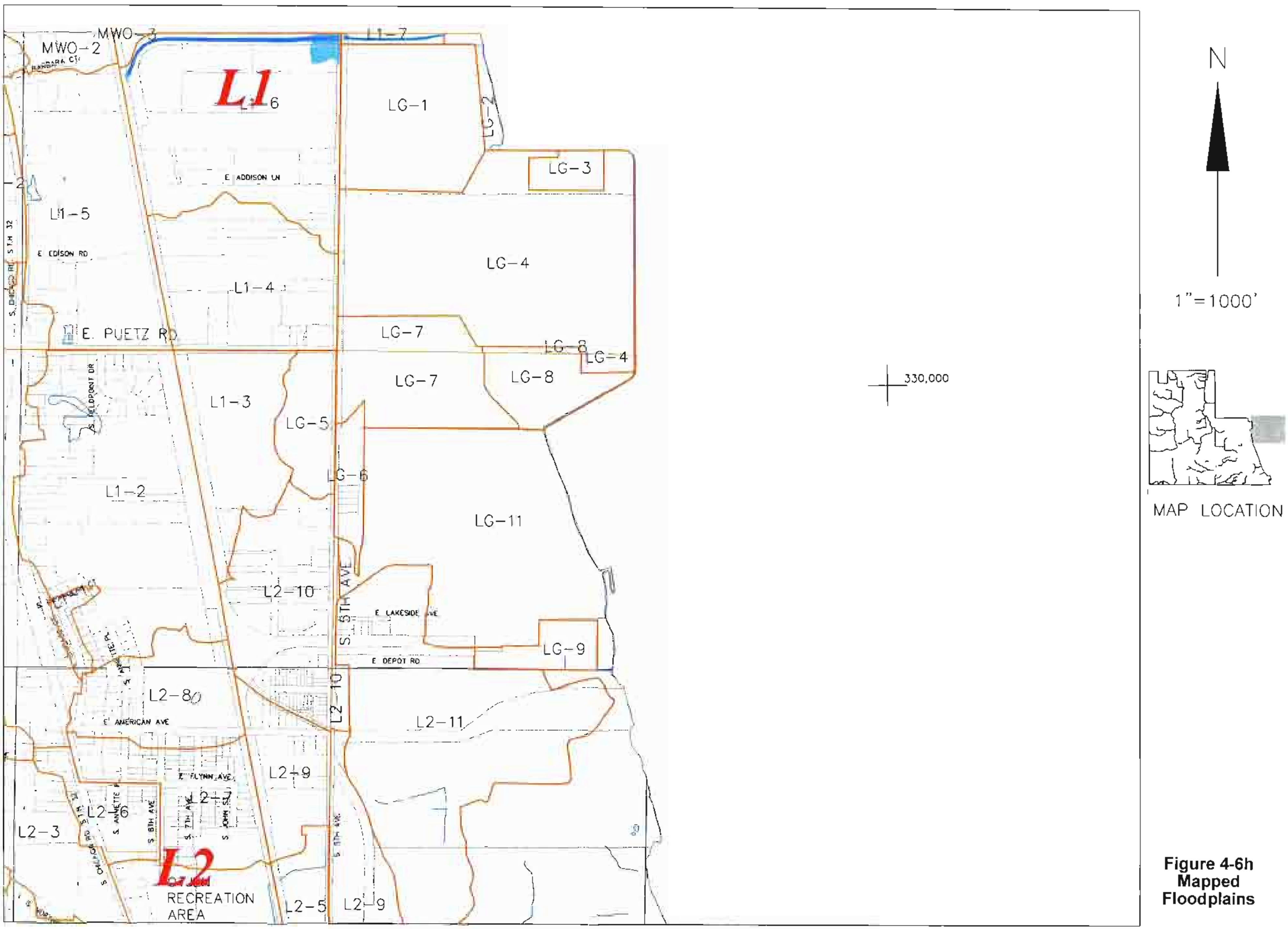


Figure 4-6h
Mapped
Floodplains

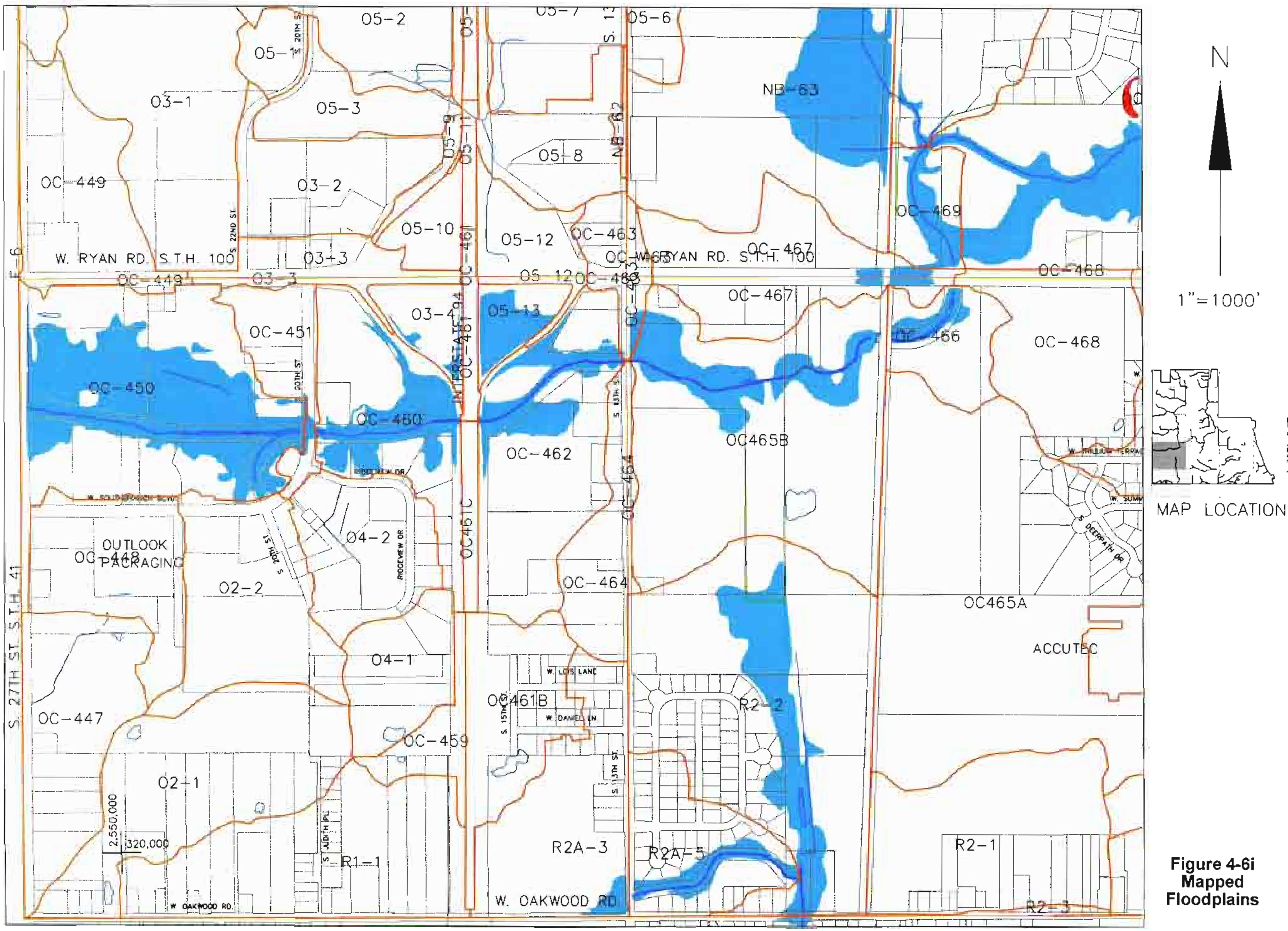


Figure 4-6i Mapped Floodplains

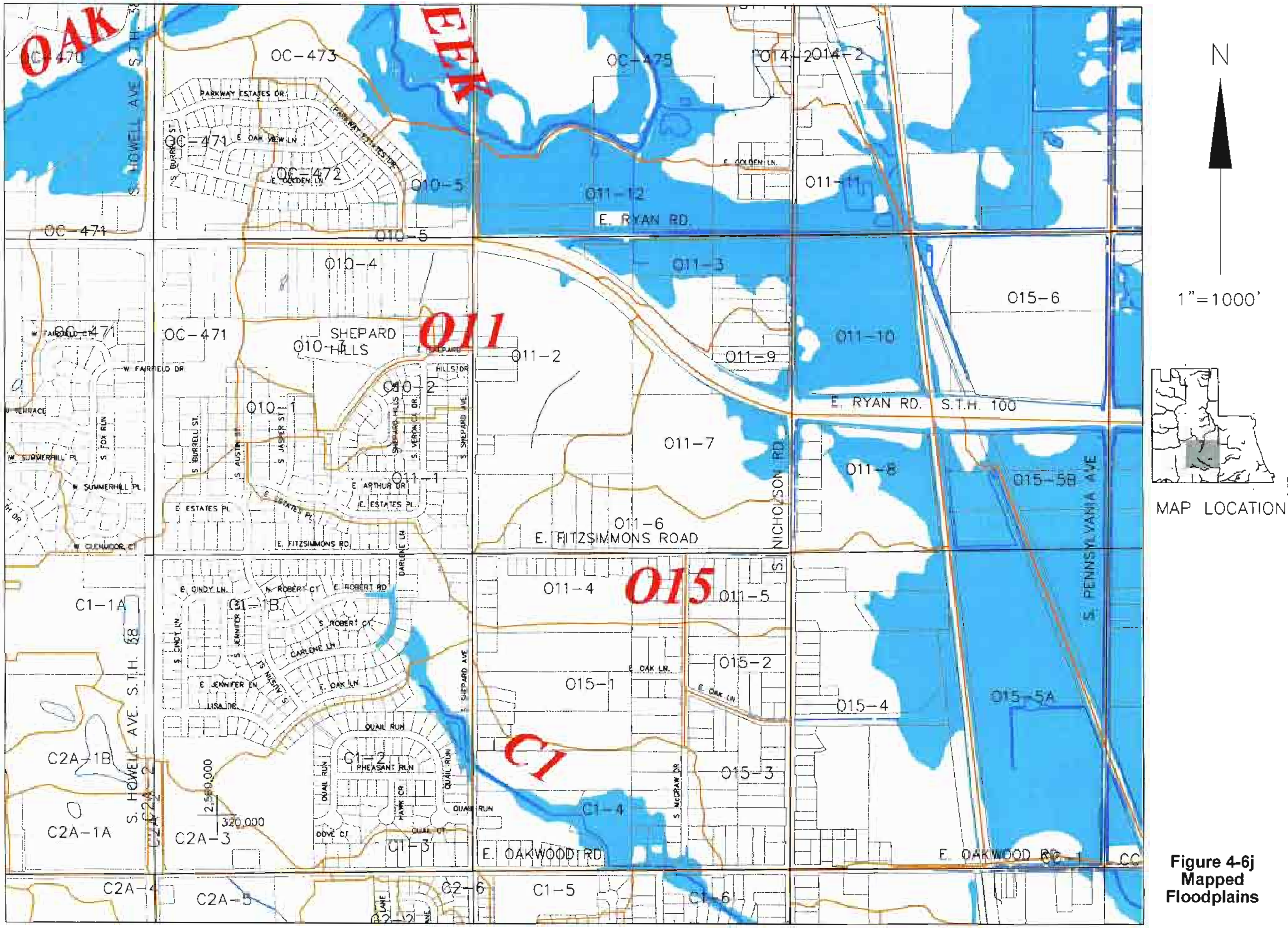


Figure 4-6j
Mapped Floodplains

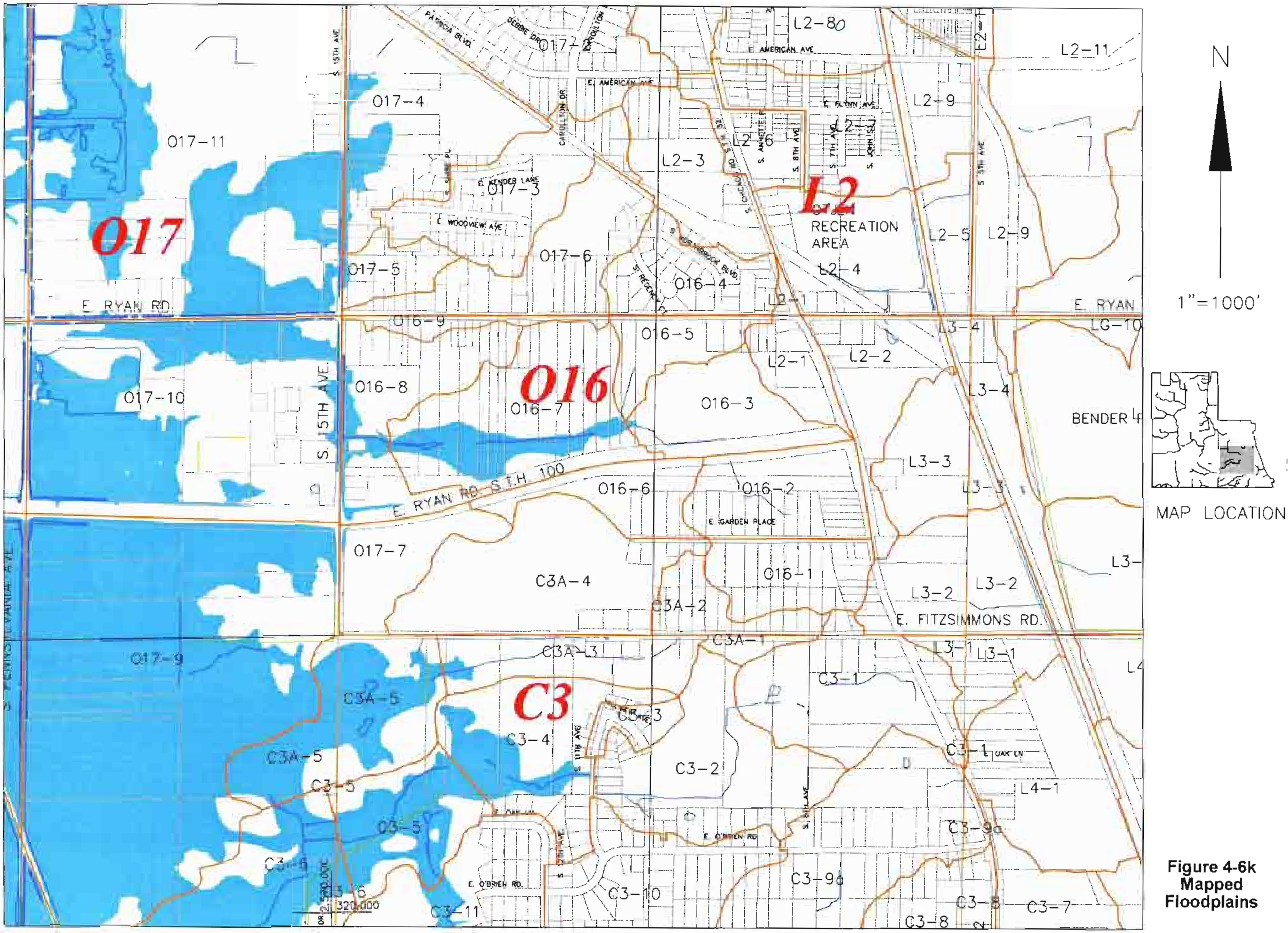


Figure 4-6k
Mapped Floodplains

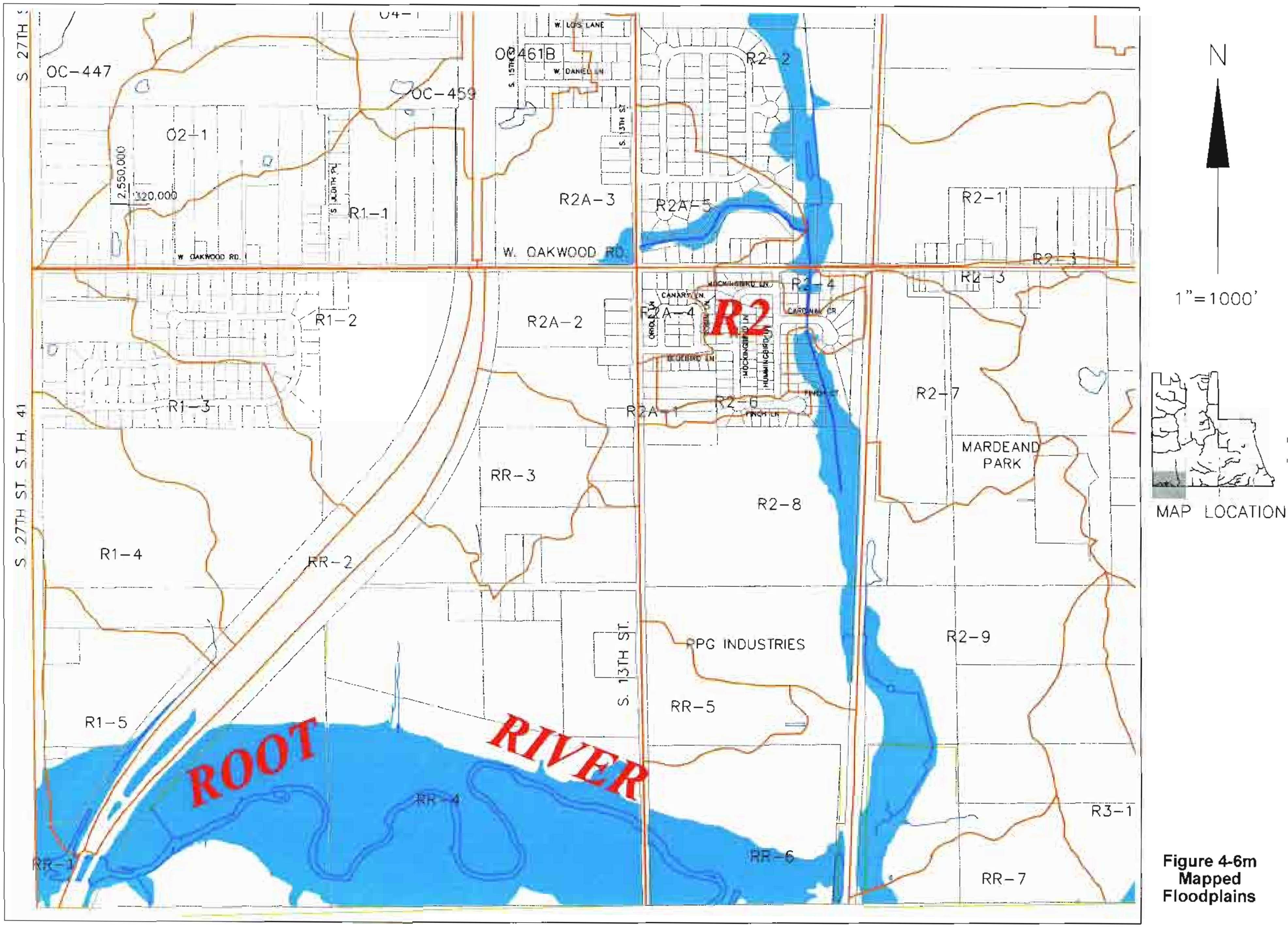


Figure 4-6m Mapped Floodplains

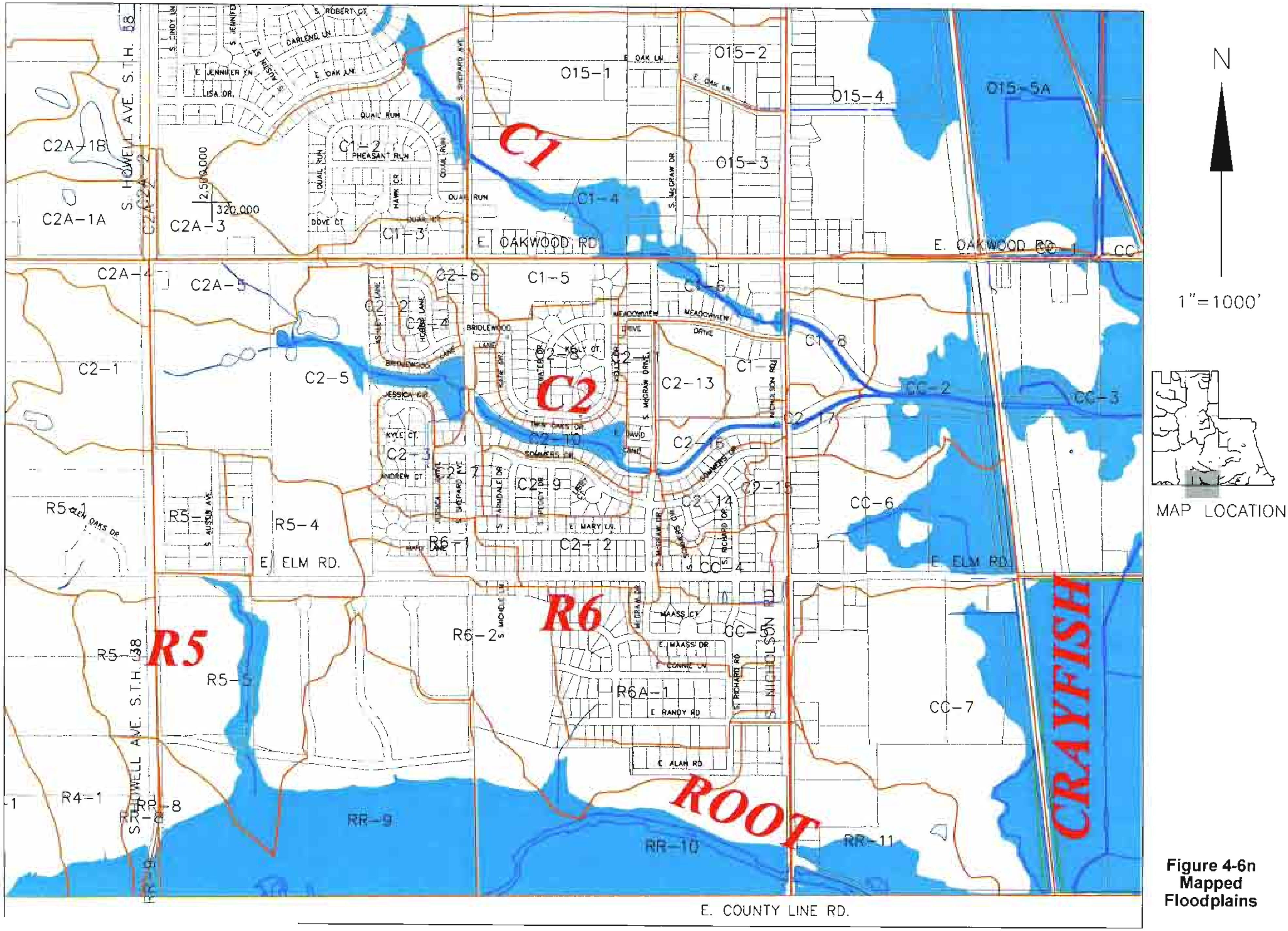


Figure 4-6n
Mapped
Floodplains

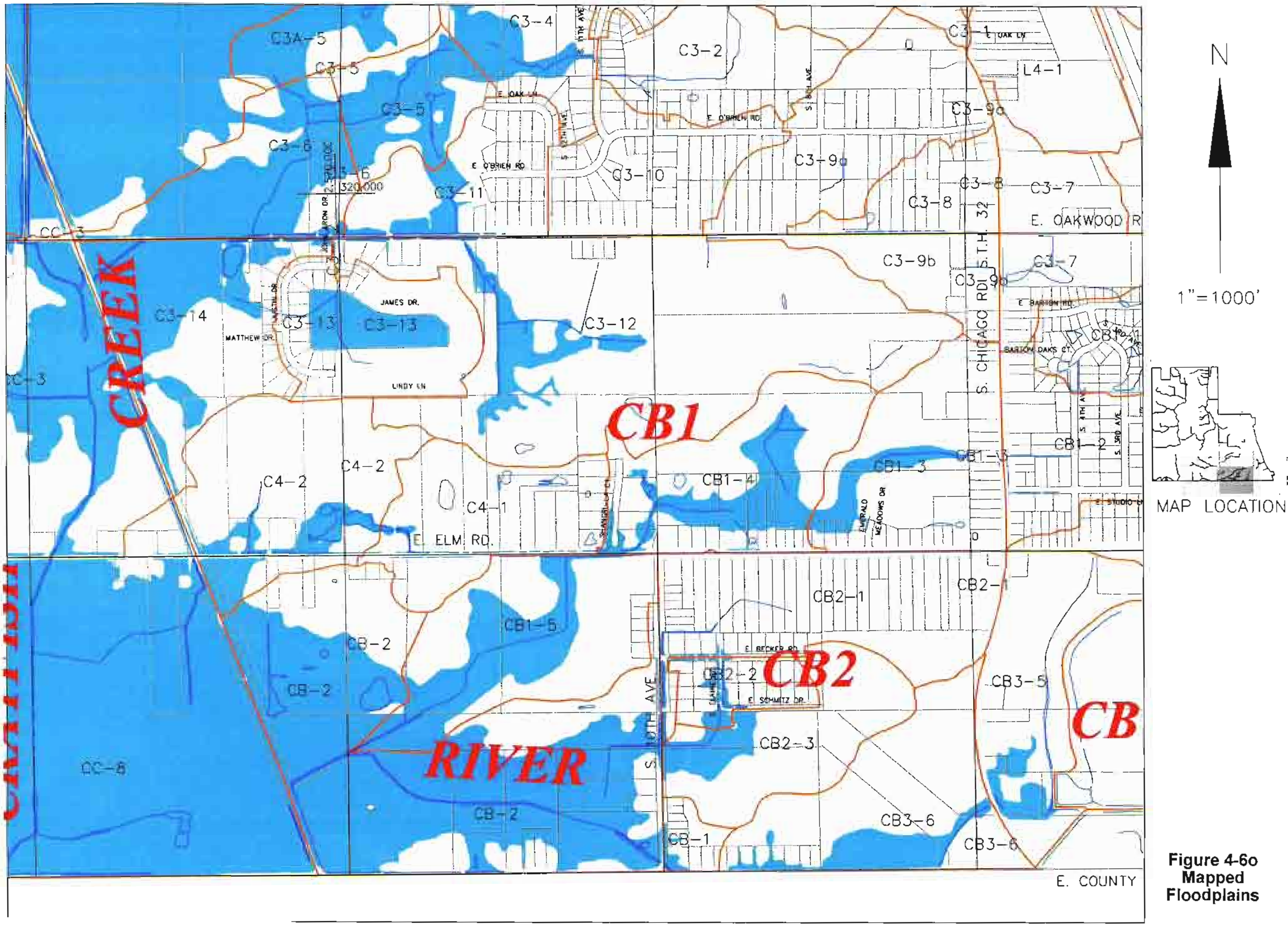


Figure 4-6o
Mapped
Floodplains

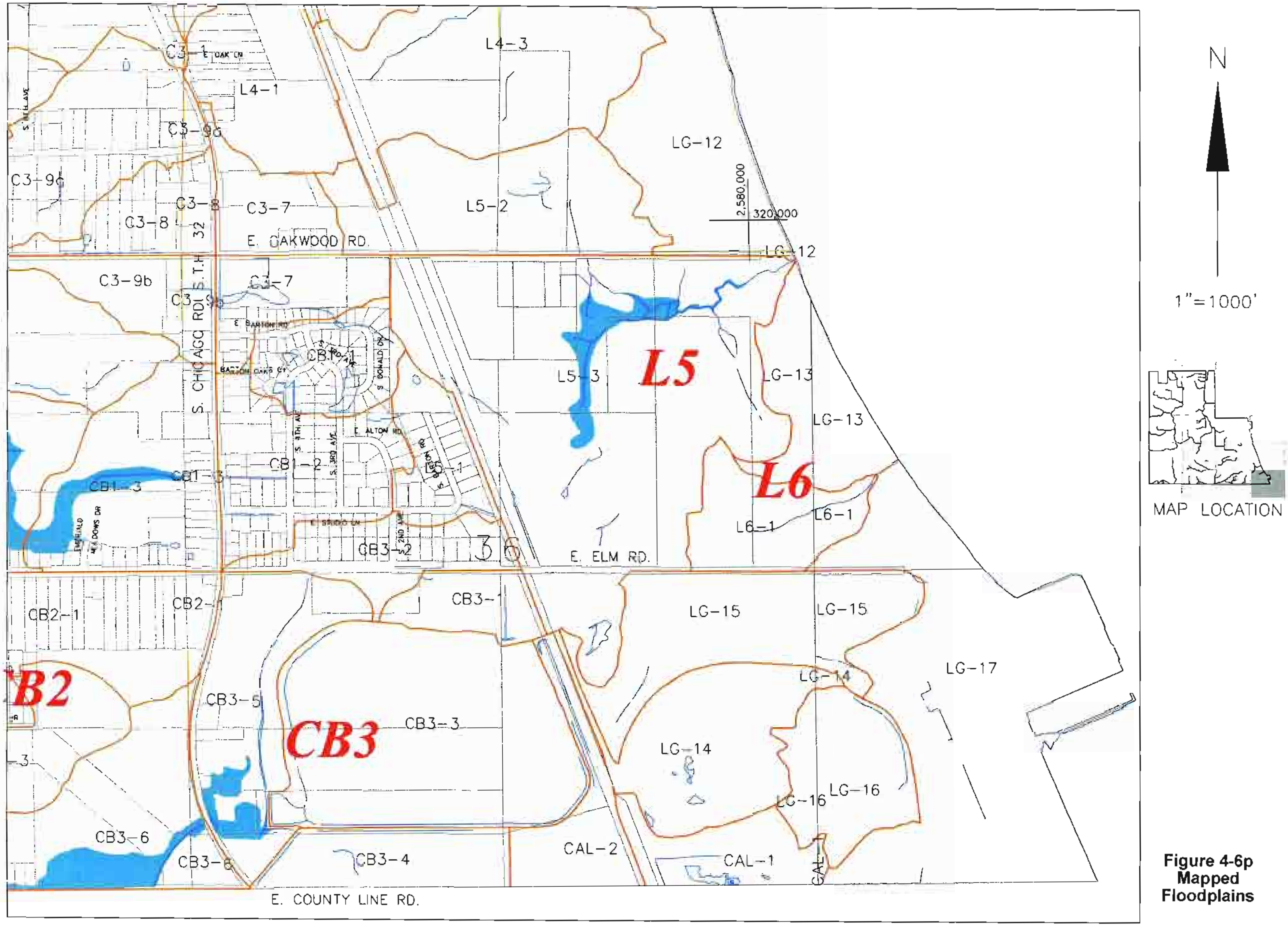
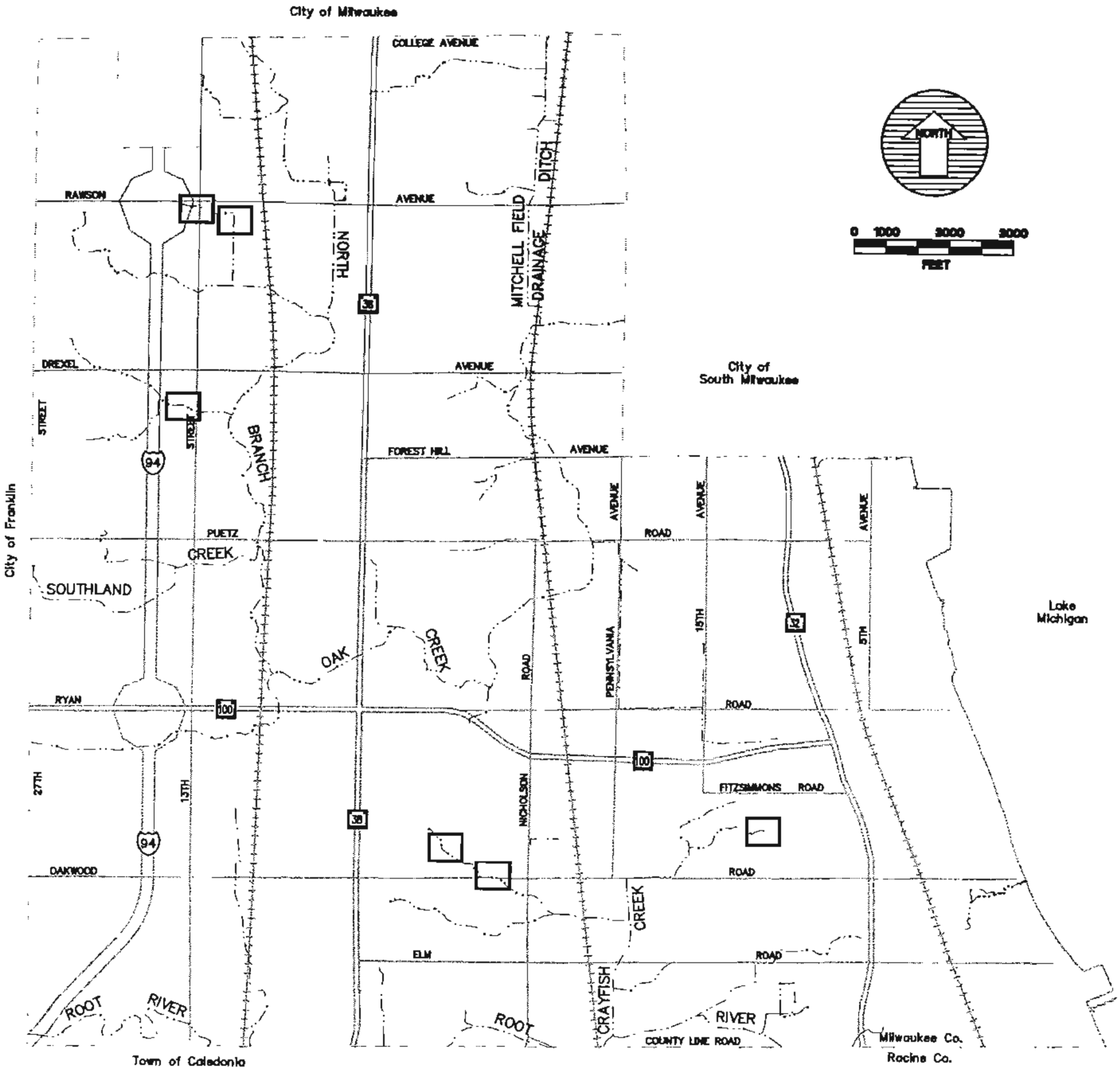


Figure 4-6p
Mapped
Floodplains

Figure 4-7
Flooding Problem Areas



Legend

☐ PROBLEM AREA IDENTIFIED BY FLOODPLAIN ANALYSIS

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Chapter 5

Water Quality Analysis

Introduction

As outlined in Chapter 2, a major goal of this stormwater management plan is to reduce the inputs of stormwater pollutants into Oak Creek, Root River and Lake Michigan. The first step in developing a management strategy for stormwater pollutants is to identify their sources on the landscape.

To identify the sources of stormwater pollutants being exported from the study area, the Source Loading and Management Model © (SLAMM) (Pitt, 1996) was used. For this analysis, Windows™ Version 7.0 of the model was used to estimate the export of total suspended solids (particulate solids), total phosphorus, particulate lead, particulate copper, and particulate zinc.

Analysis Description

As identified in Chapter 3, land use in the study area is a mixture of residential, industrial, commercial, highway, and wetland/undeveloped/open space. The City is currently 50% developed based on land cover. Land use was inventoried off of 1995 aerial photographs from the Southeastern Wisconsin Regional Planning Commission. Land covers such as roofs, streets, parking lot and landscaped surfaces were delineated from 1993 2-foot topographic maps provided by the City of Oak Creek. Declinations of surface covers were conducted in the GIS software ArcCADD. Pollutant exports were calculated for 579 subbasins delineated as part of the hydrologic analysis.

The SLAMM model was designed predominately for evaluation of urban land covers. The model has an agricultural land cover component, however, it does not evaluate individual field conditions. All agricultural land is analyzed under the same conditions; therefore the model does not allow evaluation of crop management activities or agricultural conservation practices. This analysis assumed that the pollutant loading contribution from any open water or wetland area was negligible. Therefore, these areas were deleted from the analysis. In addition, any undeveloped or floodplain land was input into the model as "undeveloped".

SLAMM Model

SLAMM calculates runoff volumes and urban pollutant loads from individual storms. For this analysis, an entire year of storms was input into the model to calculate an annual pollutant output. Analyses with the SLAMM model were made using historical precipitation data from 1983, collected in Milwaukee, Wisconsin as part of the National

Urban Runoff Project (NURP). The results of the modeling are summarized in Appendices – Volume 2, Appendix G of this report.

The SLAMM model breaks the analysis into three components. First, the model generates a runoff volume and pollutant loading from the particular land surface, such as a roof, street, or parking lot. The model then routes the water into the drainage control component. In this component, any treatment of the water in the drainage system is calculated. An example of the treatment in a drainage system would be the infiltration and filtering that would take place in a grass waterway. The third component of the modeling is called the outlet control option. Examples of outlet controls include wet detention ponds, infiltration basins, and wetlands. SLAMM can model wet detention ponds with the DETPOND module.

Drainage System Pollutant Reductions

The type of drainage system can affect the amount of pollutants being exported from a subbasin. In areas with efficient grass drainage systems, pollutants can be removed through the processes of water infiltration and filtering by the vegetation. In subbasins with grass swales, the pollutant reductions taking place were estimated using the SLAMM model. For areas with storm sewers, the SLAMM model assumes no pollutant removal, which has been documented in studies of urban runoff.

Modeling Results

For each subbasin, total pollutant loading and unit area loads were calculated. Total pollutant loading is the total amount of pollutants generated from a subbasin and represents the pounds delivered to the stream during the year of analysis. The results of the SLAMM Modeling are summarized on a subbasin basis in Appendices – Volume 2, Appendix G of this report. Table 5-1 summarizes the total pollutant loadings by pollutant.

Table 5-1 Summary of Estimated Pollutant Loadings from the City of Oak Creek

Pollutant	Loadings (pounds per year)
Total Suspended Solids	8,572,895
Total Phosphorus	15,663
Total Lead	15,625
Total Zinc	13,010
Total Copper	26,356

Figure 5-1 illustrates the areas of the City with various pollutant loadings on a unit area basis. Unit area loads represent the amount of pollution that is generated on a per-acre basis and identify those land surfaces generating the greatest concentration of pollutants. Generally, it is more cost effective to focus management alternatives on areas that generate the greatest concentration of pollution. This information will be used in Chapter 7 to target water quality treatment practices.

Figure 5-1
Nonpoint Source Pollution Loads - Total Suspended Solids

Legend

UNIT LOADING RATE

- 0–300 LB/AC/YR
- 300–560 LB/AC/YR
- 560–1700 LB/AC/YR
- OVER 1700 LB/AC/YR
- WATERSHED DRAINAGE BOUNDARY

NOTE: EACH CATEGORY REPRESENTS 25% OF THE TOTAL LOAD FROM THE CITY OF OAK CREEK

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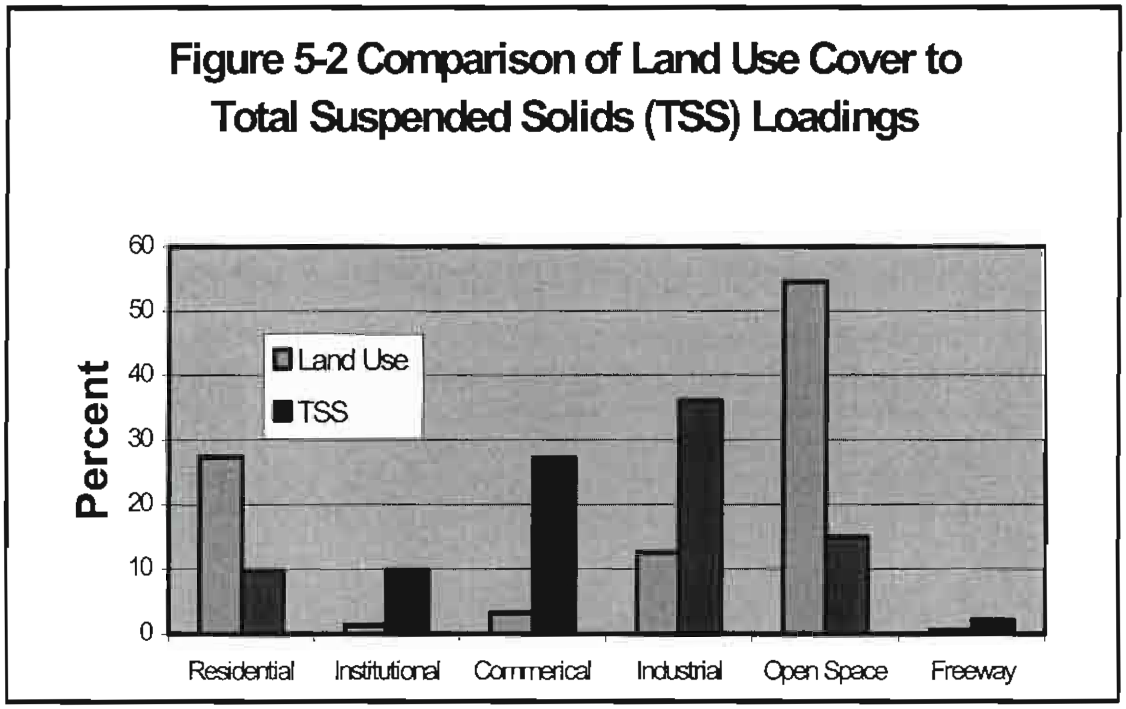
Figure 5-2 illustrates the comparison of percent land use to percent annual total suspended solids loadings. As can be seen, while commercial and industrial lands make up only 15.8% of the land cover, they contribute 63.3% of the pollution loadings.



Source: Hey and Associates, Inc.

A few observations regarding the SLAMM modeling should be noted. Many of the pollutant loading results appear to be on the high end of literature values published in the National Urban Runoff Project (NURP) and PLUARG studies sponsored by USEPA (Novotny and Olem, 1994). The SLAMM software appears to be calculating relatively high pollutant loadings for undeveloped/open space areas. Therefore, it is recommended that the modeling numbers be used on a relative basis when comparing alternatives and not used as actual loadings to the stream channels.

Chapter 6

Flooding and Drainage Alternatives and Recommendations

Introduction

Chapter 3 describes the City of Oak Creek in terms of natural features pertinent to stormwater planning and reported problem areas. Chapter 4 discusses the results of hydrologic and hydraulic analyses that were conducted to diagnose the behavior of the existing stormwater system and watershed response to hypothetical conditions, including future land development. Based on the understanding of the stormwater system and how it functions, this chapter presents solutions to identified problems. Problems were identified by City staff, citizens at public meetings, and by the hydrologic and hydraulic analyses and floodplain mapping as discussed in earlier chapters.

The management of flooding and drainage is a balance between two extremes, total storage of runoff without release using on-site detention and reservation of broad floodplains large enough to safely convey flood flows from future land use without on-site detention. The plan attempts to find a cost-effective balance between these two extremes, which protects property values, prevents flood damage, and protects water quality and aquatic ecology.

Guidelines

The process of planning and defining stormwater management and flood control facilities for the City of Oak Creek seeks to find the most cost-effective combination of implementable measures needed to achieve stated objectives. Guidelines provide the basis and give direction to the planning and design process. The following guidelines were used in this planning project to develop and evaluate alternatives:

1. Solutions to address flooding problems should be designed to store or convey runoff from the 100-year recurrence interval rainfall occurring under future land use conditions. System design must also include evaluation of interaction between detention components. A 100-year recurrence interval was selected based on the city's desire to have a system that would prevent major danger, damage, and disruption.

2. Minor drainage systems should be designed to handle runoff from a 10-year recurrence interval storm event. This design frequency is sufficient to address convenience needs and prevent nuisance problems.

3. Levees and dikes intended to remove buildings and other facilities from the 100-year floodplain shall be provided with at least three feet of freeboard.

4. Flooding problems should be resolved as close to the point of origin as possible and problems should not be shifted from one area to another. The right to develop land does not include the right to cause or aggravate off-site upstream or downstream stormwater problems. Potential adverse backwater effects of downstream increases in stormwater volume and discharge should be determined and quantified.

5. In areas undergoing development, the stormwater system should be planned and designed to generally conform to natural drainage patterns. This approach tends to minimize the capital costs of stormwater management, makes optimum use of natural storage and conveyance features, preserves open space, and protects surface water quality.

6. Gravity driven stormwater facilities are preferred to pumping facilities. Minimal use of electrical and mechanical controls is desirable. A simple gravity operated system reduces the likelihood of failure and minimizes initial construction costs and future operation and maintenance costs.

7. Runoff conforms to watershed divides and does not respect city boundaries. Therefore, stormwater planning and design must be done on the basis of the entire watershed. Implementation of recommended facilities may also require watershed-wide intergovernmental cooperation.

8. The aesthetic, recreational, and safety aspects of stormwater management alternatives should be evaluated because of the proximity of the potential facilties to residential neighborhoods.

Costs presented in this chapter were prepared based on the assumptions and unit construction and land costs presented in Appendix C. Legal fees, and financing costs are not included in the estimates. The final costs willvary from the preliminary estimates presented herein.

Alternatives

Alternative solutions were developed and evaluated to address the flooding and drainage problems reported by the City and citizens, and the flooding problems identified by the hydrologic-hydraulic analysis. Problems along streams under the jurisdiction of the MMSD are not addressed in this study. Solutions to all other problems were identified using three approaches, in order of preference: detention, conveyance, and protection. Detention alternatives considered on-site and regional detention arrangements. Conveyance solutions considered channel modifications, diversions, and storm sewers. Flood protection alternatives consisted of structure floodproofing, structure relocation, and levees.

On-site Detention

On-site detention applied throughout the upstream watershed may be a suitable solution for some problem areas. Although on-site detention is difficult to retrofit into existing developed areas, this alternative was considered where the potential for significant land development exists upstream of the problem area because it can be incorporated into new developments. On-site detention can be used to reduce runoff rates in varying degrees and can be easily combined with wetland or wet detention treatment to improve water quality. On-site detention facilities are usually off-line from the stream system. The outlet flow from on-site detention facilities may typically be less than 0.15cfs per acre of tributary drainage area.

Regional Detention

Detention facilities in specific locations may be used to reduce peak flows immediately upstream of areas with flooding problems. These facilities are typically much larger than an on-site detention facility and are designed to manage the runoff from an area larger than a single subdivision or land development. Regional detention facilities must be planned on a watershed-wide basis to avoid increases in downstream flows by changes in the timing of peak flows. A disadvantage of regional detention is the cost to convey peak flows safely to the basin.

Conveyance

Increased conveyance of floodwaters to prevent flooding may be accomplished with enlarged channel cross-sections, new channels or storm sewers, or diversion of flow. Such alternatives may be appropriate where upstream detention is not feasible, costly, or disruptive to the environment. Conveyance alternatives should be evaluated to avoid increasing downstream flood risk.

Flood Protection

In some situations, substantial changes to the stream system arenot feasible or cost effective. Site specific measures to protect individual structures from flood damages may be appropriate. These may include elevating the structure above flood stages, preventing entry of floodwaters, evacuating when flooding is imminent, modifications to minimize flood damages, and moving flood prone structures to higher ground.

Problem Specific Alternatives

Alternative solutions to reported flooding and drainage problems are presented below. The discussion is organized by the number assigned to the problem in Chapter 3 and shown on Figure 3-6. The problems identified in the hydrologic-hydraulic analysis are discussed in the subsequent section. Tributaries that do not have reported or identified problems are not discussed.

North Branch Oak Creek Watershed

Blocked Drainage at 6931 S. Howell Avenue – Problem 1

This drainage problem is at the confluence of Tributary N1 and the North Branch of Oak Creek. The problem area is on the east bank north of Rawson Avenue in the 100-year floodplain. The floodplain includes wetland and wooded areas. Wetlands have existed in portions of the area for several decades, based on 1976 and 1961 topographic mapping. Remnants of ditches are evident, but trees have grown and some of the ditches have been closed off. The 100-year flood stage on the North Branch covers much of the area. Additional floodplain is caused by backwater at the culvert that crosses Tributary N1 immediately upstream of its confluence with the North Branch.

Conveyance alternatives to relieve the drainage problem may be used if the area is not a regulated wetland. Areas which are not wetlands may be drained by clearing existing ditches of trees and other obstructions or adding drain tile lines or additional ditches. The boundaries of wetlands in the area should be delineated prior to initiating any drainage modifications. Drainage changes are the responsibility of the property owners.

Flooding at S. 13th Street to Pelton Drive – Problem 2

The Tributary N2 watershed is fully developed in the City of Milwaukee and nearly developed in the City of Oak Creek. Remaining development is downstream of the flooding problem areas. Therefore, flood flows cannot be reduced through detention controls on future development. The 2-year frequency storm causes overtopping at Pelton Drive, but elsewhere is within the existing channel. Larger storms cause flooding at Pelton Drive and west of S. 13th Street and affect four existing commercial buildings.

Regional Detention Alternative

Limiting flow at S.13th Street to the 2-year frequency flow rate or less would minimize the flooding problem. Two possible detention sites exist upstream of 13th Street, as shown on Figure 6-1. The southeast quadrant of the College Avenue and IH-94 interchange could be used to detain flows from the north. The land west of the Ramada Inn could be used to detain flows from the west. These two sites have a combined area of 11 acres and would provide up to 45 acre-feet of storage. Both sites would be required to avoid roadway overtopping during 10-year frequency events and to minimize flood depths on streets during 100-year frequency events.

The Pelton Drive crossing would need to be enlarged with an additional culvert pipe to provide capacity for the 2-year frequency flow under this alternative. This alternative would cost $940,000 to construct and approximately $165,000 for land. Cooperation of the Department of Transportation would be required for the detention in the interchange and land acquisition or easement would be required for the land west of Ramada. Both detention sites are in the City of Milwaukee.

Chapter 6

Flooding and Drainage Alternatives and Recommendations

Introduction

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1. Solutions to address flooding problems should be designed to store or convey runoff from the 100-year recurrence interval rainfall occurring under future land use conditions. System design must also include evaluation of interaction between detention components. A 100-year recurrence interval was selected based on the city's desire to have a system that would prevent major danger, damage, and disruption.

2. Minor drainage systems should be designed to handle runoff from a 10-year recurrence interval storm event. This design frequency is sufficient to address convenience needs and prevent nuisance problems.

3. Levees and dikes intended to remove buildings and other facilities from the 100-year floodplain shall be provided with at least three feet of freeboard.

4. Flooding problems should be resolved as close to the point of origin as possible and problems should not be shifted from one area to another. The right to develop land does not include the right to cause or aggravate off-site upstream or downstream stormwater problems. Potential adverse backwater effects of downstream increases in stormwater volume and discharge should be determined and quantified.

5. In areas undergoing development, the stormwater system should be planned and designed to generally conform to natural drainage patterns. This approach tends to minimize the capital costs of stormwater management, makes optimum use of natural storage and conveyance features, preserves open space, and protects surface water quality.

6. Gravity driven stormwater facilities are preferred to pumping facilities. Minimal use of electrical and mechanical controls is desirable. A simple gravity operated system reduces the likelihood of failure and minimizes initial construction costs and future operation and maintenance costs.

7. Runoff conforms to watershed divides and does not respect city boundaries. Therefore, stormwater planning and design must be done on the basis of the entire watershed. Implementation of recommended facilities may also require watershed-wide intergovernmental cooperation.

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Alternative solutions were developed and evaluated to address the flooding and drainage problems reported by the City and citizens, and the flooding problems identified by the hydrologic-hydraulic analysis. Problems along streams under the jurisdiction of the MMSD are not addressed in this study. Solutions to all other problems were identified using three approaches, in order of preference: detention, conveyance, and protection. Detention alternatives considered on-site and regional detention arrangements. Conveyance solutions considered channel modifications, diversions, and storm sewers. Flood protection alternatives consisted of structure floodproofing, structure relocation, and levees.

On-site Detention

On-site detention applied throughout the upstream watershed may be a suitable solution for some problem areas. Although on-site detention is difficult to retrofit into existing developed areas, this alternative was considered where the potential for significant land development exists upstream of the problem area because it can be incorporated into new developments. On-site detention can be used to reduce runoff rates in varying degrees and can be easily combined with wetland or wet detention treatment to improve water quality. On-site detention facilities are usually off-line from the stream system. The outlet flow from on-site detention facilities may typically be less than 0.15 cfs per acre of tributary drainage area.

Regional Detention

Detention facilities in specific locations may be used to reduce peak flows immediately upstream of areas with flooding problems. These facilities are typically much larger than an on-site detention facility and are designed to manage the runoff from an area larger than a single subdivision or land development. Regional detention facilities must be planned on a watershed-wide basis to avoid increases in downstream flows by changes in the timing of peak flows. A disadvantage of regional detention is the cost to convey peak flows safely to the basin.

Conveyance

Increased conveyance of floodwaters to prevent flooding may be accomplished with enlarged channel cross-sections, new channels or storm sewers, or diversion of flow. Such alternatives may be appropriate where upstream detention is not feasible, costly, or disruptive to the environment. Conveyance alternatives should be evaluated to avoid increasing downstream flood risk.

Flood Protection

In some situations, substantial changes to the stream system are not feasible or cost effective. Site specific measures to protect individual structures from flood damages may be appropriate. These may include elevating the structure above flood stages, preventing entry of floodwaters, evacuating when flooding is imminent, modifications to minimize flood damages, and moving flood prone structures to higher ground.

Problem Specific Alternatives

Alternative solutions to reported flooding and drainage problems are presented below. The discussion is organized by the number assigned to the problem in Chapter 3 and shown on Figure 3-6. The problems identified in the hydrologic-hydraulic analysis are discussed in the subsequent section. Tributaries that do not have reported or identified problems are not discussed.

North Branch Oak Creek Watershed

Blocked Drainage at 6931 S. Howell Avenue – Problem 1

This drainage problem is at the confluence of Tributary N1 and the North Branch of Oak Creek. The problem area is on the east bank north of Rawson Avenue in the 100-year floodplain. The floodplain includes wetland and wooded areas. Wetlands have existed in portions of the area for several decades, based on 1976 and 1961 topographic mapping. Remnants of ditches are evident, but trees have grown and some of the ditches have been closed off. The 100-year flood stage on the North Branch covers much of the area. Additional floodplain is caused by backwater at the culvert that crosses Tributary N1 immediately upstream of its confluence with the North Branch.

Conveyance alternatives to relieve the drainage problem may be used if the area is not a regulated wetland. Areas which are not wetlands may be drained by clearing existing ditches of trees and other obstructions or adding drain tile lines or additional ditches. The boundaries of wetlands in the area should be delineated prior to initiating any drainage modifications. Drainage changes are the responsibility of the property owners.

Flooding at S. 13th Street to Pelton Drive – Problem 2

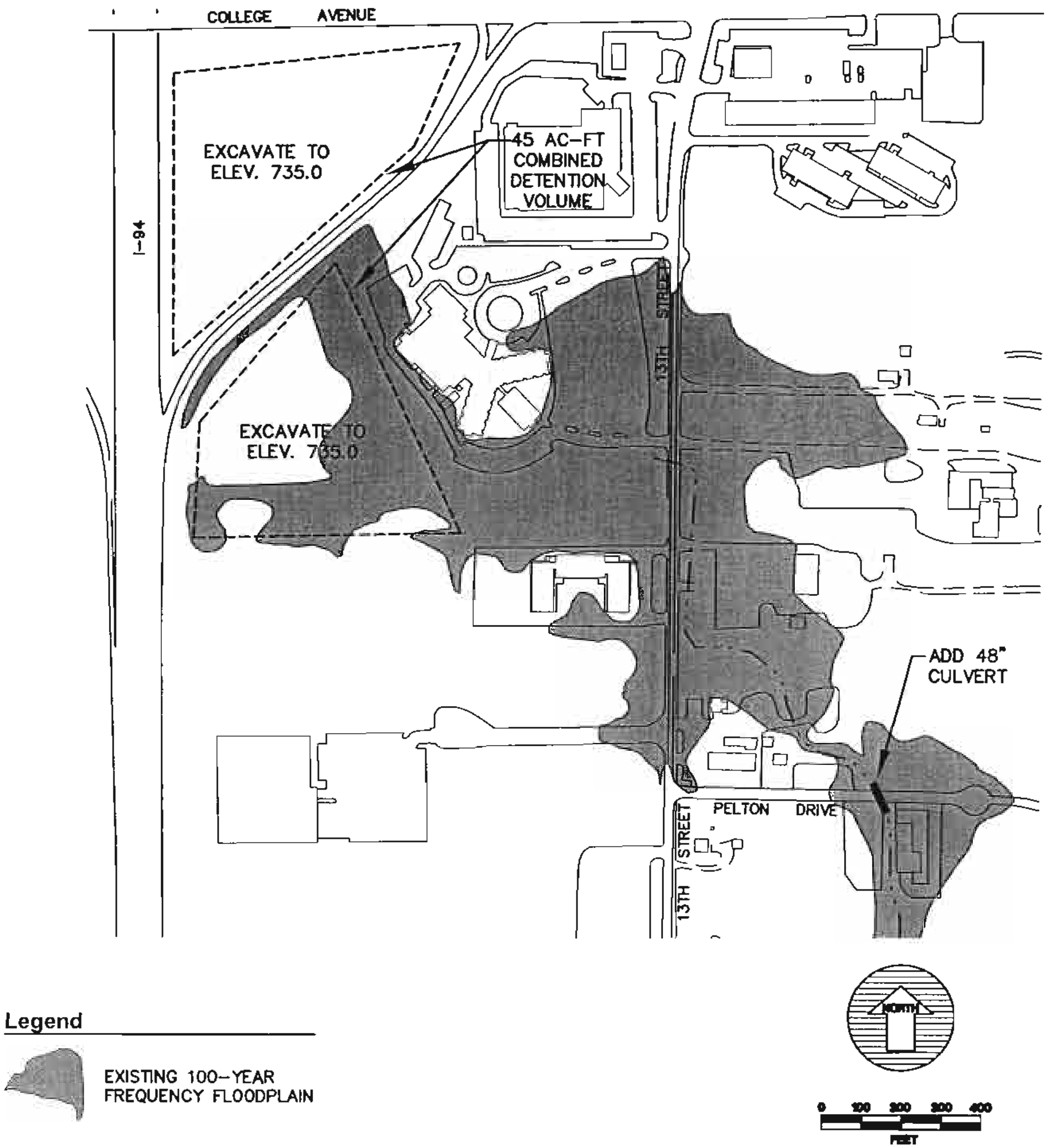
The Tributary N2 watershed is fully developed in the City of Milwaukee and nearly developed in the City of Oak Creek. Remaining development is downstream of the flooding problem areas. Therefore, flood flows cannot be reduced through detention controls on future development. The 2-year frequency storm causes overtopping at Pelton Drive, but elsewhere is within the existing channel. Larger storms cause flooding at Pelton Drive and west of S. 13th Street and affect four existing commercial buildings.

Regional Detention Alternative

Limiting flow at S.13th Street to the 2-year frequency flow rate or less would minimize the flooding problem. Two possible detention sites exist upstream of 13th Street, as shown on Figure 6-1. The southeast quadrant of the College Avenue and IH-94 interchange could be used to detain flows from the north. The land west of the Ramada Inn could be used to detain flows from the west. These two sites have a combined area of 11 acres and would provide up to 45 acre-feet of storage. Both sites would be required to avoid roadway overtopping during 10-year frequency events and to minimize flood depths on streets during 100-year frequency events.

The Pelton Drive crossing would need to be enlarged with an additional culvert pipe to provide capacity for the 2-year frequency flow under this alternative. This alternative would cost $940,000 to construct and approximately $165,000 for land. Cooperation of the Department of Transportation would be required for the detention in the interchange and land acquisition or easement would be required for the land west of Ramada. Both detention sites are in the City of Milwaukee.

Figure 6-1
Tributary N2 - Problem 2
Detention Alternative (Recommended)



Conveyance Alternative

Improving the conveyance system from S. 13th Street downstream to the railroad could mitigate flooding problems. As shown on Figure 6-2, this alternative would consist of widening and deepening the channel and replacing culverts at S. 13th Street, three private drives, and Pelton Drive. Replacement culverts would be the equivalent of concrete box culverts approximately 10 feet wide by 5 feet high. Approximately 1000 feet of channel upstream of Pelton Drive would be lowered as much as one foot and approximately 1500 feet of channel downstream of Pelton Drive would be lowered as much as two feet. The channel top width would be approximately 50 feet or less with a bottom width of 8 feet and 3 horizontal to 1 vertical sideslopes. The channel would be turf with a natural low flow channel within the bottom. Acquisition or easements would be required for 3 acres from Pelton Drive to S. 13th Street. This alternative would cost $1,215,000 to construct and approximately $45,000 for land.

Flooding at S. 20th Street and Drexel Avenue - Problem 3

Flooding occurs on Tributary N7 at the Drexel Avenue and S. 20th Street crossings because the roads are low relative to downstream flood elevations. The stream channel controls the downstream flood elevations for 10-year frequency and smaller storm events. The first downstream private driveway crossing about 550 feet east of S. 20th Street controls flood stages in larger events. During a 100-year frequency event, the driveway causes backwater approximately two feet above Drexel Avenue and S. 20th Street, and creates substantial detention storage north of Drexel Avenue (in Falk Park) and southwest of the intersection of Drexel Avenue and S. 20th Street.

If roadway overtopping during events larger than the 10-year frequency is not tolerable, the solution must address the downstream driveway crossing. Because these are collector streets that could be flooded during severe events, alternatives for the 10-year frequency event are presented.

On-Site Detention Alternative

Upstream of 20th Street the watershed has approximately 105 acres of land, or 34 percent of the tributary area, available for development. On-site detention is not feasible because the amount of developable land in the upstream watershed is insufficient to effect a reduction in the downstream flows. With zero runoff from the developable land, the 10-year frequency flow at the problem area is still three times the available capacity.

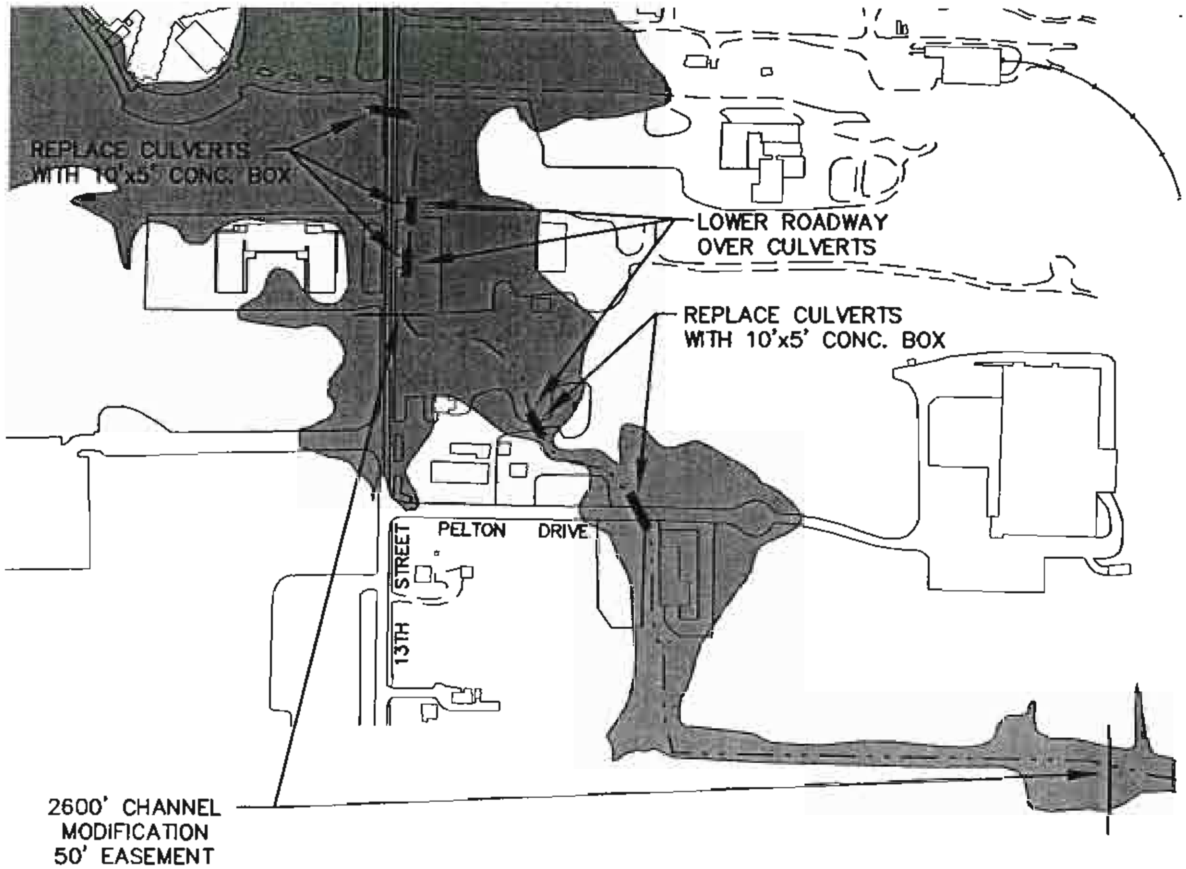
Regional Detention Alternative

To mitigate flooding of Drexel Avenue and S. 20th Street with only detention would require sufficient storage upstream of Drexel Avenue to reduce the flow to about 60cfs. This degree of detention would require substantial excavation in Falk Park and is not considered practicable.

Conveyance Alternative

Adding culverts at Drexel Avenue and at S. 20th Street would not reduce road overtopping unless the capacity of the downstream private driveway crossing would also be increased. Enlarging the driveway culvert would increase the downstream flows for events greater than the 10-year and worsen downstream flooding. Substantial volumes of natural detention storage exist upstream of Drexel Avenue and upstream of S. 20th Street. These storage areas reduce the downstream flows and should be retained. The private driveway and culvert should be maintained in place through an easement or other mechanism.

Figure 6-2
Tributary N2 - Problem 2
Conveyance Alternative



Legend

EXISTING 100-YEAR FREQUENCY FLOODPLAIN

NORTH

0 100 200 300 400
FEET

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Flood Protection Alternative

Raising Drexel Avenue and S. 20th Street to elevation 715.0 would prevent road overtopping during 10-year frequency storm events and decrease the depth over the road for the 100-year event to about 0.5 foot. Downstream flows would not increase during the 100-year frequency event. Additional culverts under Drexel Avenue west of S. 20th Street would be required to equalize the natural detention storage on the north and south sides of the street. The 100-year frequency flood elevations are a result of backwater from the downstream private drive and would not be changed significantly. As shown on Figure 6-3, approximately 800 feet of Drexel Avenue and 200 feet of S. 20th Street would be raised. The private driveway and culvert should be maintained in place through an easement or other mechanism. The estimated total construction cost of this alternative is $201,000 and $10,000 for easements..

Lack of Easement at 7538 S. 13th Street - Problem 4

Tributary N5 crosses this property after flowing in an east-northeasterly direction from the culvert beneath S. 13th Street. The stream is approximately 70 feet outside of the drainage easement boundaries for a distance of approximately 250 feet. The floodplain boundaries extend beyond the existing drainage easement.

To allow the City access to maintain the stream, the easement boundaries should be revised to coincide with the actual stream location.

An alternative would be to relocate the stream to be within the easement. This would require that the culvert crossing S. 13th Street be relocated approximately 200 feet north. The stream would have to be relocated similarly on the west side of S. 13th Street to match the culvert location. Milwaukee County is designing a replacement for this culvert. This alternative was suggested by the City and rejected by the property owner.

Storm Sewer at Marquette Avenue – Problem 5

The outlet pipes of storm sewer systems 8-7 and 8-8 are approximately 0.3 feet below the streambed at this location. The capacity analysis indicates that the systems have sufficient capacity to convey 10-year recurrence interval flows. The analysis assumes that the outlet pipes are clear of sediment and debris. Therefore, periodic maintenance is necessary to ensure that the predicted capacity is available.

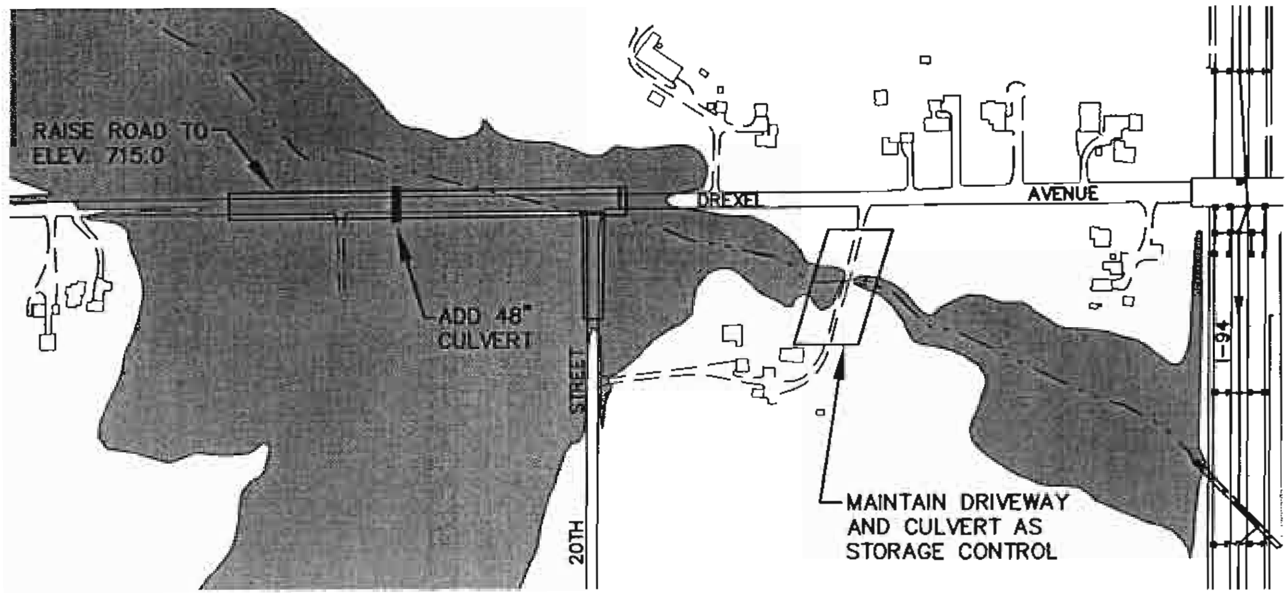
Storm Sewer at Wildwood Drive - Problem 6

The outlet pipe of storm sewer system 17-2 is approximately 0.2 feet below the streambed between Drexel Avenue and Wildwood Drive. The capacity analysis indicates that the storm sewer system has sufficient capacity to convey the peak 10-year recurrence interval flow without surcharging. The analysis assumes that the outlet pipes are clear of sediment and debris. Therefore, periodic maintenance is necessary to ensure that the predicted capacity is available.

Street flooding in 2000 Block of W. Puetz Road – Problem 7

The City addressed flooding over W. Puetz Road in 1998 by installing a 57" x 38" culvert, in addition to the existing 42" x 29" culvert, and raising the road 0.5 feet. In addition, a detention facility was constructed immediately upstream in conjunction with the Apple Creek Subdivision.

Figure 6-3
Tributary N7 - Problem 3
Flood Protection Alternative (Recommended)



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Mitchell Field Drainage Ditch Watershed

Sewer surcharging at 7289 S. Quincy Avenue – Problem 8

Runoff from the agricultural field west of S. Quincy Avenue reportedly surcharges storm sewer system 9-1. The capacity analysis indicates that the storm sewer system has sufficient capacity to convey 10-year recurrence interval flows without surcharging at the manholes. Surcharging may occur at the yard inlets along the sewer. Runoff from the agricultural field may not be adequately directed into the storm sewer and therefore flow into the backyards. There does not appear to be either an easement or a defined overflow route west of Quincy Avenue for flows that exceed the storm sewer capacity. The City should obtain an easement for the storm sewer.

Alternative solutions would be increasing the size of the storm sewer system, grading an overflow swale, or upstream detention to reduce the peak flows. With any alternative, grading to create a diversion berm or swale along the east border of the field is recommended to direct runoff to the storm sewer.

Regional Detention Alternative

A detention basin could be constructed west of the inlet, possibly as part of future land development activities. The detention facility design should also address overflow during storms larger than the design frequency. Detention would provide the additional benefit of reduced peak flows downstream into storm sewer system 9-2. This alternative would cost approximately $50,000 to construct and acquisition of approximately 2 acres of land would be required at a cost of $30,000.

Conveyance Alternatives

Enlarging the storm sewer would require replacing approximately 900 feet of pipe from the inlet, west of S. Quincy Avenue to the outlet at S. Shepard Avenue. This alternative would cost $545,000 to construct.

Constructing an overflow swale between the houses west of Quincy Avenue would direct excess runoff to the street where it would flow south and east. The grading for a swale would alter the landscape of two developed lots. This alternative would cost $21,000 to construct and would require a 30-foot wide easement. The $1,500 easement would cover the existing storm sewer and the overflow swale.

Basement flooding at 7152 S. Taylor Avenue – Problem 9

The drainage system in the problem area consists of roadside ditches and culverts beneath driveways and roads. The problem area is at the low point in the street on the southeast corner of S. Taylor Avenue and E. Missouri Avenue. The ditch does not have an adequate outlet to the north or to the west. The natural drainage route from the corner is toward the southeast.

Detention Alternative

A detention facility at the west end of Missouri Avenue to control runoff from the agricultural field may benefit the problem area. However, it would address less than half of the tributary drainage area and would not be expected to solve the problem. Detention is not a feasible alternative for this problem.

Conveyance Alternative

Constructing a swale toward the southeast along the property line would accommodate runoff in the natural flow direction. There is sufficient elevation difference to drain the roadside ditch toward the rear lot line over a distance of less than 200 feet. The swale would be 2 to 3 feet deep and would require an easement. This altemative would cost $14,000 to construct and an easement at a cost of approximately $2,000.

Oak Creek - Main Stem Watershed

Storm Sewer at E. Puetz and Pennsylvania Avenue – Problem 10

The outlet pipes of storm sewer systems 15-5 and 15-6 are reported to be below the streambed. Based on the available information, the outlet pipes are more than 1 foot above the Oak Creek streambed at this location. The capacity analysis indicates that the systems have sufficient capacity to convey 10-year recurrence interval flows. The analysis assumes that the outlet pipes are clear of sediment and debris. Therefore, periodic maintenance is necessary to ensure that the predicted capacity is available.

Blocked Drainage at 1020 E. Forest Hill Avenue – Problem 11

The driveway culvert discharges to a low area that is higher than the Oak Creek Tributary O19A floodplain. The low area appears to be formed by a natural depression and swale.

Conveyance alternatives to relieve the drainage problem may be used if the area is not a regulated wetland. Areas that are not wetlands may be drained by adding drain tile lines or additional ditches. Drainage changes are the responsibility of the property owners.

Road Flooding at 700 W. Ryan Road (STH 100) – Problem 12

The railroad underpass is subject to frequent flooding. The underpass is drained by a storm sewer system to the Oak Creek. High stages on the creek prevent drainage from the underpass. Creek waters also backup through the storm sewer and cause prolonged flooding of Ryan Road as long as the creek stages are high. The low point in Ryan Road is approximately 3 feet below the 10-year frequency flood stage and 4 feet below the 100-year frequency flood stage on the creek.

Detention Alternative

The capacity of the pumping station could be reduced if the stormwater was routed to a detention basin prior to pumping. However, such a detention basin would have to be lower than the road and would require substantial overburden excavation to achieve storage at this low elevation. The land requirement and the excavation requirement make this altemative infeasible.

Conveyance Alternative

To mitigate the problem it would be necessary to disconnect the storm sewer system from the creek. This would require a pumping station on the storm sewer to lift stormwater into the creek. The 73-acre drainage area to the underpass would require a pumping station with a capacity of approximately 50cfs to handle a 10-year frequency storm event without flooding. During less frequent, more severe, storm events, short-duration temporary flooding of the underpass would be expected to continue to occur. This alternative would cost $733,000 to construct. There would also be significant operation and maintenance costs. Resolution of this problem must involve the Wisconsin Department of Transportation.

Note: After preparation and review of the draft report, MMSD initiated design and construction of the conveyance alternative to address the road flooding problem on Ryan Road.

Flooding in Stonegate Estates, south of E. Puetz Road – Problem 13

Several houses and a portion of Stonegate Drive along Tributary O19A are subject to flooding caused by limited downstream culvert capacity and the lack of an overflow route. The existing culverts and roadside ditch along the north side of Puetz Road are adequate for 2-year frequency flows. Larger storms cause driveway overtopping and the elevation of Puetz Road causes flooding in the Stonegate subdivision.

Detention Alternatives

The upstream watershed is fully developed and there are no sites to construct detention facilities with sufficient storage capacity upstream of the problem area.

Conveyance Alternative

As shown on Figure 6-4, additional conveyance could be provided along the south side of Puetz Road for major storms. This alternative would consist of removing the culvert crossing south of Puetz Road and grading the abandoned railroad right-of-way embankment to allow flow toward the east along the south side of Puetz Road. The low area south of Puetz Road would convey flow toward Nicholson Road. Approximately 400 feet of Puetz Road would be lowered to allow flow over the road to the north during major storms. A new culvert beneath Puetz Road would drain the overflow route south of Puetz Road. An easement would have to be obtained from Milwaukee County for crossing the abandoned railroad right-of-way where a bike trail is being planned. This alternative would cost $299,000 to construct, and approximately $5,000 for land easements.

Storm Sewer at Parkway Estates and Oak View Lane – Problem 14

The outlet pipe of storm sewer system 21-9 is reported to be below the streambed. Based on the available information, the outlet pipe is approximately 0.9 feet above the streambed. The capacity analysis indicates that the storm sewer system has sufficient capacity to convey the peak 10-year recurrence interval flow without surcharging. The analysis assumes that the outlet pipes are clear of sediment and debris. Therefore, periodic maintenance is necessary to ensure that the predicted capacity is available.

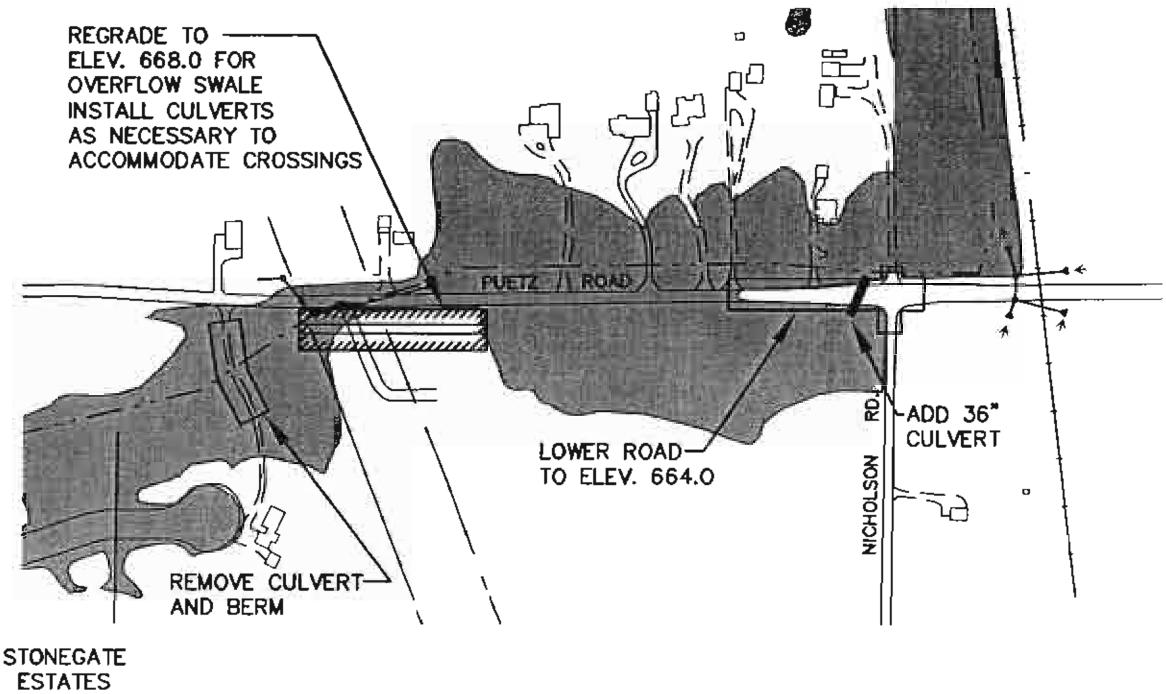
Flooding at 9000 S. Pennsylvania Avenue – Problem 15

Road flooding along Tributary O16 will be mitigated by reconstruction of the road in 2000. The City intends to consolidate the drainage ditches to the west side of the road. The ditch along the east side of the road would be eliminated. Cross culverts would be placed at the locations of swales on the east side of the road. This design was evaluated in the hydrologic-hydraulic analysis and found to be adequate to address drainage needs and minimize road flooding.

Flooding of S. 15th Avenue north of E. Ryan Road – Problem 16

Development of Hidden Ponds subdivision reportedly increased the flow in Tributary O17 along S.15th Avenue, causing road flooding, washed out driveway culverts, and safety concerns. The City designed and constructed a detention facility to mitigate the problems. This design was evaluated in the hydrologic-hydraulic analysis. With the detention basin, the peak flows reaching S.15th Avenue are approximately 65 percent of the flows without the detention. However, the ditch and culverts along S.15th Avenue are insufficient to carry the projected 2-year frequency flows.

Figure 6-4
Tributary O19A - Problem 13
Conveyance Alternative (Recommended)



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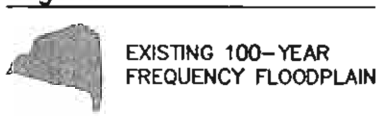

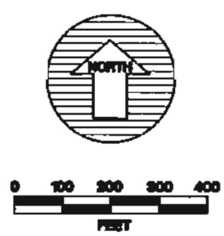

Additional conveyance capacity is needed to supplement the detention at Hidden Ponds subdivision. As shown on Figure 6-5, four additional culverts north of Woodview Avenue with diversion swales would direct stormwater flow toward the west. Approximately 1 acre for drainage easements would be needed. This alternative would cost $203,000 to construct and $15,000 in land costs.

Drainage at Puetz Road and Nicholson Road – Problem 17

This problem is caused by the lack of depth in the ditch between Puetz Road and the Oak Creek along the west side of the railroad, east of Nicholson Road. Lowering the ditch bottom would not be expected to lower the flood stages along this tributary. Backwater from the E. Forest Hill Avenue crossing extends upstream to Puetz Road. The E. Forest Hill Avenue culvert has capacity for the 10-year frequency flows without overtopping.

Conveyance Alternative A

The culverts along E. Puetz Road and at E. Forest Hill Avenue are approximately two feet lower than the ditch elevation. Apparently there is an underground utility cable that has prevented the ditch from being lowered. Lowering the ditch bottom approximately 2.5 feet along the 2750-foot long route from Puetz Road north to Forest Hill Avenue, as shown on Figure 6-6, would mitigate the poor drainage problem. This ditch appears to be within the railroad right-of-way and approval from the railroad would be required. This alternative would cost $384,000 to construct, excluding unusual utility relocation costs. Land costs would be approximately $48,000 for 3.2 acres.

The utilities in conflict with lowering the ditch bottom should be specifically identified and utility relocation alternatives should be evaluated during the preliminary engineering design. If deepening the existing ditch is not permitted by the railroad, a new channel in a new easement on adjacent properties would be required at a much greater construction cost.

Conveyance Alternative B

An alternative outlet from the intersection of E. Puetz Road and S. Nicholson Road would be toward the east rather than to the north as shown on Figure 6-6. An east outlet would be a shorter distance to the Oak Creek, by approximately 1400 feet. Although the flood stages in the creek at E. Puetz Road are approximately 0.8 feet higher than at the existing outlet north of E. Forest Hill Avenue, this would be offset by a shorter channel and larger culvert. The east route would require a new culvert beneath the railroad and a channel along the north side of Puetz Road. Railroad approval for a new pipe crossing would be required. There are no permanent driveways or structures in the route. The utility cable discussed above may also influence this alternative. This alternative would cost $383,000 to construct, excluding unusual utility relocation costs. Land costs would be $23,000 for approximately 1.5 acres.

Storm Sewer in S. 11th Avenue south of E. Puetz Road – Problem 18

The west ditch along S. 11th Avenue has been enclosed over time with 21-inch diameter corrugated metal pipes causing local flooding, especially near E. Puetz Rd. The City has considered replacing this system with a 54" sewer.

Conveyance Alternative

The capacity analysis indicates that the proposed 54-inch diameter storm sewer system would have sufficient capacity to convey the peak 10-year recurrence interval flows without surcharging. This conveyance alternative would cost $500,000 to construct.

Figure 6-5
Tributary O17 - Problem 16
Conveyance Alternative (Recommended)

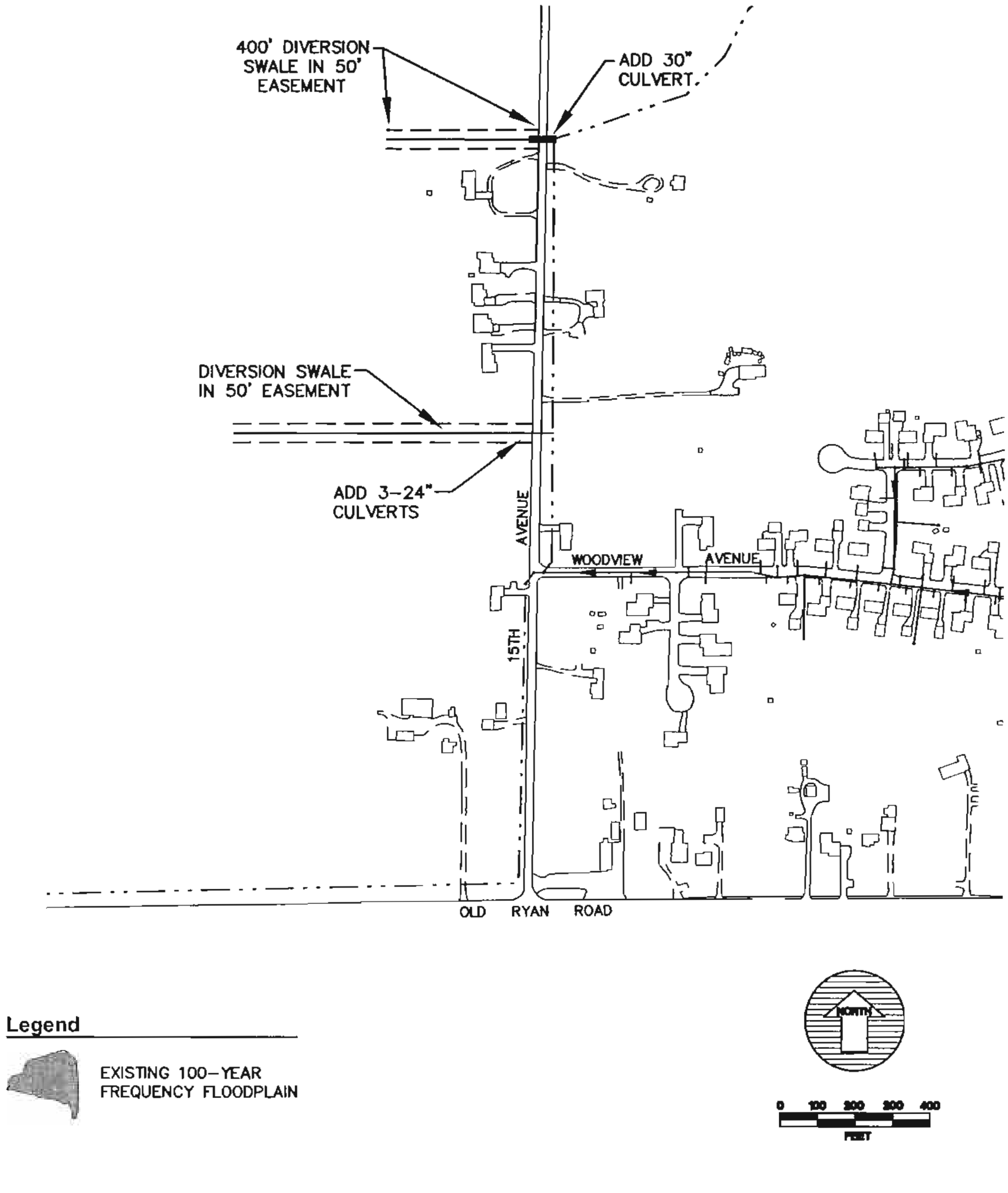

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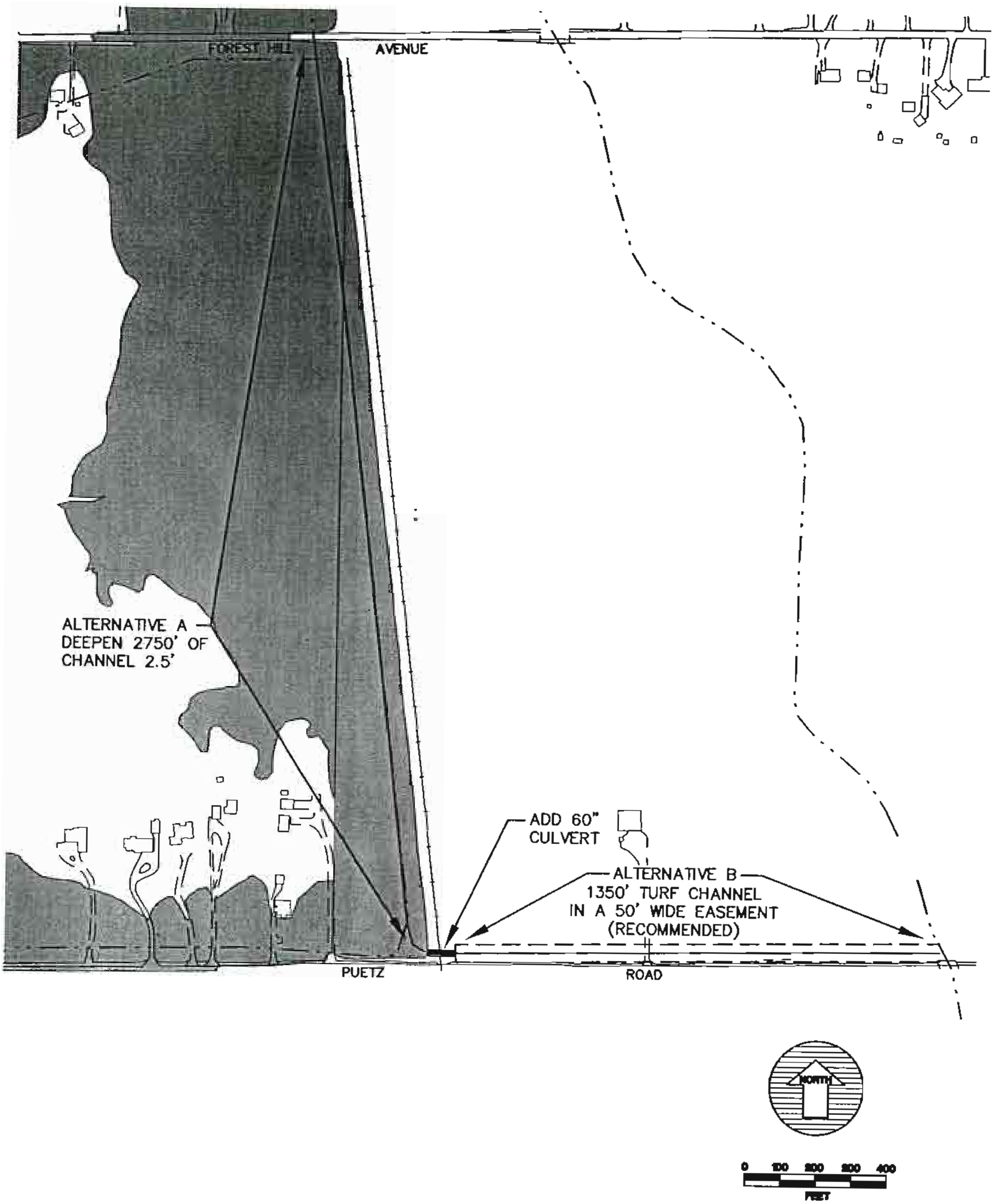
Figure 6-6
Tributary O19A - Problem 17
Drainage Alternative



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Flooding at S. 15th Avenue south of E. Ryan Road – Problem 19

The City reports that the road floods along Tributary O16 due to lack of conveyance from the east side to the west side of the road. The analysis indicates that a 3-foot x 4-foot box culvert should be added approximately 500 feet south of E. Ryan Road. This alternative would cost $75,000 to construct.

Flooding along E. Ryan Road, Pennsylvania to Nicholson Avenue – Problem 20

The road is approximately at elevation 665.7 to 666 feet. The 100-year frequency flood stage is 667.2 and the 10-year frequency flood stage on Oak Creek is 666.1. The only solution to the problem is to raise the road and provide adequate culverts to convey the flow without increasing the upstream stage. The three culverts crossing this road are adequate. Approximately 4000 feet of road would need to be raised ½ to 1 foot to elevate the road above the 10-year recurrence interval flood stage. This construction is estimated to cost $622,000.

Blocked Drainage at 9978 S. Nicholson Road – Problem 21

This property drains toward the east, to a ditch along the east side of the railroad. The railroad ditch appears to drain to the north toward the Oak Creek. The ditch drains to the north through a culvert beneath STH 100 and also drains east through a culvert beneath the railroad. This area is within the 10-year recurrence interval floodplain of Oak Creek. There does not appear to specific blockage, which if removed would improve the drainage in this area.

The ditch and culverts beneath the railroad could be surveyed to determine if dredging would improve the flow of surface water. The boundaries of wetlands in the area should be delineated prior to initiating any drainage modifications. Permits must be obtained from the U.S. Army Corps of Engineers for drainage of regulated wetlands. Drainage changes are the responsibility of the property owners.

Blocked Drainage 10016 S. Nicholson Road and 1834 E. Oakwood Road – Problem 22

This problem was reportedly attributed to an uncompleted drainage ditch and sediment in the ditch and culverts along Oakwood Road. The hydrologic analysis concluded that this area is at the southern boundary of the Oak Creek watershed, although it may drain toward Crayfish Creek under some conditions. The area is quite flat and contains numerous wetlands.

To address the reported problems, the City should determine if a drainage easement exists on this property and return full rights to the property owner if the easement is not needed. The ditch and culverts along Oakwood Road could be surveyed to determine if dredging would improve the flow of surface water from agricultural lands or wetlands. Permits must be obtained from the U.S. Army Corps of Engineers for drainage of regulated wetlands. The boundaries of wetlands in the area should be delineated prior to initiating any drainage modifications. Drainage changes are the responsibility of the property owners.

Blocked Drainage 2300 E. Oakwood Road – Problem 23

The reported problem consists of increased flooding and worsening drainage over the past 25 years due to STH 100 construction and lack of ditch maintenance along Pennsylvania Avenue. This area is at the southern boundary of the Oak Creek watershed, although it may drain toward Crayfish Creek under some conditions. The area is quite flat and contains numerous wetlands. The ditch and culverts along Oakwood Road should be surveyed to determine if dredging would improve the flow of surface water from agricultural lands or wetlands. Permits must be obtained from the U.S. Army Corps of Engineers for drainage of regulated wetlands. The boundaries of wetlands in the area should be delineated prior to initiating any drainage modifications. Drainage changes are the responsibility of the property owners.

Storm Sewer Outlet at Arthur Drive – Problem 24

The outlet pipe of storm sewer system 28-2 is back-pitched and is approximately 2.8 feet below the grade of the receiving wetland at the headwater of Tributary O11. The capacity analysis indicates that the storm sewer system has sufficient capacity to convey the peak 10-year recurrence interval flow without surcharging above the street. The analysis assumes that the outlet pipes are clear of sediment and debris. Therefore, periodic maintenance is necessary to ensure that the predicted capacity is available.

Relaying the outlet pipe with a positive gradient to the channel invert would require extending the 30-inch storm sewer approximately 1450 feet. As shown on Figure 6-7, the storm sewer route would be north along Shepard Avenue approximately 750 feet and then east 700 feet. A 0.32 acre easement would be needed for the east segment. This alternative would cost $632,000 to construct. Land costs would be $5,000.

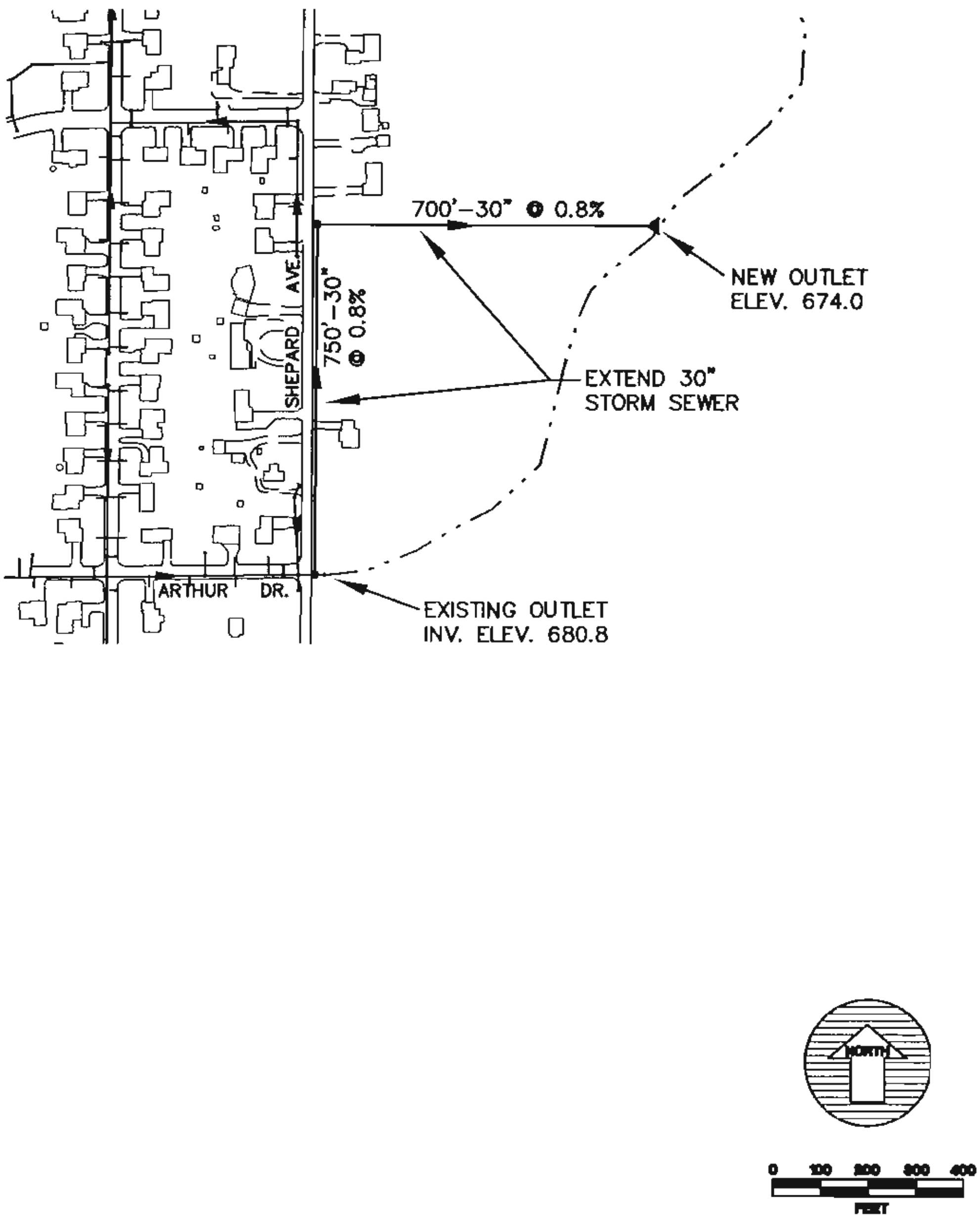
Storm Sewer at Ridgeview Drive – Problem 25

The outlet pipe of storm sewer system 30-9 is approximately 1.7 feet below the channel streambed. The capacity analysis indicates that the storm sewer system has sufficient capacity to convey the peak 10-year recurrence interval flow without surcharging. The analysis assumes that the outlet pipes are clear of sediment and debris. Therefore, periodic maintenance is necessary to ensure that the predicted capacity is available. Relaying the outlet pipe with a positive gradient to the channel invert may be necessary to avoid frequent maintenance.

Storm Sewer at Southbranch Blvd. and Reinhart Drive – Problem 26

The outlet pipe of storm sewer system 30-6 is reported to be below the streambed. Based on the available information, the outlet pipe is approximately 0.4 feet above the streambed. The capacity analysis indicates that the storm sewer system has sufficient capacity to convey the peak 10-year recurrence interval flow without surcharging. The analysis assumes that the outlet pipes are clear of sediment and debris. Therefore, periodic maintenance is necessary to ensure that the predicted capacity is available.

Figure 6-7
Tributary O11
Conveyance Alternative



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Lake Michigan Watershed

Runoff to Street at 9310 S. 8th Avenue – Problem 27

This problem was reported to be sediment and runoff onto 8th Street caused by grading changes on the property south of the end of 8th Street. Runoff from the area previously drained to the east and not toward the street. The site grading should be corrected to maintain this flow direction. Erosion control measures should be used by the property owner to prevent sediment discharge from the site.

Root River Watershed

Flooding of County Line Road east of Nicholson Road – Problem 28

County Line Road is approximately at elevation 665.6. The 10-year frequency flood stage on the Root River is 667. The only solution to the problem is to raise approximately 2200 feet of the road approximately 1.5 to 2 feet. This construction is estimated to cost $384,000. Right-of-way acquisition from Milwaukee County may be required depending on the road width and the right-of-way boundaries.

Root River – Crayfish Creek Subwatershed

The remaining problems are related to drainage and street flooding at road crossings in the Crayfish Creek watershed. Some of these problems were addressed in a previous study, Stormwater Management Plan for the Crayfish Creek Subwatershed (Southeastern Wisconsin Regional Planning Commission, 1988). A subsequent letter report to the City of Oak Creek and Milwaukee County addressed specific problems in greater detail (Southeastern Wisconsin Regional Planning Commission, 1994). These previous analyses and drainage recommendations were reviewed and generally found to be sound.

Flooding at E. Oakwood Road Crossing – Problem 29

The previous study hydraulic analysis indicates that the Oakwood Road crossing of Crayfish Creek is above the 100-year recurrence interval floodplain under existing and future watershed conditions. If the actual conditions differ from the analysis and road flooding occurs, the only feasible solution is to raise the road and provide adequate culverts to convey the flow without increasing the upstream stage. Additional field survey and analysis beyond the scope of this plan is needed to determine the extent of this solution.

Flooding at Darlene Lane– Problem 30

The outlet pipe of storm sewer system 28-3 is approximately 5.7 feet below the channel streambed at Tributary C1. This sewer system drains the Shepard Hills Subdivision at S. Darlene Lane and S. Robert Court. Part of the capacity problem is an undersized, back-pitched portion of storm sewer at the outlet of the system. The 66-inch storm sewer connects to a 50-foot long section of 54-inch corrugated metal pipe (CMP) at the outlet. The outlet section is back-pitched to meet the existing open channel. This situation results in sewer backup and subsequent street and yard flooding during frequent storm events.

During this study, the City requested early consideration of mitigation measures for this problem area. A safe overland flow route was recommended for water from S. Darlene Lane during storms that exceed the capacity of the storm sewer system. The existing topography causes ponding on Darlene Lane in excess of 3 ft. deep before water can overflow from the street. An overflow route beginning at the top of the curb and extending to the ditch south of E. Oak Lane would reduce the potential ponding depth on Darlene Lane to less than 2 feet during a 100-year recurrence interval storm. The existing 20 ft. wide easement is sufficient to create an overflow from Darlene Lane to Oak Lane. An additional easement would be required for the swale from the north side of Oak Lane to the ditch.

The City constructed an overflow between the house and driveway using a culvert in 1998.

Two alternatives are available to address the problem of the back-pitched storm sewer outlet. Alternative A would consist of increasing the 50-foot section of outlet storm sewer from a 54-inch to a minimum 66-inch pipe. The pipe would need to be inspected annually and cleaned out whenever sediment exceeds 1 foot, to maintain capacity. This alternative would reduce the existing elevations by approximately 0.5 feet and would eliminate surface flooding at S. Darlene Lane during a 10-year recurrence interval, 1-hour duration storm event. The estimated construction cost is $15,000 for this alternative.

Alternative B would consist of replacing the 54-inch outlet pipe with 66-inch RCP as in Alternative 1 and cleaning out the channel from the storm sewer outlet to Shepard Avenue and implementing routine maintenance program of removing nuisance vegetation from the new channel. This would lower the channel elevation at the outlet by about 2.3 feet, allowing for less back-pitch on the outlet pipe. The channel cleaning would require a dredging permit from the Wisconsin DNR. The estimated construction cost is $65,000 for this alternative.

Flooding at 410 E. Robert Road – Problem 31

Standing water in the backyard and flooding within 20 feet of the house were reported at this problem location. The City has designed an additional catchbasin and 105 feet of storm sewer within the drainage easement in the backyard. The catchbasin will connect to the storm sewer already in the adjacent yard. This solution should adequately address the problem.

Flooding at E. Elm Road Crossing – Problem 32

The previous study hydraulic analysis indicates that Elm Road is above the 100-year recurrence interval floodplain of Crayfish Creek under existing and future watershed conditions. If the actual conditions differ from the analysis and road flooding occurs, the only feasible solution is to raise the road and provide adequate culverts to convey the flow without increasing the upstream stage. Additional field survey and analysis beyond the scope of this plan is needed to determine the extent of this solution. Right-of-way acquisition from Milwaukee County may be required depending on the road width and the right-of-way boundaries.

Poor Drainage at 2307 E. Oakwood Road – Problem 33

This problem is caused primarily by the low elevation of the property. The previous studies stated that removal of sediment from the West Branch and Crayfish Creek would improve the drainage only along the southern margin of the property. Further resolution of the problem would require drain tiles with pumping to lower the water level. Drainage changes such as tiling and pumping are the responsibility of the property owner. Solutions were previously identified by SEWRPC.

Poor Drainage along E. Elm Road from Chicago Road to Shangri La Court – Problem 34

Development east of S. Chicago Road has increased the runoff volume to the wetland north of Elm Road and west of Chicago Road. The water elevation in the wetland during rain events has increased in recent years. The wetland drains southwest through a culvert crossing Elm Road.

The wetland is a natural retention area for upstream runoff and should be retained. Drainage along Elm Road could be improved with a storm sewer as recommended in the previous studies.

Problems Identified by Floodplain Analysis

Alternative solutions to the problems identified in the hydrologic-hydraulic analysis are discussed in the subsequent section by tributary watershed. The locations are shown in Figure 4-6.

Tributary N4

Tributary N4 has flooding problems between S. 10th Street and west of 13th Street at the upstream study limit near the exit ramp from northbound I-94.

Flooding West of S. 13th Street

West of 13th Street, the floodplain includes a portion of the eastbound lanes of Rawson Avenue. Milwaukee County Department of Public Works is replacing the culvert at 13th Street on Tributary N4. The new culvert will reduce the flood stage and mitigate flooding of Rawson Avenue west of 13th Street.

Flooding between S. 10th Street and S. 13th Street

Flooding occurs at the north end of the S. 10th Street boulevard, just south of Rawson Avenue. At this location, the stream channel enters a storm sewer system. The storm sewer inlet does not have sufficient capacity and causes flooding of S. 10th Street and adjacent private properties. The 100-year floodplain includes one residential property east of S. 13th Street.

On-Site Detention Alternative

The Tributary N4 watershed has approximately 70 acres of land, or 16 percent of the total watershed area to be developed. The future development lands are located north of Rawson Avenue and along S. 13th Street. Because the potential development is a small portion of the watershed and in scattered locations, on-site detention is not a feasible alternative to achieve reductions in flood flows.

Detention Alternative

Mitigating the flooding problem with only detention would require sufficient storage upstream of S. 13th Street to reduce the peak flow from 340 cfs to 140 cfs. The potential locations for regional detention facilities in the watershed are the areas within the interchange of Rawson Avenue and I-94. The northeast quadrant of the interchange already provides storage and peak flow attenuation. The potential detention storage areas will be reduced by additional on and off ramps proposed for construction. There are no detention sites in the watershed where sufficient storage could be created to achieve the flow reductions needed to resolve the flooding problem.

Conveyance Alternative

As shown on Figure 6-8, modifying the connection to the storm sewer system at S. 10th Street would reduce the backwater and flooding at S. 10th Street. The existing stub of 5-foot x 8-foot box culvert would be extended 175 feet north to the channel location. Hydraulically smooth curved transitions would be constructed to guide flow into the new box culvert and through the connection to the existing stub. Modifying approximately 1050 feet of the channel upstream of S. 10th Street would remove the residential property from the floodplain at S. 13th Street. The channel would be enlarged to lower the 100-year frequency flood stages by at least 1 foot. This alternative would require a 50-foot wide easement and cost $689,000 to construct. Land costs would be approximately $18,000.

Tributary N7

Tributary N7 has flooding problems at Drexel Avenue, S. 20th Street, Willow Drive, and S. 13th Street.

Branch N7A does not have any flooding problems, although S. 20th Street would be overtopped during the 2-year and larger frequency storms. The depth of flow over the road for the 100-year event would be about 0.5 foot. The culvert at S. 20th Street was replaced in 1997 with the same size culvert.

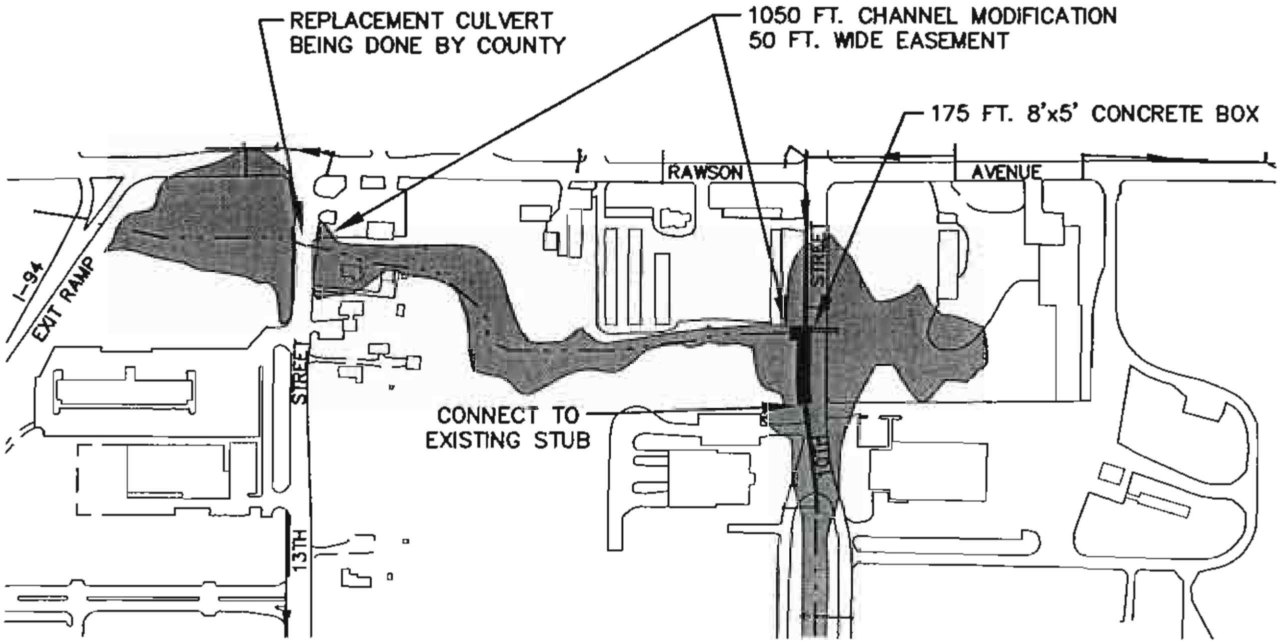
Flooding at S. 13th Street and Willow Drive

The S. 13th Street crossing has adequate capacity for the 10-year frequency event, but is overtopped by the 100-year frequency storm event. Willow Drive is overtopped by the 10-year frequency event, partly due to backwater from S. 13th Street. The 100-year frequency event includes flooding of two residential properties. Lowering the 100-year frequency flood stage upstream of S. 13th Street by at least 2 feet would be required to remove S. 13th Street and the private properties from the floodplain. Willow Drive is 2 feet lower than S. 13th Street and would still be overtopped for the 10- and 100-year events.

On-site Detention Alternative

Upstream of S. 13th Street, the watershed has approximately 266 acres of land, or 40 percent of the tributary area, available for development. On-site detention is not feasible because the amount of developable land remaining in the upstream watershed is insufficient to effect the flow reductions necessary to mitigate the flooding. With zero runoff from the developable land, the 10-year frequency flow at the problem area is approximately the same as the available capacity and the 100-year frequency flow is two times the available capacity.

Figure 6-8
Tributary N4
Conveyance Alternative (Recommended)



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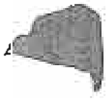
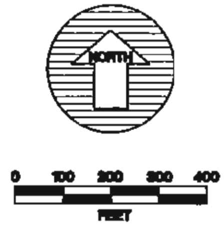


EXISTING 100-YEAR
FREQUENCY FLOODPLAIN



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Without additional detention in the watershed, the 100-year frequency peak flow from Tributary N7 under future development conditions is only 3 percent greater than under existing conditions.

Regional Detention Alternative

To mitigate flooding of S. 13th Street and Willow Drive with detention would require sufficient storage upstream of Willow Drive to reduce the flow to approximately 150 cfs. To achieve this reduction, detention would be required on both Tributaries N7 and N7A. There are three potential sites for detention storage areas: on Tributary N7 east of I-94 to Willow Drive, on N7 west of I-94, on N7A west of I-94. The most feasible site for the larger storage area is on Tributary N7A west of I-94. As shown on Figure 6-9, this site requires the least amount of excavation to create storage and much of the future development upstream of S. 13th Street will occur in its watershed. Tributary N7 has considerable natural detention storage that reduces its peak flows downstream of S. 20th Street. Additional storage on Tributary N7 between I-94 and Willow Drive would require less excavation than a basin west of I-94.

As shown on Figure 6-9, the storage on Tributary N7A would consist of excavation and construction of an earthen berm approximately 900 feet long just west of I-94. The berm would be 11 feet high at its highest point to create approximately 33 acre-feet of detention storage. The normally dry detention basin would require portions of three parcels (approximately 20 acres) plus access from S. 20th Street. Although approximately ½ acre of wetland would need to be filled to construct the dam, the existing wetlands in the bottom would remain and could be expanded. The WDNR may consider the facility a dam and Administrative Code NR 333 regulations may apply. If only this basin was constructed, the reduced 10- and 100-year discharges at Willow Drive (125 and 250 cfs, respectively) would approximately equal the existing 2- and 10-year discharges (125 and 240 cfs, respectively.)

The storage on Tributary N7, east of I-94, would consist of an off-channel basin designed to take flow from just downstream of the I-94 culvert and release it at a reduced rate upstream of Willow Drive. The excavated basin would provide 22 acre-feet of detention storage on approximately 6 acres. This basin, along with the detention proposed on N7A, would reduce the 100-year discharge at S. 13th Street to 145 cfs. Both detention facilities would be needed to prevent flooding at S. 13th Street and Willow Road. The estimated total construction cost of this alternative is $722,000. Land costs would be $390,000.

Conveyance Alternative

As shown on Figure 6-10, this alternative would consist of replacing culverts at S. 13th Street and Willow Drive to increase capacity. An additional 6-foot wide by 4-foot high concrete box would be installed at S. 13th Street. The existing culverts at Willow Drive would be replaced with two 66-inch diameter corrugated metal pipe culverts. Willow Drive would also be raised to a minimum elevation of 711.0. This alternative would provide capacity to convey the future condition 100-year frequency flood flows without overtopping 13th Street. Willow Drive would convey the 10-year flows without overtopping and have about 0.4 foot of flow over the street during a 100-year frequency event. The estimated total construction cost of this alternative is $300,000.

Figure 6-9
Tributary N7
Detention Alternative

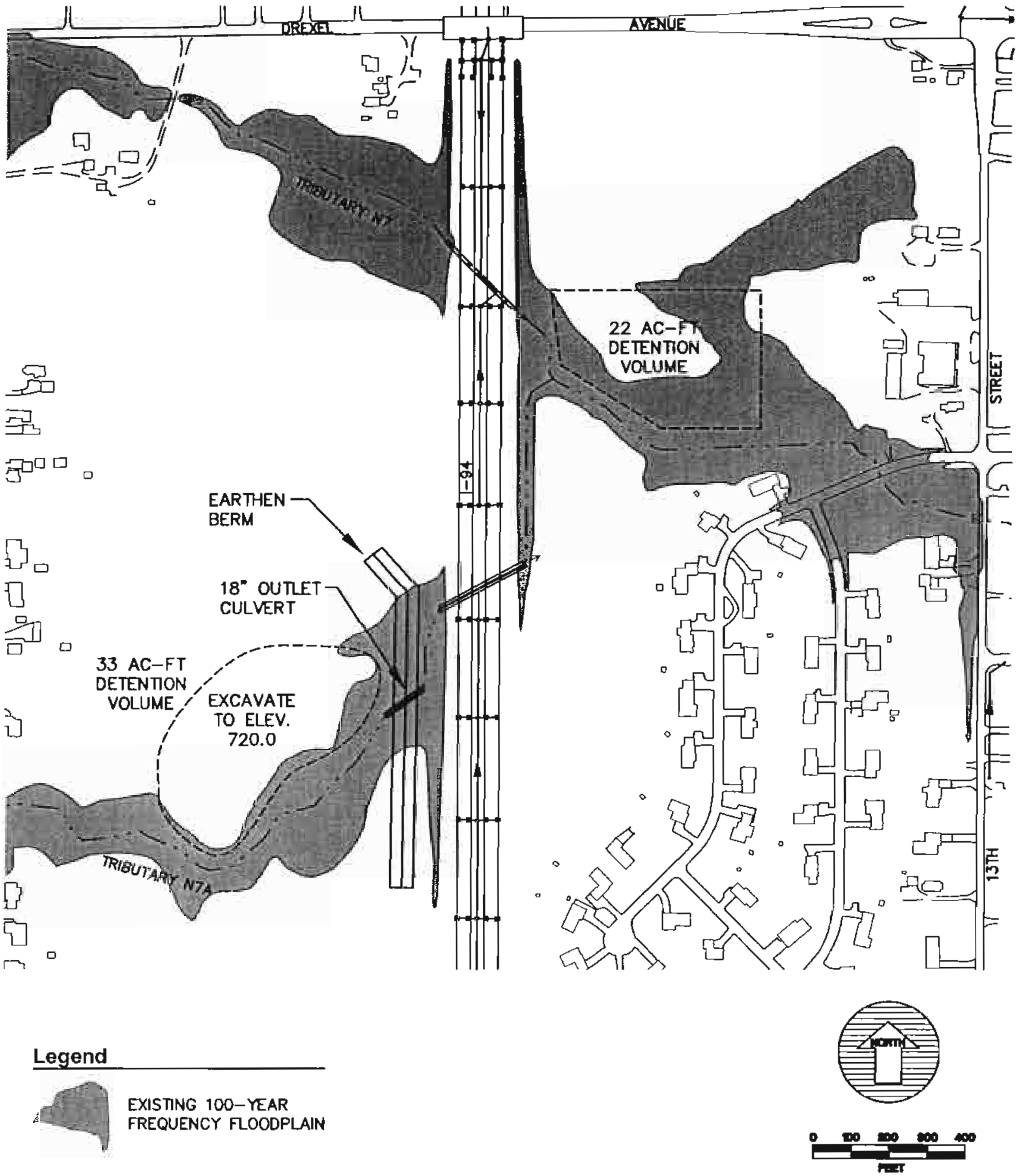

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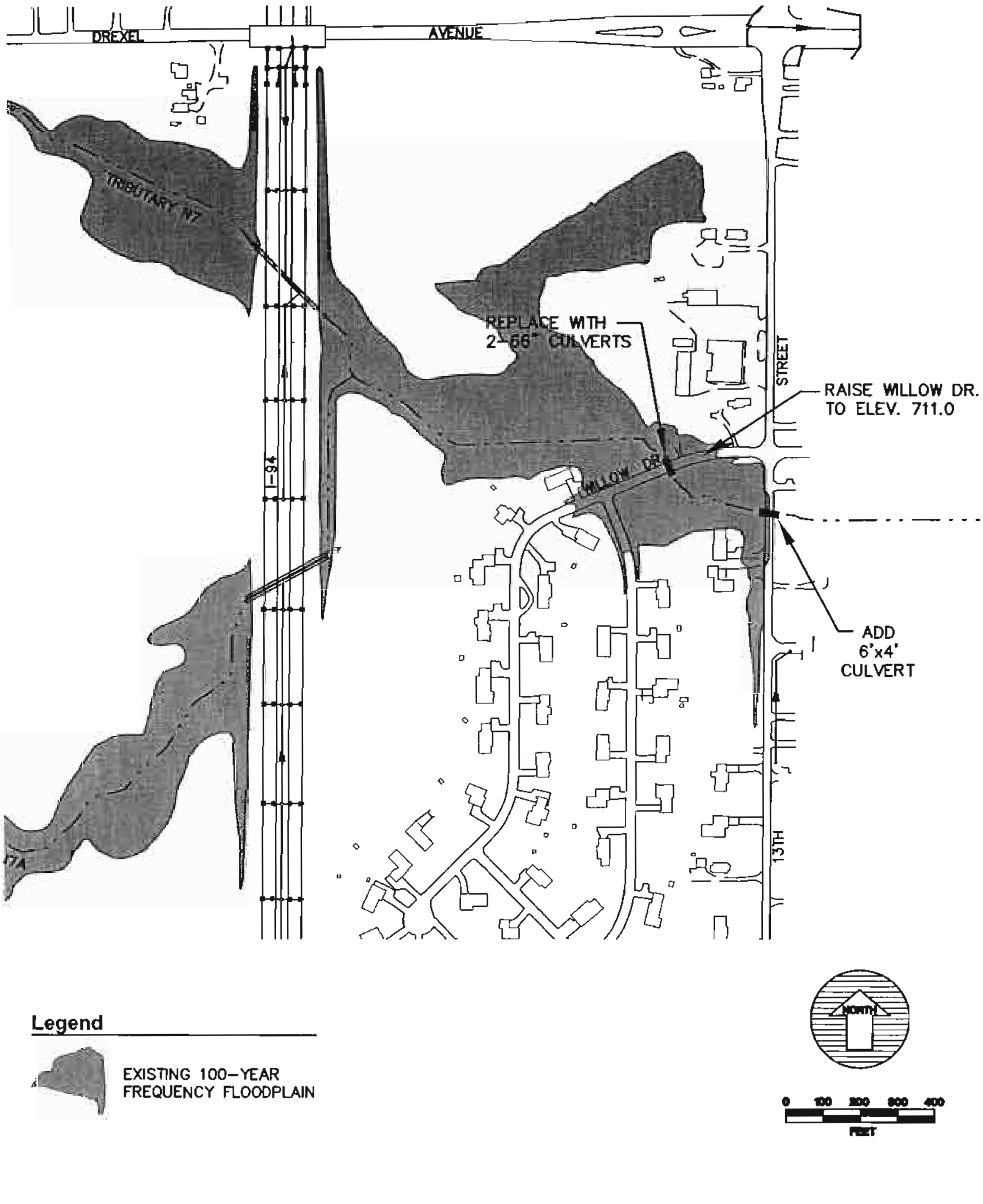
Figure 6-10
Tributary N7
Conveyance Alternative (Recommended)



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Tributary C1

This tributary watershed is developed in the upper portion and developing in the lower portion. Future condition flows will not increase significantly from the existing flows. There are several problem areas along the tributary that were defined by the hydrologic-hydraulic analysis. Although there several culverts with restricted capacities, the roads are overtopped and the crossings do not retain sufficient floodwater storage to reduce the downstream flows. The culvert sizes may be increased without causing additional flooding downstream.

Flooding Upstream of Shepard Avenue

The inadequate capacity of the culverts for flows larger than the 2-year frequency event and the high road elevation will be expected to cause backwater upstream to a depth of more than 2 feet on Darlene Lane during severe infrequent storm events. Detention solutions are not available because of full development upstream. Additional capacity is required. As shown on Figure 6-11, three additional 48-inch culverts would provide sufficient capacity to alleviate flooding during a 10-year frequency storm and reduce the backwater flooding depth on Darlene Lane to less than one foot during a 100-year frequency storm event. These additional culverts would cost $80,000 to construct.

Flooding Upstream of W. Oakwood Road

The floodplain boundary includes two houses north of Oakwood Road and west of Nicholson Road. The flood stages are caused by backwater at the west driveway culvert and by Oakwood Road. Additional capacity is required to reduce the 100-year frequency flood stages. As shown on Figure 6-11, two additional 48-inch culverts at the west driveway, lowering the west driveway approximately 6 inches, and an additional 6 by 4 foot box culvert at Oakwood Road would provide sufficient capacity to alleviate flooding during a 10-year frequency storm. This alternative would reduce the 100-year frequency flood stages to remove the house from the 100-year frequency floodplain. These additional culverts would cost $181,000 to construct.

Tributary C3

Flooding at S. 11th Avenue

The hydrologic-hydraulic analysis identified flooding over S. 11th Avenue for 10-year recurrence interval and larger storm events. This street is the only access to the subdivision. The 100-year flood stage is 0.65 feet over the road and the 10-year frequency flood stage is 0.2 feet over the low point in the road.

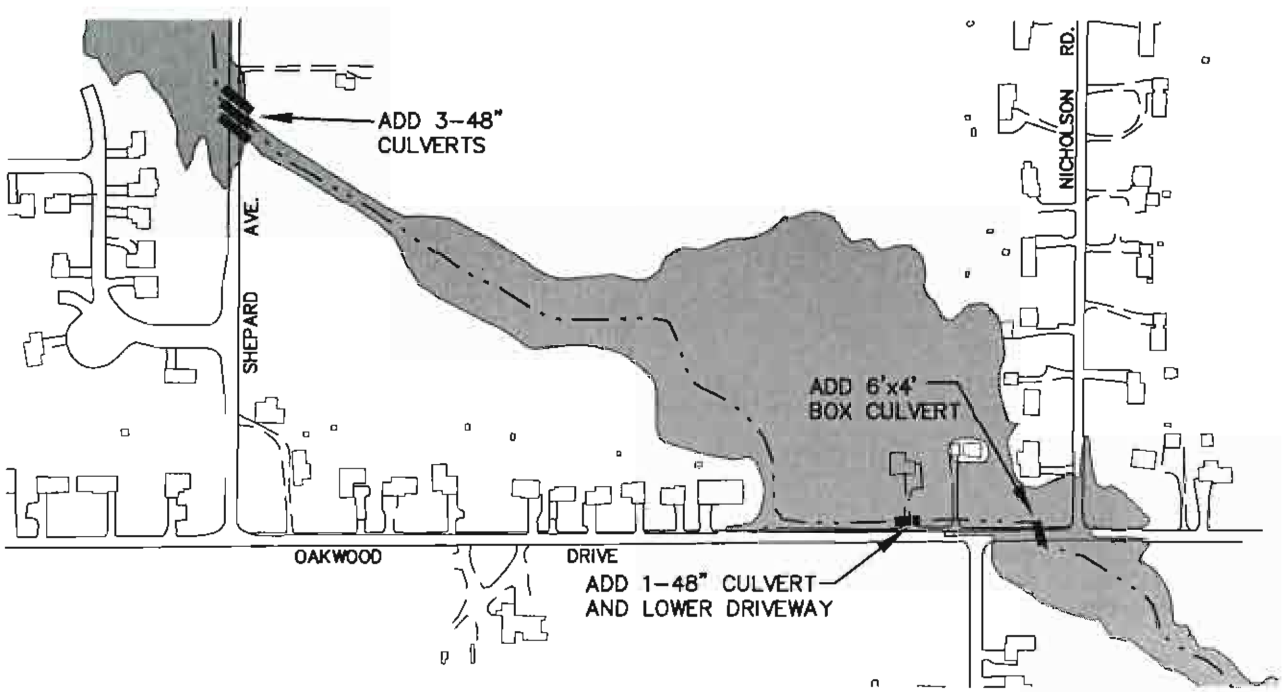
Detention Alternatives

Much of the upstream tributary area is undeveloped agricultural land that is zoned to remain in agricultural use. Therefore detention in conjunction with new development is not likely in the near future. A detention basin east of 11th Avenue could be used to reduce the peak flow and mitigate the flooding.

Conveyance Alternative

Mitigating the flooding problem would require replacing the two existing culverts at S. 11th Avenue with a 10' x 3' box culvert. This culvert would reduce the 10-year recurrence interval flood stages lower than the road and the 100-year stage to 0.2 over the road. This replacement culvert would cost $187,000 to construct.

Figure 6-11
Tributary C1
Conveyance Alternative (Recommended)



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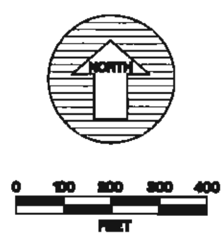
EXISTING 100-YEAR FREQUENCY FLOODPLAIN



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Recommendations

Based on evaluation of the alternatives described in the preceding section, recommended solutions for the problem areas are identified in this section. In general, the least cost alternative is recommended unless there are overriding considerations such as adverse ecological impacts, implementation barriers, or safety concerns. The costs of alternatives for the various problem areas are summarized in Table 6-1. Detailed cost assumptions are presented in Appendix C. All costs are in 1998 dollars.

Table 6-1 Flood Control and Drainage Alternative Costs

			Capital Construction Cost (1)			
			Alternative			
ID No.	Watershed	Location	Regional Detention	On-site Detention	Conveyance	Flood Protection
1	N1	6931 S. Howell Ave.			(2)	
2	N2	S. 13th St. to Pelton Dr.	$ 1,105,000		$ 1,260,000	
3	N7	S. 20th St. and Drexel Ave.				$ 211,000
4	N5	7538 S. 13th St.	No capital construction required			
5	North Branch	Marquette Ave.	No capital construction required			
6	North Branch	Drexel Ave. and Wildwood Dr.	No capital construction required			
7	Oak Creek	2000 block W. Puetz Rd.		Construction completed by City		
8	Mitchell Field Drainage Ditch	7289 S. Quincy Ave.	$ 80,000		$ 545,000	$ 22,500
9	Mitchell Field Drainage Ditch	7152 S. Taylor Ave.			$ 16,000	
10	Oak Creek	E. Pennsylvania Ave. & Sharon Dr.	No capital construction required			
11	Oak Creek	1020 E. Forest Hill Ave.			(2)	
12	Oak Creek	700 W. Ryan Rd.			$ 733,000	
13	O19A	South of E. Puetz Rd. east of S. Shepard Ave.			$ 304,000	
14	Oak Creek	Parkway Estates & Oak View Ln.	No capital construction required			
15	O17	9000 S. Pennsylvania Ave.			Construction by City	
16	O15	S. 15th Ave. north of E. Ryan Rd.	Exists		$ 218,000	
17	O19A	Puetz Rd. and Nicholson Rd.			A: $ 432,000 B: $ 406,000	
18	Oak Creek	S. 11th Ave.- E. Puetz Rd. to Madeira Dr.			$500,000	

(1) Operation and maintenance costs are not included.
(2) Private property owner's responsibility.
(3) Blanks indicate that this was not a viable alternative.

Table 6-1 Flood Control and Drainage Alternative Costs (continued)

			Capital Construction Cost (1)
			Alternative

ID No.	Watershed	Location	Regional Detention	On-site Detention	Conveyance	Flood Protection
19	O16	15th Ave. - STH 100 to E. Ryan Rd.			$ 75,000	
20	Oak Creek	E. Ryan Rd. - Penn. Ave. to west of Nicholson Rd.				$ 622,000
21	Oak Creek	9978 S. Nicholson Rd.			(2)	
22	Oak Creek	10016 S. Nicholson Rd. and 1834 E. Oakwood Rd.			(2)	
23	Oak Creek	2300 E. Oakwood Rd.			(2)	
24	O11	Arthur Dr.			$ 637,000	
25	Oak Creek	Ridgeview Dr.	No capital construction required			
26	Oak Creek	Southbranch Blvd. & Reinhart Dr.				
28	Root River	2200 E. County Line Rd. to Nicholson Rd.				$ 384,000
29	Crayfish Creek	2400 to 3200 E. Oakwood Rd.				
30	C1	Darlene Ln.			A: $15,000 B: $65,000	
31	O16	410 E. Robert Rd.			City	
32	Crayfish Creek	2200 to 2600 E. Elm Rd.				
33	Crayfish Creek	2307 E. Oakwood Rd.			(2)	
34	CB2	E. Elm Rd.-Chicago Rd. to Shangri La Ct.			(2)	
	N4	S. 13th St. to 10th St. and west of S. 13th St.			$ 689,000	
	N7	Willow Dr. and S. 13th St.	$ 1,112,000		$ 300,000	
	C1	S. Shepard Ave.			$ 80,000	
	C1	E. Oakwood Rd.	$ 210,000		$ 181,000	
	C3	S. 11th Ave.	$0		$ 187,000	

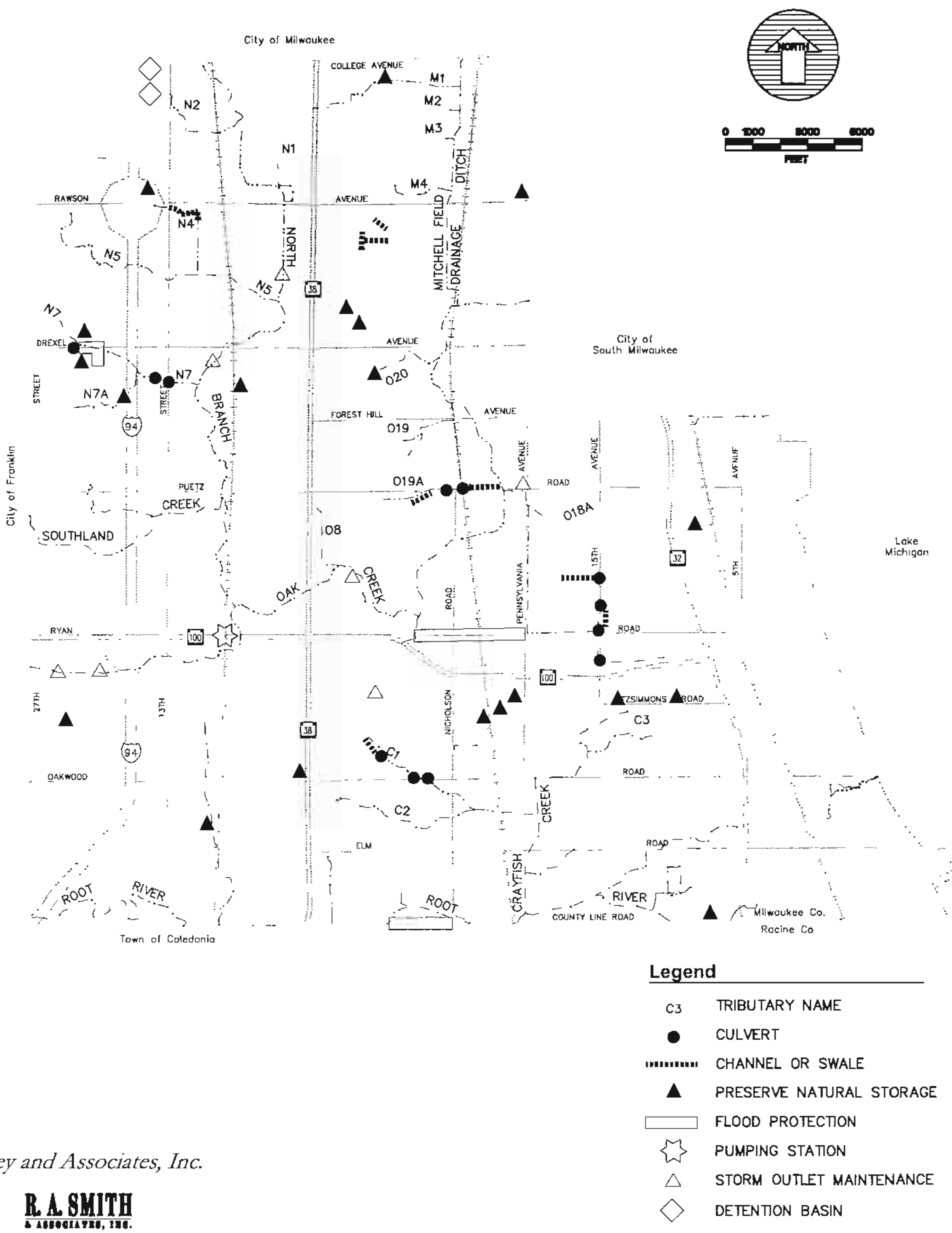
(1) Operation and maintenance costs are not included.
(2) Private property owner's responsibility.
(3) Blanks indicate that this was not a viable alternative.

The recommendations are shown on Figure 6-12 and described in the following sections organized by watershed-wide recommendations, flood control recommendations, and drainage recommendations. Within each section the recommendations are organized by watershed and tributaries beginning with the North Branch, followed by Mitchell Field Drainage Ditch, Oak Creek-Main Stem, Root River-Crayfish Creek, and ending with the Lake Michigan watershed.

City-wide Recommendations

In addition to problem specific solutions, several issues deserve discussion as City-wide recommendations. Natural detention storage areas, as identified in the hydrologic-hydraulic analyses, should be preserved because they reduce peak flows. Filling the

Figure 6-12
Flood Control and Drainage Recommendations



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areas or increasing the capacity of downstream culverts should be avoided. The locations of these natural storage areas are shown on Figure 6-12.

Stream maintenance and regulation of stormwater runoff from future development are discussed in the following sections.

Stream Maintenance

Watercourses and tributary streams are subject to change due to flow conditions, sediment loads, and vegetative growth. Periodic inventory of the conditions of watercourses and tributary streams is recommended to verify that the hydrologic-hydraulic models remain representative of the watershed and stream conditions. Of particular concern is the hydraulic capacity of watercourses that have had heavy sediment loads. Such streams are most likely to change adversely with respect to flooding and drainage problems.

The inventory should include surveys of channel cross section and comparison to the cross sections in the hydraulic models. The analyses and recommendations in this study are generally based on the hydrologic-hydraulic models developed for this study and in previous studies. The models prepared for this study were based on 1993 topographic mapping and 1996 surveys of culverts and bridges. The models prepared for previous studies were based on older surveys and older topographic mapping in some areas. The streams represented by these older data sources should be the first to be inventoried.

Because of potential difficulties in obtaining permits for the stream maintenance, we recommend a pilot project approach be used to demonstrate how ecologically sensitive stream cleaning can be accomplished. The pilot project would allow a collaborative effort with the WDNR and mutual education on the issues affecting the project permitting and construction. The pilot project would begin with identification of a stream segment that is impaired by sediment deposition or heavy vegetation growth.

Future Development Regulation

The goals and objectives established by the Stormwater Committee call for the management of future discharges to prevent increases in flooding both within and downstream of Oak Creek. As stated earlier, the management of flooding in a watershed is a balance between storage and conveyance. Storage places the responsibility for stormwater management on properties as they develop. Conveyance places the responsibility for stormwater management on downstream properties, which must be reserved free of development to allow for conveyance of flood flows.

Management of stormwater runoff is an even more complicated issue in Oak Creek because much of the City is already developed. Also, rapid release of stormwater without storage may benefit some sections of Oak Creek, while hurting others and downstream communities. The model studies performed for Oak Creek suggest that for many specific areas storage alone cannot relieve existing drainage problems. However, it is equally clear that storage for new development can reduce the cost of some of these drainage improvements by maintaining the rate of design flows after development takes place.

Of more concern from a philosophical standpoint is the increase in downstream discharges, which will inevitably result from failure to adopt a very stringent on-site stormwater detention regulation. Development of land increases the volumes of stormwater runoff dramatically. When these increased volumes are allowed to release at pre-development rates, they eventually combine with other discharges downstream, provided along the south side of Puetz Road for major storms by grading the abandoned railroad right-of-way embankment to allow flow toward the east along the south side of Puetz Road. The low area south of Puetz Road would convey flow toward Nicholson Road. Approximately 400 feet of Puetz Road would be lowered to allow flow over the road to the north during major storms. New culverts beneath Puetz Road would drain the overflow route south of Puetz Road.

Root River

The only feasible recommendation for the flooding of County Line Road, east of Nicholson Road, is to raise approximately 2200 feet of the road approximately 1.5 to 2 feet.

Crayfish Creek

The SEWRPC study hydraulic analysis indicates that E. Oakwood Road and E. Elm Road are above the 100-year recurrence interval floodplain under existing and future watershed conditions. If the actual conditions differ from the analysis, and road flooding occurs, we recommend raising the roads and providing adequate culverts to convey the flow without increasing the upstream stage. Additional field survey and analysis beyond the scope of this plan is needed to determine the extent of this solution.

Tributary C1

The recommended solution to minimize flooding at Darlene Lane consists of replacing the 54-inch outlet pipe and adding three culverts at S. Shepard Avenue. The outlet pipe would be replaced with a minimum 66-inch pipe. As shown on Figure 6-11, three additional 48-inch culverts would provide sufficient capacity to alleviate flooding during a 10-year frequency storm and reduce the backwater flooding depth on Darlene Lane to less than one foot during a 100-year frequency storm event. Cleaning out the channel from the storm sewer outlet to Shepard Avenue and implementing a routine maintenance program of removing nuisance vegetation from the new channel are also recommended. This would lower the channel elevation at the outlet by about 2.3 feet, allowing for less back-pitch on the outlet pipe. The channel cleaning requires a dredging permit from the Wisconsin DNR.

At E. Oakwood Road, additional capacity is recommended to reduce the 100-year frequency flood stages. As shown on Figure 6-11, two additional 48-inch culverts at the west driveway, lowering the west driveway approximately 6 inches, and an additional 6-foot by 4-foot box culvert at Oakwood Road would provide sufficient capacity to alleviate flooding during a 10-year frequency storm. This construction would reduce the 100-year frequency flood stages sufficiently to remove the house from the 100-year frequency floodplain.

Tributary C3

The hydrologic-hydraulic analysis identified flooding over S. 11th Avenue for 10-year recurrence interval, and larger storm events, under existing watershed conditions. Because this street is the only access to the subdivision, we recommend that the affect of any further upstream development on this problem be evaluated. Emergency access is possible, as the 100-year flood stage is 0.65 feet over the road. The upstream area is zoned agriculture, and development is not anticipated. However, increased runoff could make the road impassable during 100-year frequency storm events.

Drainage Problem Solutions

North Branch Oak Creek Watershed

The outlet pipes of storm sewer systems at Marquette Avenue and Wildwood Drive should be maintained to keep the outlet pipes clear of sediment and debris to ensure that the predicted capacity is available.

Mitchell Field Drainage Ditch Watershed

At 7289 S. Quincy Avenue, we recommend that the City obtain an easement and construct an overflow swale over the storm sewer between the houses west of Quincy Avenue to direct excess runoff to the street. Grading to create a diversion berm or swale along the east border of the field is also recommended to direct runoff to the storm sewer.

At 7152 S. Taylor Avenue, we recommend a swale toward the southeast along the property line to accommodate excess runoff from the roadside ditch. The swale would be in the natural flow direction toward the southeast. The swale would be 2 to 3 feet deep and would require an easement.

Oak Creek – Main Stem Watershed

The outlet pipes of storm sewer systems at E. Puetz Road and Pennsylvania Avenue, Parkway Estates and Oak View Lane, Ridgeview Drive, Southbranch Boulevard, and Reinhart Drive should be maintained to keep the outlet pipes clear of sediment and debris to ensure that the predicted capacity is available.

Regarding drainage problems at 10016 S. Nicholson Road and 1834 E. Oakwood Road, we recommend that the City determine if a drainage easement exists on this property and return full rights to the property owner if the easement is not needed.

Tributary O11

We recommend the outlet pipe at Arthur Drive be maintained to keep the outlet pipes clear of sediment and debris to ensure that the predicted capacity is available. If maintenance is excessive, we recommend extending the 30-inch storm sewer approximately 1450 feet. As shown on Figure 6-7, the storm sewer route would be north along Shepard Avenue approximately 750 feet and then east 700 feet. An easement would be needed for the east segment.

Tributary O19A

To improve drainage at E. Puetz Road and Nicholson Road, we recommend a new outlet from the intersection of E. Puetz Road and S. Nicholson Road toward the east rather than to the north, as shown on Figure 6-6. An east outlet would be a shorter distance to the Oak Creek, by approximately 1400 feet. The east route would require a new culvert beneath the railroad and a channel along the north side of E. Puetz Road. There are no permanent driveways or structures in the route. An underground utility cable may need to be relocated. An easement would be required for the channel.

Root River - Crayfish Creek Watershed

No drainage projects are recommended for the Root River and Crayfish Creek Watershed.

Lake Michigan Watershed

Regarding runoff to the street at 9310 S. 8th Avenue, we recommend that the City investigate this site and determine if the problem remains.

Easements and Land Acquisition

Recommended channel modifications are within street right-of-ways where possible. However, easements are needed for construction of some recommended flood control and drainage modifications. Channel modifications along existing drainageways and detention facilities require permanent easements or land acquisition through purchase or condemnation.

Approximate land areas needed for recommended projects are provided in the solution descriptions. The actual boundaries of easements and lands to be acquired will vary with more detailed mapping and design. Specific descriptions should be determined during the preliminary engineering phase of project implementation.

Chapter

7

Water Quality Alternatives and Recommendations

Introduction

Stormwater quality management practices for urban and urbanizing areas fall into two categories: practices to control the runoff from new development, and practices to treat the runoff from existing areas. Management practices for new development are ones that control stormwater at the source through development standards such as lot characteristics, drainage system types, and local on-site storage. Management practices for existing development are those that must be retrofitted into the existing urban landscape to control existing sources of water and pollutants. Management practices for existing development are often limited by location and density of existing buildings, roads and utilities, and, therefore, must take advantage of limited space and site conditions. The City of Oak Creek is currently 50% developed based on land cover. Therefore, management alternatives in this report will focus on both practices that address existing and future sources of water and pollutants.

Studies of urban runoff by the U.S. Environmental Protection Agency (EPA), as part of the National Urban Runoff Program (NURP), have shown that the amount of pollution generated off the land surface is directly proportional to the quantity of runoff (Pitt, 1991). To meet the goals and objectives outlined in Chapter 2, both the rate and volume of surface runoff need to be addressed. To effectively control urban stormwater runoff, management alternatives need to be reviewed in a hierarchy, from alternatives that control the water and pollutants at their source, to practices that treat the water before it is discharged to the downstream waterways.

The philosophy of the stormwater hierarchy is to first control pollutants at their source, to prevent them from getting into the surface water in the first place. Keeping the pollutants out of the water is more cost effective than trying to remove the pollutants by treatment downstream. Source controls include housekeeping practices such as construction site erosion control, street sweeping, catch basin cleaning, fertilizer management, litter control, pet waste control, and control of dumping of wastes into the drainage system.

As discussed earlier, the amount of pollutants is directly proportional to the volume of the runoff. By reducing the volume of runoff, the volume of pollutants can be reduced. Reduced runoff volumes can also reduce downstream flooding problems. The only effective method of reducing the volume of runoff, not just the rate of runoff, is to infiltrate water into the ground, thereby moving it into groundwater storage. Infiltration in the urban environment can be encouraged by discharging impervious surfaces such as parking lots, streets, and roofs onto pervious areas such as grass or engineered infiltration facilities. The amount of infiltration that can be achieved in a given area is dependent on the density of the impervious surfaces and the permeability of the local soils.

Of course, not all of the rainwater captured in an urban area can be made to infiltrate into the ground. Water that cannot be infiltrated becomes surface runoff and will need to be stored and treated to allow pollutants to be settled out. Once the water has been stored and treated, it needs to be released at a safe rate to prevent downstream flooding, channel erosion and destruction of aquatic habitat.

The various stormwater management practices, their constraints, and effectiveness will be described in this chapter. Total suspended solids will be used as the target pollutant for this analysis. It is assumed that if total suspended solids are controlled, other particulate pollutants such as phosphorus and heavy metals will be controlled.

This chapter includes estimated costs for stormwater management practices. The capital and operation and maintenance costs are based on the assumptions and unit costs presented in Appendix C.

Source Controls

Construction Site Erosion Control

It is estimated that soil erosion from construction sites can equal or exceed 30 tons/acre/year, much higher than average soil loss rates from agricultural lands (WDNR, 1991). Construction site erosion can be controlled by as much as 90% through practices such as siltation barriers, sedimentation basins, storm sewer inlet protection, temporary rock construction entrances, diversions, and seeding and mulching. Effective practices for construction site erosion control are outlined in the Wisconsin Construction Site Best Management Practice Handbook (WDNR, 1989).

To assure that adequate erosion control takes place, Wisconsin Statues 144.26 and 60.62 provide the authority to towns to adopt local ordinances to regulate erosion from construction sites. The League of Wisconsin Municipalities and the Wisconsin Department of Natural Resources (WDNR) have prepared a model construction site erosion control ordinance (WDNR, 1987) for use by local communities.

In 1992 and 1994 the State of Wisconsin adopted regulations to control construction site erosion. The Wisconsin Department Commerce has adopted administrative rules under the Wisconsin Uniform Building Code, regulating erosion from the construction of single family homes, duplexes, and commercial buildings. The WDNR, under the authority of the 1987 Clean Water Act revisions, has issued a general permit regulating erosion from developments five acres and larger in size. All sites greater than five acres in size must submit a notice of intent to WDNR 14 working days prior to the start of construction and have an erosion control plan that meets the standards of Wisconsin Administrative Code NR 216, and the Wisconsin Construction Site Best Management Practice Handbook.

Feasibility of Alternative

The City of Oak Creek has a construction site erosion control ordinance. Ordinance language is found in Sections 14.111, 13.80, and 13.87 of the Municipal Code. The ordinances were last revised in January of 1999. The City Building Inspector administers the ordinance along with the provisions of the Uniform Building Code. Continued administration and enforcement of the ordinance is recommended as part of this plan.

Street Sweeping

Street sweeping involves the removal of dust, debris and trash from parking lots and street surfaces. Streets are normally swept with either mechanical broom or vacuum sweepers. The theory behind pollution control by street sweeping is: if the materials are removed from the streets where they are deposited, they are no longer available to be transported by surface runoff. In most communities, street sweeping is done for aesthetics and urban housekeeping rather than pollution control. Unlike many urban nonpoint source control measures, street sweeping can be readily applied to existing urban areas without any physical disturbance or change to the landscape.

Street sweeping is most effective for the removal of coarse particles, leaves, trash, and other similar materials. Studies have shown that most of the pollutants on street surfaces with curbs and gutters are located within 1 meter of the curb (Novotny and Olem, 1994). Pollutants on the street surface are redistributed along the curb by wind turbulence generated from automobile traffic. The curb acts as a barrier, trapping pollutants blown off the center of the street by the cars. In areas without a curb, much of the pollution mass is blown out into adjacent grass areas. Therefore, for street sweeping to be effective on streets, the street must have a curb. Pollutants reduced by street sweeping include sediment, nutrients, and oxygen demanding compounds (MPCA, 1989).

The effectiveness of street sweeping is a function of the type of equipment, effectiveness of the operator, presence or absence of parked cars along the curb, time of the year, traffic volumes, and frequency of sweeping. Table 7-1 outlines the effectiveness of street sweeping using a broom style sweeper for the removal of sediment based on various sweeping frequency in Milwaukee, Wisconsin.

Table 7-1 Sediment Removal Effectiveness of Street Sweeping

Land Use	Percent Sediment Removal by Frequency of Street Sweeping (Times Per Month)			
	0.3	1.0	2.0	4.0
Low Density Residential	<1%	1%	2%	3%
Medium Density Residential	<1%	1.5%	2%	4%
High Density Residential	<1%	1%	2%	3.5%
Commercial	10%	26%	35%	47%
Industrial	7%	9%	20%	28%

Source: SEWRPC, 1991

It can be seen that street sweeping using a broom sweeper does not remove sufficient sediment quantities in residential areas to be effective as a pollution control practice. Sweeping in commercial and industrial areas can provide some pollution reduction; however, sweeping frequencies of at least 4 times per month (once per week) are required for any reasonable levels of control. Street sweeping in the fall, when large amounts of leaves are on the street surface, and in the spring, following winter accumulation of particulates and prior to heavy spring rains, provide the greatest pollutant removal efficiencies per sweeping. Street sweeping in the summer months is not as effective because frequent rainstorms typically remove the pollutants from the street prior to the sweeping operation.

Tests are being conducted on several new lines of "high efficiency" sweepers. These new sweepers are designed to pick up smaller particle sizes and more contaminants off the pavement surface. Preliminary results indicate that efficiencies range from 50% for monthly sweeping to 76% if done weekly on major arterial streets. The Wisconsin Department of Transportation is conducting a study of a high efficiency sweeper manufactured by Schwarze, Inc. on the interstate system in Milwaukee starting in 1999.

The cost of street sweeping ranges from $15.48 to $32.64 per curb mile. Capital costs for a mechanical street sweeper ranges from $78,000 to $114,000, and traditional vacuum sweepers range from $132,000 to $144,000 (SEWRPC, 1991, updated to 1998 dollars). High efficiency sweepers cost between $190,000 to $250,000.

The City of Oak Creek currently sweeps all of the City streets with curbs twice per year, in the spring and fall. Milwaukee County sweeps the streets outlined in Table 7-2, 5 to 6 times per year. It is estimated that this activity reduces the annual total suspended solids exported from the City by less than 5,000 pounds per year.

Table 7-2 Highway Areas Swept by Milwaukee County

Highway	Area Swept[1]	Traffic Volume[2]	Curb Miles Swept
Interstate 94	Median and ramps only. Outside lanes have no curbs.	74,170 to 149,920	12.5
HWY 100 (E. Ryan Rd.)	I-94 to Shepard Ave.	8,950 to 13,110	10.0
HWY 38 (S. Howell Ave.)	College Ave.to Oakwood Rd.	8,040 to 22,760	20.3
HWY 41 (S. 27th St.)	Median only. Outside lanes have no curbs.	4,990 to 24,400	12.1
CTH ZZ (W. College Ave.)	27th Street to Howell Ave.	10,320 to 27,290	8.0
CTH BB (W. Rawson Ave.)	27th to Pennsylvania Ave.	8,310 to 37,060	13.9

[1] Source Milwaukee County Department of Public Works.
[2] Source 1996 Wisconsin Highway Traffic Volume Data (WDOT, 1997).

Feasibility of Alternative

If street sweeping, using the existing mechanical equipment, was increased on the major roadways in the City to twice per month, or weekly from April through October, it is estimated that total suspended solids loadings could be reduced by 249,000 to 334,250 pounds per year respectively. These reductions represent 3.0 to 4.0% of the total solids loadings. Major roadways include I-94, Ryan Road, Howell Avenue, 27th Street, College Avenue, Rawson Avenue, Drexel Avenue, Puetz Road, and Forest Hill Avenue. The annual operation and maintenance cost of sweeping weekly is estimated to range from $44,000 to $92,250.

As will be discussed later in this chapter, treatment options for many of the existing commercial and industrial areas and the freeway are limited by available open space. Street sweeping in these areas is one of the few water quality treatment options. It is recommended that the major roadways discussed above be swept once per week from April through October. If research on the new high efficiency sweepers shows positive results, it is recommended that the City of Oak Creek sweep all commercial and industrial areas with the new equipment at the frequencies recommended by the research.

Fertilizer Management

A source of phosphorus and nitrogen in the runoff from landscaped surfaces can be the excessive use of lawn fertilizers. Fertilizer management involves the control of the rate, timing, and method of fertilizer application in urban areas so that excess nutrients do not contaminate the surface or groundwater. By applying fertilizers at rates that are proportional to the lawn's needs, excess nutrients are not available to be removed by the runoff. Based on the limited monitoring data available, it is not possible to evaluate the total effectiveness of fertilizer management on downstream water quality.

The following is a list of recommendations for safe fertilizer application:

1. Have the soil tested for its nutrient needs and follow the recommendations of the test. In most states the University Extension provides soil testing at a nominal fee through the local County Extension Office.

2. Apply fertilizer twice per year, in the spring and fall. Never apply more than is recommended on the manufacturer's label.

3. Leave grass clippings on the lawn. This is equal to one fertilizer application per year.

4. Water the lawn after fertilizing, but do not allow the water to runoff into the ditch or street.

5. Any fertilizer spilled on roads or sidewalks should be promptly cleaned.

6. Never apply fertilizer to frozen ground.

7. Leave a buffer strip along ditches, waterways, and ponds that are not fertilized.

Feasibility of Alternative

The City of Oak Creek should adopt the above guidelines for all lands managed by the City, including local parks and municipal properties. In addition, the City should conduct a public education program on lawn care by providing information at the City Hall and through the City's newsletter, the Acorn. Educational material is available from the University of Wisconsin Extension.

Litter Control

Litter control involves the removal of leaves, grass clippings, and other debris from hydraulically active areas such as curbs and waterways. It has been estimated that an average tree drops 14.5 to 26 kilograms of leaves per tree per year (Novotny and Chesters, 1981). The leachate from leaves and lawn clippings is a source of phosphorus in urban runoff. Preventing these materials from being placed in an area where they can be washed away can reduce phosphorus loadings.

Feasibility of Alternative

The City does not collect leaves from private properties. Residents are allowed to bring leaves to the City's recycling yard at 800 W. Puetz Road where they are composted and made available to residents as organic mulch. The City does not accept grass clippings at the recycling center.

Pet Waste Control

Pet waste can be a source of fecal bacteria, nutrients, and oxygen demanding compounds in urban runoff when allowed to be deposited on sidewalks or street surfaces. To control pet waste, the owner should pick up any material deposited by their pet and dispose of it in a proper manner by placing it in the garbage, flushing it down the toilet, or burying it in the backyard. To prevent the potential spread of disease, pet waste should not be placed in compost piles where the compost will be used on vegetable gardens (UW-EXT, 1994).

Feasibility of Alternative

The City of Oak Creek regulates animal waste through local ordinance. Section 7.45 of the Municipal Code prohibits the deposit of fecal matter on any areas off the owner's premises. Section 7.62 of the Code regulates kennel operations and the disposal of pet waste.

Control of Waste Dumping

Many people falsely believe that the storm sewer inlet in the street leads to the local wastewater treatment plant and that waste dumped down these inlets will be treated. The truth is that dumping material, such as used oil, down an inlet is like dumping the material right into the local stream.

In Wisconsin, the University of Wisconsin Extension (UWExt) has developed a storm sewer stenciling program to educate people where the storm sewer leads and that waste should not be dumped down inlets. The program involves stenciling a statement such as "Dump no Waste-Leads to Stream" on the curb next to the inlet. In addition, a leaflet explaining the program and what local residents can do to protect water quality is left at the door of nearby homes. Materials to conduct the program are available to local municipalities and civic organizations.

Feasibility of Alternative

The City of Oak Creek Municipal Code contains sections 8.04, 8.20, 11.102 and 17.0805 that prohibit the discharge or dumping of waste in the City's drainage system.

The City of Oak Creek School District has taken advantage of the UWExt stenciling program and has stenciled many of the streets in the City. An annual program to inspect the stencils should be conducted and worn stencils should be repainted.

Volume Reduction Alternatives

Grassed Swales

Conventional grassed swales are earthen channels that convey stormwater. Swales remove pollutants from urban stormwater runoff by filtration through the grass and infiltration through soil (Ferguson, 1994). The filtering capacity of the vegetation is dependent on the depth of flow. Typically, when the flow depth is above the top of the vegetation, filtering is minimal. Typical pollutant removals for grass swales are outlined in Table 7-3.

Table 7-3 Percent Pollutant Load Reduction by Grass Swales

Pollutant	Study						
	Seattle (1992)		Florida (1988)		Virginia (1989)	Maryland (1989)	Florida (1989)
			wet	dry			
Swale length (ft)	100	200	230	230	185	193	185
Suspended sediment	60	83	81	87	65	(-85)	98
Total phosphorus	45	29	17	83	41	12	18
Total lead	15	67	50	90	41-55	18-92	67-94
Total zinc	16	63	69	90	49	47	81
Total copper	2	46	56	89	28	14	62-67
Total aluminum	16	63					
Total cadmium			42	89	12-98	85-91	29-45
Total chromium			37	88	12-16	22-72	51-61
Nitrate	neg.	neg.	52	80	11	(-143)	45
TPH (hydrocarbons)	49	75					
Organic carbon					76	23	64

Source: (Seattle METRO, 1992) (Harper, 1988) (Dorman, et.al., 1989).

It is recommended by the Minnesota Pollution Control Agency (MPCA, 1989), for a grass swale to be effective, it should be constructed as a broad, wide channel with side slopes of no greater than 3:1 and a grade no greater than 2 percent. To prevent channel erosion, velocities in the swale should not exceed 3-6 feet per second (Goldman, et.al., 1986). To maximize the potential for infiltration, velocities should not exceed 2 feet per second for the design storm. For effective pollutant control, the depth of the water should not be greater than 12 to 18 inches. To maintain proper drainage, grass swales should not be constructed with less than 1.5% grade. Enhanced grassed swales, or biofilters, utilize check dams and wide depressions to increase runoff storage, promote greater settling of pollutants, and allow water to be stored to facilitate infiltration.

The cost of a typical grass swale with a 3-foot bottom width and 1-foot depth is estimated at $9.75 per foot (SEWRPC, 1991, updated to 1998 dollars).

Maintenance activities for grassed swales include clearing of debris, periodic mowing, spot reseeding or resodding, weed control, and watering during drought. Grass height should be maintained at 4-6 inches to filter runoff and slow down flow velocities. Application of pesticides and fertilizers should be minimized. Estimated annual operation and maintenance costs range from $0.70 per lineal foot for a 1.5 foot deep, 10 foot wide swale, to $0.90 per lineal foot for the three foot deep, 21 foot wide swale (SEWRPC, 1991, updated to 1998 dollars).

Feasibility of Alternative

Storm sewers drain much of the City of Oak Creek. Grass swales are found predominately in older developments and along major state or county highways. Stormwater quality modeling, using the SLAMM model, indicates that existing grass swales in the City reduce total suspended loadings by 13 %.

Grass swales are not encouraged by the City due to maintenance problems caused by the high groundwater levels in the area. Under section 14.123 of the Municipal Code and Chapter 5 of the City's Engineering Manual, all new developments in the City of Oak Creek shall have separate storm sewer and sanitary sewer systems (as opposed to a combined sewer, which would carry both storm and sanitary flows.) Grass swales can be used in areas developed under the City's Rs-1 and Equestrian zoning categories and for relief swales to provide overland flow routes for storms larger than the design capacity of the storm sewer system. Therefore, use of grass swales, as a stormwater quality treatment practice has only limited feasibility in the City. The practice could be used for isolated sites where the swale is integrated into the design of the development in combination with storm sewers, such as a parking lot or roof drain system.

Filter Strips

Filter strips are vegetated sections of land designed to accept runoff as overland sheet flow from upstream development. They may adopt any natural vegetated form, from grassy meadow to small forest. The dense vegetative cover facilitates pollutant removal. In areas of A and B soils, filter strips can facilitate infiltration. Filter strips cannot treat high velocity flows; therefore, they are generally used for small drainage areas. Grass filter strips provide higher pollutant removal rates than grass swales. Filter strips differ from grassed swales in that swales are concave vegetated conveyance systems, whereas filter strips have fairly level surfaces.

The rate of pollution removal is a function of the length, slope, soil, and permeability of the filter strip. Strips are effective in removing sediment and sediment associated pollutants such as bacteria, particulate nutrients, pesticides and metals. At least a 40% removal of sediment can be expected from strips as narrow as 25 feet, and strips 90 to 300 feet wide may remove all of the sediment load, depending on the soil permeability and sediment source (SEWRPC, 1991).

General guidelines for grass filter strips are outlined in Table 7-4.

Table 7-4 Guidelines for Grass Filter Strip Design

Design Parameter	Design Criteria
Filter width	Minimum width 50 to 75 feet (15 to 23 meters), plus 4 additional feet for each 1% slope.
Filter slope	Maximum slope of 5%.
Flow velocity	Maximum flow velocity of 2.5 fps (0.75 m/s).
Grass height	Optimum grass height of 6 to 12 inches (15 to 30 cm).
Flow distribution	Should include a flow spreader at the upstream end to facilitate sheet flow across the filter.

Source: (MPCA, 1989) (Novotny and Olem, 1994).

Costs of filter strips vary widely depending on if they are constructed, or if existing landscaped or open space areas are used. Costs per foot of length of a constructed 1,000 foot long buffer strip range from $10.80 to $27.60 for a 25 foot wide strip, $20.40 to $51.60 for a 50 foot wide strip, and $38.40 to $98.40 for a 100 foot wide strip (SEWRPC, 1991, updated to 1998 dollars).

Dense grass needs to be maintained in filter strips. Gully and channel formation should be prevented. Spot repairs of the turf, watering, and fertilization may be needed. Grass heights should remain at six inches or greater. Pesticide and fertilizer use should be limited to the minimum necessary for dense growth. Annual operation and maintenance of filter strips includes mowing and the repair of bare spots. Estimated annual operation and maintenance costs range from $0.61 per foot for a 25-foot wide filter strip, to $2.05 per foot for a 100-foot wide strip (SEWRPC, 1991, updated to 1998 dollars).

Feasibility of Alternative

Filter strips may be feasible for individual developments to treat parking lot or roof drainage.

Infiltration Basins

An infiltration basin is a water impoundment constructed over permeable soils. The purpose of the basin is to temporarily store surface water runoff from a specific design storm and allow it to infiltrate through the bottom and sides of the basin. Pollutants are removed by the filtering action of the soil. Infiltration basins also provide for groundwater recharge, reduced volumes of runoff, and reduced peak discharges. Table 7-5 outlines typical long-term pollutant removal rates for infiltration basins and trenches.

Table 7-5 Typical Long-Term Pollution Removal Rates for Infiltration Trenches and Basins

Pollutant	Typical Removal Rates
Sediment	75-90%
Total Phosphorus	50-70%
Total Nitrogen	45-60%
Biological Oxygen Demand	70-80%
Metals	75-90%
Bacteria	75-90%

Source: Schueler, 1987

For infiltration basins to be feasible, the subsoils needs to have an infiltration rate of 0.27 inches per hour or greater (MPCA, 1989). This corresponds to soils in the A and B hydrologic soil classification, which includes silt loam, loam, sandy loam and sandy soils. Construction methods for infiltration basins must ensure that the soils are not compacted, reducing their infiltration capacity.

The potential for groundwater contamination is an obvious concern when planning an infiltration basin. The basin should be designed to have a 2- to 4-foot separation between the bottom of the basin and the water table. Studies of five infiltration basins conducted by NURP have found that soil beneath the basins effectively traps the pollutants and that no significant groundwater contamination was taking place (MPCA, 1989). However, infiltration basins should not be used to treat runoff that may contain large quantities of very soluble pollutants, such as nitrates or pesticides like diazinon.

Infiltration basins need to drain down and dry out in a reasonable period of time to prevent sealing of the bottom by a slime layer of algae, bacteria, and fungus. If water is allowed to sit in the bottom of the basin more than 72 hours in most climates, the conditions to allow slime formation is high.

To maintain the infiltration capacity of the basin, it is important that excessive sediment loadings be avoided. Studies in the State of Florida have found that infiltration basins with grass bottoms tended to perform longer than basins with earthen bottoms. A potential reason for the improved performance of grass bottom basins may be that the organic debris of the grass provides habitat for burrowing insects and worms that assist in naturally keeping the soil aerated, maintaining infiltration capacity of the upper soil layer.

General guidelines for the design of infiltration basins are summarized in Table 7-6.

Table 7-6 Guidelines for Infiltration Basin Design

Design Parameter	Design Criteria
Drainage area range	5 to 50 acres
Minimum infiltration rate	0.27 inches/hour
Maximum ponding time	72 hours
Inlet control	Pre-filtration of settleable solids

Source: (MPCA), 1989)

Maintenance needs include inspections annually and after large storms, mowing at least twice a year, debris removal, erosion control, and control of nuisance odor or mosquito problems. Deep tilling may be needed at 5 to 10 year intervals to break up a clogged surface layer. The tilled surface would then need to be graded and re-vegetated. In some cases, an underdrain pipe may be needed to maintain adequate drawdown conditions. Accumulated sediments may also have to be removed by light equipment. The average annual operation and maintenance costs are about three to four percent of the capital cost (SEWRPC, 1991).

Feasibility of Alternative

Soils within the City of Oak Creek fall predominantly in the C and D hydrological classification, making infiltration on a large scale not feasible. Isolated areas of B classification soils are present making infiltration basins feasible for small isolated sites. On site investigations would be required to determine the feasibility of this alternative on a site-specific basis. Caution should also be taken during siting and design of infiltration basins to protect existing underground structures, such as foundations and sanitary sewers.

Infiltration Trenches

A conventional infiltration trench is a shallow, excavated trench that has been backfilled with stone to create an underground reservoir. Stormwater runoff diverted into the trench gradually exfiltrates from the bottom of the trench into the subsoil and eventually into the water table. Stormwater is treated by the soil adjacent to the trench. Infiltration trenches work similar to infiltration basins and have similar pollutant removal capacities. General guidelines for the design of infiltration trenches are summarized in Table 7-7.

Table 7-7 Guidelines for Infiltration Trench Design

Design Parameter	Design Criteria
Drainage area range	2 to 5 acres
Minimum infiltration rate	0.27 inches/hour
Min. separation from groundwater	2 to 3 feet
Inlet control	Pre-filtration of settleable solids

Source: (MPCA), 1989) (Schueler, et.al., 1991)

Infiltration trench costs range from $50.40 to $600.00 per lineal foot depending on the trench width and depth (SEWRPC, 1991, updated to 1998 dollars).

Enhanced infiltration trenches have extensive pretreatment systems to remove sediment and oil. They require on-site geotechnical investigations to determine appropriate design and location.

Maintenance includes inspections annually and after large storms, buffer strip maintenance and mowing, and rehabilitation of the trench when clogging begins to occur. Surface clogging can be relieved by replacing the top layer of the trench, but bottom clogging requires the removal of all of the filter and stone aggregate. Estimated annual operation and maintenance costs range from $342 for a 3-foot deep, 4-foot wide, 100-foot long trench, to $738 for a 6-foot deep, 10-foot wide, 100-foot long trench (SEWRPC, 1991, updated to 1998 dollars).

Feasibility of Alternative

Due to the low permeability of most of the soils in the City of Oak Creek, use of infiltration trenches on a large-scale basis is limited. Infiltration trenches may be feasible for the infiltration of roof top drainage on selected sites. Site specific soil boring would be required to determine the site-specific feasibility of this stormwater practice.

Porous Pavement

Porous pavement is an alternative to conventional pavement whereby runoff percolates through a porous surface layer and into an underground stone reservoir. Porous pavements can provide for stormwater storage and enhanced infiltration. The stored runoff in porous pavement gradually infiltrates into the subsoil or is drained away by a subdrain system. The pavement is either made from asphalt, in which the fine filler fractions are missing, or modular or specially poured concrete. Results from a study in Rochester, New York, indicated that peak runoff rates were reduced by 83% when porous asphalt was used (Novotny and Olem, 1994). Hydraulic conductivity of porous pavements have been measured to be greater than typical rates of stormwater runoff. Hydraulic conductivity measured by Jackson and Ragan (1974) was about 250 cm/hr, indicating that properly installed porous pavement can infiltrate 100 percent of most design storms without causing surface ponding.

Pollutant removal using porous pavement, based on two monitoring studies, has been shown to control 80% of suspended sediment, 60% of the total phosphorus, 80% of nitrogen, and high levels of trace metals and organic matter (Schueler, et.al., 1991).

General guidelines for the design of porous pavement are summarized in Table 7-8.

Table 7-8 Guidelines for Porous Pavement Design

Design Parameter	Design Criteria
Drainage area range	Maximum 10 acres
Minimum infiltration rate	0.5 inches/hour
Min. separation from groundwater	2 to 3 feet
Maximum pavement slope	5 percent
Maintenance	Frequent vacuum sweeping of fine sediment

Source: (Schueler, et.al., 1991)

Porous pavements can easily become clogged with fine sediment, and therefore, are not recommended for high traffic areas and require frequent cleaning with vacuum-type street sweeping equipment.

The capital cost of a conventional asphalt parking lot is approximately $48,000 per acre. The additional cost for a porous asphalt parking lot is estimated to range from $48,000 to $93,600 per acre in Southeastern Wisconsin. Annual maintenance cost for cleaning is estimated at $24.00 per acre (SEWRPC, 1991, updated to 1998 dollars).

Feasibility of Alternative

Due to the high groundwater table, this alternative has limited feasibility in the City of Oak Creek.

Stormwater Storage and Treatment Alternatives

Wet Detention Ponds

Wet detention ponds are impoundments that have a permanent pool of water and also have the capacity to temporarily store stormwater runoff until it is released in a safe manner. The capacity to hold runoff and release it at a lower rate than incoming flows has made detention ponds a popular practice for flood control and stormwater management. Ponds with a properly designed permanent pool can trap sediment and prevent it from being scoured off the bottom by future storms. Dry detention ponds have lower pollutant removal efficiencies than wet bottom ponds, as sediment can be scoured off the bottom by incoming flows. Table 7-9 outlines typical pollutant removal for various detention pond types.

Table 7-9 Pollutant Removal Capacities of Various Detention Pond Designs

Pond Type	Suspended Sediment	Total Phosphorus	Total Nitrogen
Dry detention	0-20		
Extended dry	30-70	10-30	10-60
Wet detention	50-90	30-90	40-80
Enhanced wet	52-98	47-69	54

Source: (Schueler, et.al., 1991)

Wet detention ponds are effective at removing sediment-related pollutants. Pollutants removed by wet detention ponds include sediment, nutrients, heavy metals, oxygen demanding compounds (BOD), hydrocarbons, and bacteria. An expanded list of typical pollutant removal efficiencies for wet detention ponds is outlined in Table 7-10.

Pollutant removal in wet detention ponds is primarily due to the settling of particulate pollutants and sediment due to gravity. The State of Wisconsin has developed a detention pond sizing methodology that is outlined in the Wisconsin Stormwater Manual, Part Two: Technical Design Guidelines for BMP's (WDNR, 2000).

Table 7-10 Pollutant Removal Efficiencies of Wet Detention Ponds

Pollutant	Percent Removal
Suspended Solids	85-96%
Oxygen Demanding Compounds	50-70%
Total Phosphorus	40-70%
Dissolved Phosphorus	40-72%
Nitrate Nitrogen	60-80%
Kjeldahl Nitrogen	20-40%
Copper	60-80%
Lead	80-95%
Zinc	40-80%

Source: Walker, 1987

The methodology recommended in the Wisconsin Stormwater Manual is based on data from the National Urban Runoff Project (NURP) and sizes the pond based on land use characteristics of the drainage area and particle size distribution of the runoff. To achieve a 90% removal efficiency of 5 micron and larger particles, Wisconsin has developed a sizing method that sizes the permanent pool based on a percent of the drainage area and type of land use. Table 7-11 outlines the percent of each land use in a drainage area that is required as a permanent pool. To meet the 90% removal efficiency, the pond must have a minimum depth of 3 feet, and have live storage to retain the runoff from the first 1.5 inches of rainfall. The outlet structure is sized to maintain overflow velocities below the settling velocity of the smallest target particle size.

Table 7-11 Percent of Drainage Area Required as Wet Detention Permanent Pool

Land Use	Percent of Drainage Area [1]
Freeways	2.8%
Industrial	2.0%
Commercial	1.7%
Institutional	1.7%
Residential	0.8%
Open Space	0.6%

Source: Pitt, 1991
[1] Assumes average depth of 3 feet.

An alternative to the sizing criteria in the Wisconsin Stormwater Manual is to size the basin based on a maximum release rate. The maximum release rate would be based on historic flows from the area. Studies in northeastern Illinois, in similar soils and topography, show that a release rate of 0.04-cfs per acre for the 2-year storm simulates natural background flow conditions better than the WDNR approach. A comparison of the advantages of this type of basin to the WDNR approach is outlined in Table 7-12. The sizing criteria for a 0.04-cfs/acre basin as a percent of various land uses are outlined in Table 7-13.

Table 7-12 Comparison of the Benefits of the Maximum Release Rate and WDNR Pond Sizing Criteria

Sizing Criteria	Benefits
WDNR Criteria for Wet Detention	1. Reduction in suspended solids 2. Reduction in phosphorus and heavy metals
Maximum 2-year Release Rate of 0.04 cfs/ac	1. Reduction in suspended solids 2. Reduction in phosphorus and heavy metals 3. Reduced downstream erosion 4. Reduced downstream drainage problems 5. Reduced damage to aquatic habitat downstream

Source: WDNR, 1999

Table 7-13 Percent of Drainage Area Required as Wet Detention Based on a Maximum Release Rate of 0.04-cfs per acre for the 2-year Storm

Land Use	Percent of Drainage Area [1]
Freeways	6.0%
Commercial	5.0%
Industrial	4.0%
Residential	2.7%
Open Space	0%

Source: Hey and Associates, Inc.
[1] Assumes average depth of 3 feet.

To control maintenance cost, wet detention ponds can be constructed with a forebay to trap coarse sediments in a location from which they can be easily removed. The cost of a wet detention pond varies greatly depending on the basin size and design, site constraints, and the cost of the land. Capital costs have been estimated to range from as low as $33,600 for a 0.25-acre basin to $410,400 for a five-acre basin (SEWRPC, 1991, updated to 1998 dollars).

Routine maintenance tasks include vegetation care, basin inspections, debris removal, erosion control, and nuisance plant control. Periodic maintenance tasks include inlet and outlet repairs and sediment removal. The estimated annual operation and maintenance cost for a wet detention basin is about three to five percent of the capital cost (SEWRPC, 1991).

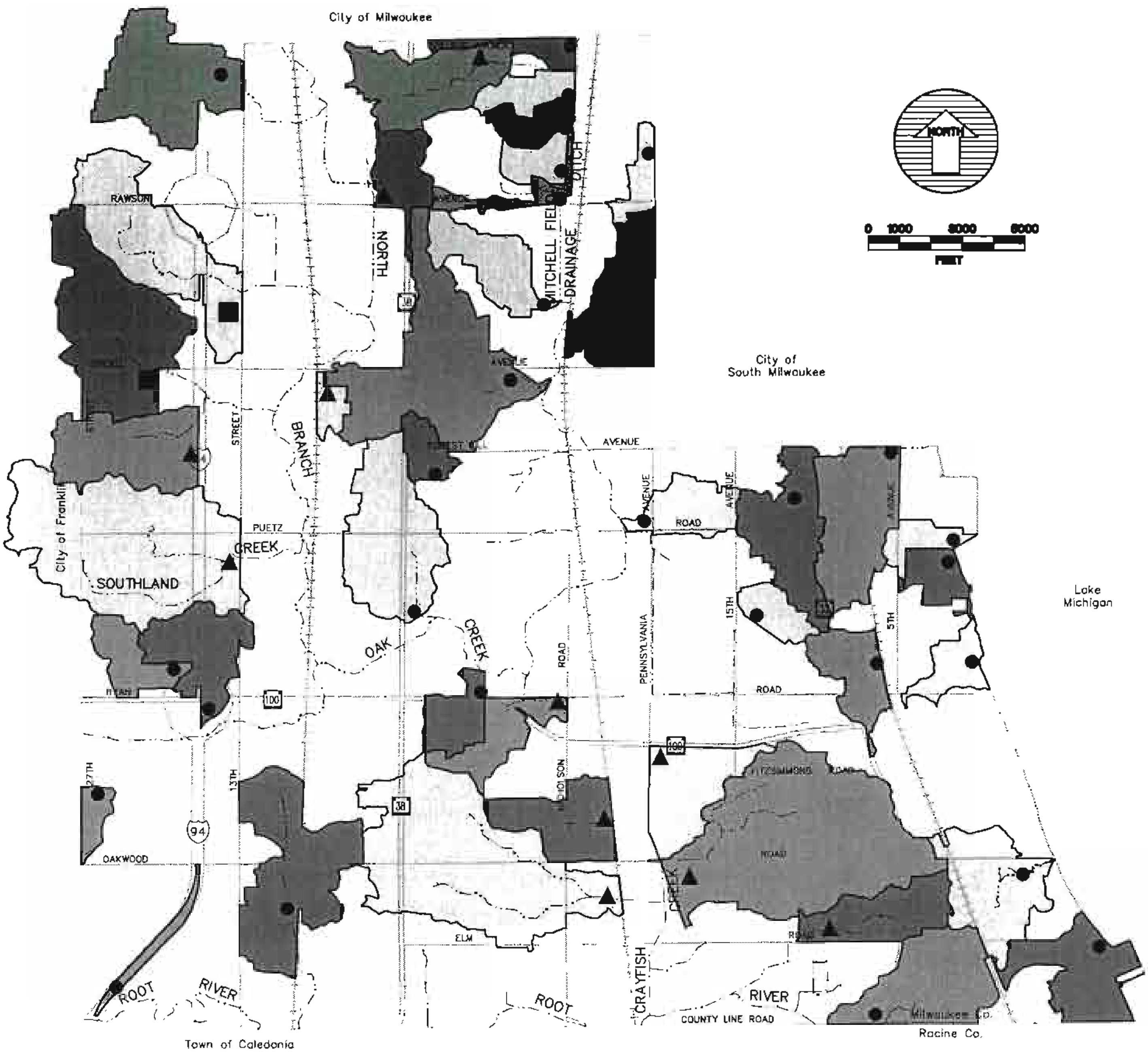
Feasibility of Alternative

Wet detention appears to be the most feasible water quality treatment alternative for use in the City of Oak Creek. Wet detention basins or wetland filters are recommended for all new developments. To meet the 50 % suspended solids reduction from existing development recommended in the A Regional Water Quality Management Plan for Southeastern Wisconsin: An Updated and Status Report (SEWRPC, 1995,) several key subbasins would need to be retrofitted with detention ponds.

Target areas for water quality treatment of existing development should be based on the highest concentrations of pollutants. Target areas include subbasins that drain industrial, institutional, commercial, and highway areas. However, in the City of Oak Creek many of the target areas do not have available space for detention storage due to existing development. To identify potential detention pond locations, each of the subbasins was ranked in order of total suspended solids loadings on a unit area basis. Starting with the highest unit area loading, each drainage area was evaluated for potential detention based on drainage and available open space. Table 7-14 summarized the location of potential wet detention basins, the total suspended solids reductions, and cost. Figure 7-1 illustrates the locations for the potential wet detention ponds that could be utilized to meet the plan goals.

Routine maintenance of wet detention ponds include lawn care, basin inspections, debris removal, erosion control and nuisance plant control. Periodic maintenance tasks include inlet and outlet repairs and sediment removal. The estimated annual operation and maintenance cost for a wet detention basin is about three to five percent of the capital cost (SEWRPC, 1991). Because of the potential for contaminated sediment, the material would need to be sampled and tested before removal. A permit would be required from the WDNR for the sediment dredging and disposal.

Figure 7-1
Recommended Detention Pond and Wetland Locations



Legend

- ● PROPOSED NEW OR RETROFIT WET DETENTION POND
- ▲ PROPOSED NEW OR RETROFIT WETLAND TREATMENT SYSTEM
- ■ POTENTIAL REGIONAL WATER QUALITY POND FOR NEW DEVELOPMENT

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Table 7-14 Potential Location of Wet Detention Basins

Subbasin Location of Detention Pond	Subbasins Treated	Total Suspended Solids Reduction per Year	Permanent Pool Surface Area (acres)[1]	Estimated Capital Cost[2]
CB3-6 (retro)	CB3-1 through CB3-6	50,115	1.69	$144,900
L1-6	L1-1 through L1-6	90,102	3.24	$268,500
L2-7 (retro)	L2-1 through L2-7, except L2-5	37,653	1.19	$105,000
L5-3	L5-1 through L5-3	106,199	2.07	$175,180
LG-8	LG-5 through LG-8	677,789	0.82	$75,500
LG-11 (north)	50% LG-11	73,425	1.17	$103,500
LG-11 (south)	50% LG-11	78,844	1.22	$107,400
LG-17 (retro)	LG-15 Through LG-17	283,457	2.99	$248,600
M2-2	M2-1 and M2-2	20,404	0.47	$47,600
M3-2	M3-1 and M3-2	16,301	0.52	$51,600
M5-7	M5-1 through M5-7	32,981	1.02	$91,500
MF-10	MF-7 through MF-10	20,680	0.39	$41,300
MF-20	MF19 and MF-20	16,788	0.40	$42,000
MF-21	MF-21 and MF-22	51,737	0.39	$40,900
N2-5G	N2-1 through N2-5	109,273	3.58	$295,900
O3-2	O3-1 and O3-2	47,688	1.00	$89,900
O5-13	O5-1 through O5-13	103,593	1.90	$161,700
O8-13	O8-1 through O8-13	204,032	3.35	$277,300
O10-5	O10-1 through O10-5	27,279	0.83	$76,300
O17-2 (retro)	O17-1 and O17-2	4,746	0.26	$30,900
O18-5	O18-5 through O18-9	27,071	0.82	$75,500
O19-6	O19-1 through O19-6	14,798	0.48	$48,400
O20-14&15	O20-1 through O20-15	179,454	4.80	$392,900
O24-6 (retro)	O24-1 through O24-6	53,062	1.85	$157,700
O25-4	O25-1 through O25-5	21,623	0.67	$63,600
OC-447 (retro)	OC-447	34,236	0.42	$43,600
OC-500	OC23-1 through OC23-5, and OC-500	21,623	0.77	$71,900
RR-2	RR-2	31,367	0.39	$41,300
Total		**2,436,320**	**38.7**	**$3,370,380**

[1] Size based on Wisconsin Stormwater Manual

[2] Easement and land acquisition cost are not included

If installed, the above detention basins would reduce the existing annual total suspended solids loadings by 2,436,320 pounds per year, or 28.4%.

Regional Water Quality Basins

In the A Comprehensive Plan for the Oak Creek Watershed (SEWRPC, Planning Report 36, 1986), the Southeastern Wisconsin Regional Planning Commission (SEWRPC) recommended that three regional (centralized) detention facilities be constructed for water quality. The basins are located on the Mainstem of Oak Creek upstream of the confluence with the North Branch, on the North Branch upstream of Drexel Avenue, and on the Mitchell Field Drainage Ditch north of Rawson Avenue. The three basins are 7-, 8-, and 6-acres in size respectively. The water quality benefits of these three basins are being examined. The results will be supplied at a later date.

Feasibility of Alternative

The water quality benefits of these three basins were examined using the EPA (1986) pond sizing methodology. This methodology evaluates the pond performance under dynamic conditions during storm events and during quiescent conditions between storms using statistical analysis of storm frequencies and monitored pond performance. In the analysis, long-term mean storm volume and intensity were used based on data reported by EPA. The methodology looks at the average removal over all events for an average year.

In the SEWRPC Oak Creek watershed plan, it was recommended that the sedimentation basins would "*have a fixed surface water elevation and volume. The basins thus would not store additional runoff during storm events.*" This would result in pollutant removal only during the storm event (dynamic conditions). For this analysis it was assumed that the basins would be designed to have 2-feet of live storage to improve their performance during quiescent conditions.

Table 7-15 summarizes the results of the pond performance analysis for the three SEWRPC recommended basins.

Table 7-15 Performance of SEWRPC Recommended Detention Ponds

Particle Size (um)	Percent of TSS in Urban Runoff[1]	Settling Velocity (ft/hr)	Percent Removal			Percent Removal from Entire Watershed[2]
			Pond A	Pond B	Pond C	
2	0-20	0.03	10.41	10.90	10.90	4.37
5	20-40	0.3	22.81	35.84	42.40	13.36
12	40-60	1.5	42.40	56.80	60.73	21.40
26	60-80	7	56.80	90.40	91.53	31.84
80	80-100	65	92.00	90.40	91.53	37.26
Average			44.88	56.87	59.42	21.65

[1] Source: EPA, 1986.
[2] Based on a weighted percent of total watershed treated.

The ability of the three ponds to trap a 5-micron particle varies from 22% to 42% for the ponds individually and 45% to 59% for all of the sediment particles. When weighted based on the percentage of the drainage area treated, the performance of the three ponds combined is shown to be approximately 13% for the 5-micron particle size and 22% for all particles. The implementation of the SEWRPC watershed plan recommended sedimentation basins would provide about a 22% reduction in total suspended solids.

Implementation of this alternative would involve construction of the ponds on navigable streams, which are under the jurisdiction of the WDNR. WDNR discourages wet ponds on streams because of detrimental affects, particularly on fish movement. WDNR will not grant pollutant removal credit for ponds constructed on navigable streams even if permits are granted for the construction. Another impediment to this alternative, would be that portions of the proposed pond locations have been developed for other uses since the SEWRPC watershed plan was developed.

Extended Detention Ponds

Extended detention ponds are modified dry detention basins, designed to remove pollutants while still drawing down to a dry area between storms. Extended detention ponds temporarily detain stormwater runoff for up to 24 hours after a storm. Such extended detention ponds allow urban pollutants to settle out during storm events, but are designed to prevent resuspension during future storms. Extended detention basins are typically equipped with a riser pipe outlet, as compared to the straight outlet pipe in traditional dry detention ponds. A multiple-stage outlet design is usually needed to allow a high discharge rate for large storms, while providing very low outflow rates--possibly by under drains or perforated pipe--for small storms.

As illustrated in Table 7-9, extended detention basins have lower pollutant removal rates than wet detention ponds, but are a feasible alternative where a permanent pool is not safe and pollution control is needed. The extended detention ponds are normally "dry" between storm events and do not have any permanent standing water.

Costs and maintenance for extended detention basins are similar to those of wet detention basins.

Feasibility of Alternative

Extended detention basins should be used only on a limited basis where safety concerns prohibit the installation of other detention alternatives.

Stormwater Wetlands

Conventional stormwater wetlands are shallow pools that create growing conditions suitable for the growth of marsh plants. These constructed stormwater wetlands are designed to maximize pollutant removal through the processes outlined in Table 7-16.

Table 7-16 Biofiltration Process of Stormwater Wetlands

Biofiltration Processes	
Sedimentation	Volatilization
Filtration	Precipitation of colloids
Absorption	Photo-oxidation
Microbial decomposition	Vegetative uptake

Source: Kadlec and Knight, 1995

The effectiveness of natural and constructed wetlands to remove stormwater pollutants is outlined in Table 7-17.

Table 7-17 Percent Pollutant Removal by Constructed and Natural Wetlands

Wetland Type	Suspended Solids	Total Phosphorus	NH_3	Lead	Zinc
Constructed	80	58	44	83	42
Natural	76	5	25	69	62

Source: (Strecker et. al. 1992)

As can be seen from Table 7-17, constructed wetlands can perform better than natural wetlands for some pollutants, such as phosphorus, ammonia, and some heavy metals, when properly designed. The performance of a constructed wetland system is dependent on pollutant loading, hydraulic loading, detention time, and pollutant uptake of the system. As a general rule of thumb, a treatment wetland needs to be sized to be between 2 and 5% of the watershed area (Schaefer, et al., 1996).

Construction costs for stormwater wetlands vary greatly, and are difficult to predict except on a case by case basis.

Feasibility of Alternative

Due to the shallow water table in the City of Oak Creek, wetland filters are well suited to the area. Many of the existing wetlands could be retrofitted to provide improved downstream water quality following the wetland classification procedures outlined in Chapter 3. Table 7-18 outlines the potential locations for wetland treatment systems. The locations of these systems are illustrated on Figure 7-1.

Table 7-18 Potential Location of Wetland Treatment Systems

Subbasin Location of Wetland Treatment Systems	Subbasins Treated	Total Suspended Solids Reduction per Year	Surface Area of Wetland Needed (acres)[1]	Estimated Capital Cost[2]
C3-14	C3A-1 through C3A-5, and C31-1 through C3-14	151,447	36.35	$150,000
CB1-4	CB1-1 through CB1-4	38,359	8.09	$37,000
CC-2	C1-1 through C1-8, C2-1 through C2-17, C2a-1 through C2a-5, and CC-2	210,687	32.71	$136,000
M1-4	M1-1 through M1-4	51,983	11.00	$49,000
N1-2	N1-1, N1-2, & NB-27	170,268	5.23	$26,000
N5-6	N5-1 through N5-6	106,261	17.89	$77,300
N6-1	N6-1	4,679	1.77	$19,000
N7-6	N7-1 through N7-6	100,147	19.93	$85,000
N7-13	N7-11 through N7-13	48,801	12.13	$54,000
N10-15	N10-1 through N10-15, and N-10-F1 through N10-F6	132,622	31.87	$136,000
O11-3	O11-1 through O11-3	25,708	5.96	$29,000
O15-4	O15-1 through O15-4	27,371	8.29	$38,000
O17-9	O17-9	58,222	13.17	$58,000
R2-8	R2-1 through R2-8	89,858	17.87	$76,000
Total		**1,216,413**	**223.26**	**$970,300**

[1] Based on 5% of subbasin drainage area

[2] Easement and land acquisition cost are not included

If installed, the above wetland treatment areas would reduce the existing annual total suspended solids loadings by 1,216,191 pounds per year, or 14.2%.

Catch Basins

Catch basins are sumps, or chambers, installed in storm sewer inlets designed to trap coarse sediment. By trapping course sediment, the catch basin prevents trapped solids from clogging the sewer or being washed into receiving waters. To be effective, however, the sumps need to cleaned periodically.

Storm sewer inlets with sumps are effective at trapping coarse sediment and large debris, such as fast food containers and leaves. Typical catch basins, with a capacity of 0.5 to 1.5 cubic yards, have been estimated to retain up to 57% of the coarse solids and 17% of equivalent BOD (MPCA, 1989). A study in Boston, Massachusetts, found catch basins with routine cleaning can reduce solids by 60 to 70%, COD by 10 to 56% and BOD by 54 to 88% (Novotny and Olen, 1994).

In the absence of cleaning, catch basins can actually make water quality conditions worse. It has been reported that once a sump is 40 to 50% full, inflow water can begin to scour sediment and pollutants out of the sump, making the catch basin a source of pollutants (MPCA, 1989). Therefore, catch basins need to be cleaned when they reach 30 to 40% of their storage capacity.

Cost of catch basin cleaning has been estimated to range from $9.60 per basin for vacuum equipment, to $18.00 for manual cleaning. The capital costs for material and labor to install a catch basin generally range from $2,400 to $4,800 per basin (SEWRPC, 1991, updated to 1998 dollars).

Feasibility of Alternative

The City of Oak Creek currently cleans catch basins only when they become plugged. Within the City there are approximately 2,500 catch basins. The cost to clean each of these catch basins twice per year would range from $24,000 to $45,000 depending on the cleaning method used. The total suspended solids reduction produced by an active cleaning schedule is estimated at 2,000,000 pounds per year, or 25% of the annual loading.

Sand Filters

Sand filters are a relatively new technique for treating stormwater, whereby the first flush of runoff is diverted into a self-contained bed of sand. The runoff is then strained through the sand, collected in underground pipes, and returned back to the stream or channel. Monitoring has shown that by treating the first 1/2 inch of runoff through a sand filter, 85% of the sediment, 40% of phosphorus, and 50 to 70% of the heavy metals, oil and grease can be removed from the runoff (Schueler, et. al 1991).

Sand filters can be designed in several configurations including surface basin filters, underground vaults, and double trench systems. Enhanced sand filters utilize layers of peat, compost, limestone, and/or topsoil, and may also have a grass cover crop. The adsorptive media of enhanced sand filters is expected to improve removal rates. Pollutant removal rates for sand peat filters has been measured at 90% for total phosphorus, 70% for total nitrogen, and 90% for BOD (Schueler, et. al 1991).

Construction cost for sand filters range from $3 to $10 per cubic foot of runoff treated (Schueler, et. al 1991). For comparison purposes, sand filters cost about 2 to 3 times the cost of infiltration trenches.

Routine maintenance tasks include inspections annually and after large storms, debris removal, and upkeep of the pre-treatment practice, such as grass filter strips. Several designs are equipped with back flushing systems used to fluff the bed and maintain permeability of the sand. Periodic maintenance includes scraping off a clogged top layer of sand and replenishing the sand material.

Feasibility of Alternative

Sand filters should be considered for commercial developments where excess quantities of oils and grease in the runoff are anticipated, such as automobile service centers.

Chapter 8

Implementation Recommendations

Introduction

The following stormwater management recommendations address flooding, drainage, water quality, and environmental protection issues. The goal of the Stormwater Management Master Plan is as follows:

> *The goal of the City of Oak Creek Stormwater Management Master Plan is to protect, maintain, and enhance the public health, safety, and general welfare by developing a plan to control the adverse impacts of increased stormwater runoff associated with existing and planned land use and to recommend solutions to drainage problems. Proper management of stormwater runoff will minimize damage to public and private property, prevent inconvenience to local residents, protect water quality of surface and groundwater, maintain and enhance fish and wildlife habitat, protect public open space, and maintain the quality of life in the community.*

This chapter summarizes the Stormwater Master Plan recommendations, and discusses activities required for their implementation and financing options.

Improvement Priorities and Responsibilities

Chapter 2 of this report outlines the objectives needed to meet the above goal. The recommendations are consistent with the objectives. Implementation will require action by the City of Oak Creek and other agencies.

Due to fiscal constraints, not all of the recommendations can be implemented at one time. Therefore, a prioritization of the improvements is necessary. The priorities are presented in Table 8-1.

It should be noted that the recommendations and priorities might change if conditions change. The ranking of the recommendations is only a guide for planning purposes. Actual placement of projects into the City's capital improvement or maintenance budget will be based on available funds and ranking against other competing priorities.

Summary of Stormwater Management Recommendations

Flood Control and Drainage Recommendations

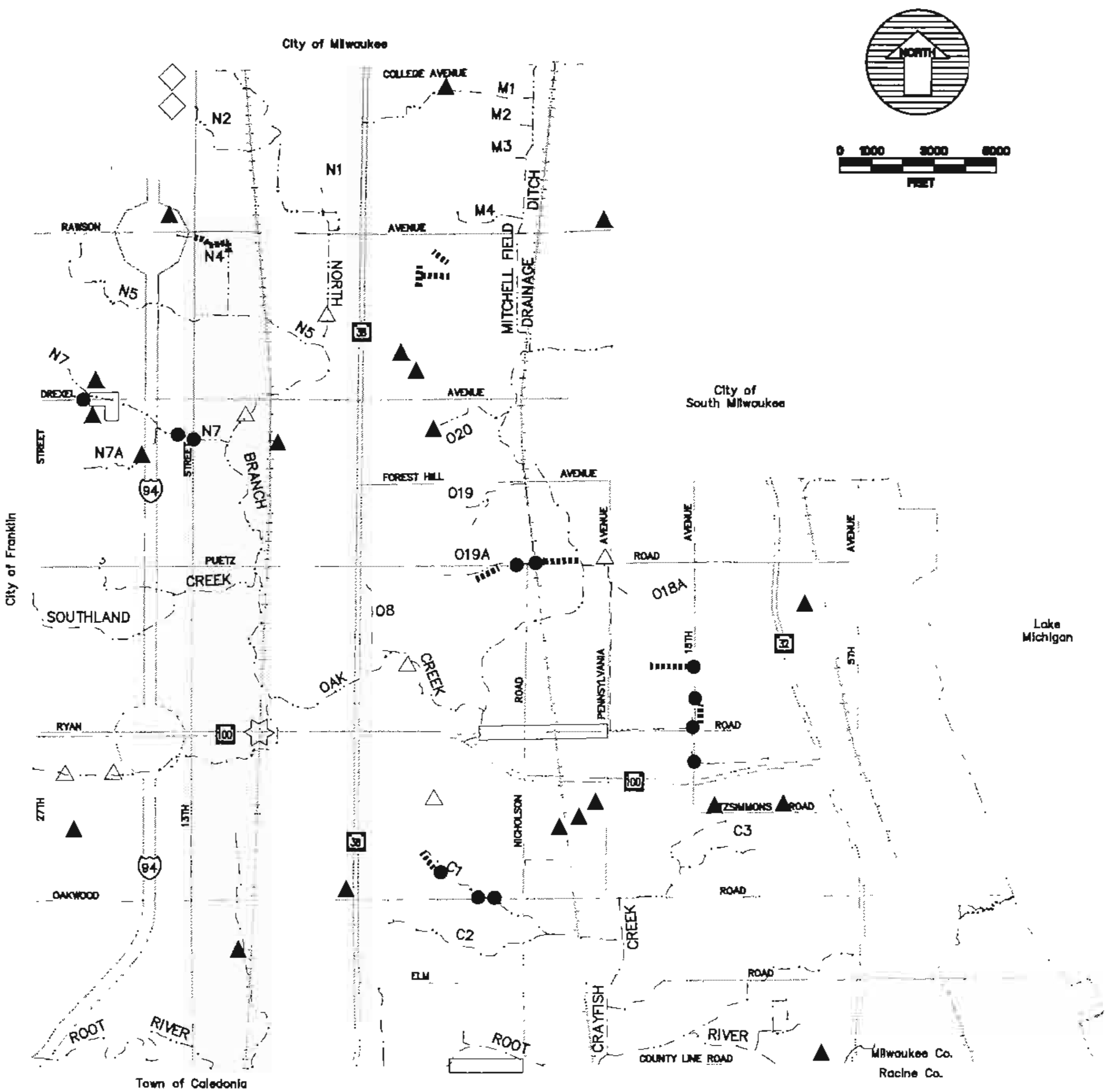
Recommended solutions for the flooding and drainage problem areas are summarized in Table 8-1 and illustrated in Figure 8-2. These recommendations are, in general, the least cost alternatives unless there are overriding considerations such as adverse ecological impacts, implementation barriers, or safety concems. The recommended priority and implementing agency are identified for each recommendation in Table 8-1.

Table 8-1 Flood Control and Drainage Recommendations

Tributary Stream	Recommendation	Capital Improvement Cost (1)	Annual O&M Cost	Implementing Agency	Priority
North Branch	Maintain storm sewer outlet at Marquette Ave.	–	$1,000	City	Inspect Annually
North Branch	Maintain storm sewer outlet at Drexel Ave. and Wildwood Dr.	–	$1,000	City	Inspect Annually
N2	Detention west of S. 13th St. and additional culvert at Pelton Dr. (coordinate with water quality recommendation for wet detention basin)	$ 1,105,000	$2,000	City & WDOT	9
N5	Revise easement at 7538 S. 13th St.	–	–	City	17
N4	Channel modification downstream of S.13th St. to box culvert at S. 10th St.	$ 689,000	–	City	7
N7	Culverts at Willow Dr. and S. 13th St. and raise Willow Dr.	$ 300,000	–	City	13
N7	Raise road and additional culvert at S. 20th St. and Drexel Ave. Obtain control of private driveway.	$ 211,000	–	City	8
Mitchell Field Drainage Ditch	Diversion berm and overflow swale at 7289 S. Quincy Ave.	$ 22,500	–	City	12
Mitchell Field Drainage Ditch	Swale along north property line at 7152 S. Taylor Ave.	$ 16,000	–	City	11
Oak Creek	Maintain storm sewer outlet at E. Puetz Rd. & Pennsylvania Ave. (coordinate with water quality recommendation for wet detention basin)	–	$1,000	City	Inspect Annually
Oak Creek	Pumping Station at 700 W. Ryan Rd. (STH 100)	$ 733,000	$ 40,000	City & WDOT	1
Oak Creek	Maintain storm sewer outlet at Parkway Estates & Oak View Ln.	--	$1,000	City	Inspect Annually
Oak Creek	Install storm sewer S. 11th Ave. (south of E. Puetz Rd.) to Madeira Dr.	$500,000	–	City	3
Oak Creek	Raise E. Ryan Rd. – Pennsylvania Ave. to west of Nicholson Rd.	$ 622,000	–	City	15
Oak Creek	Maintain storm sewer outlet at Southbranch Blvd. & Reinhart Dr.	–	$1,000	City	Inspect Annually
O11	Maintain storm sewer outlet at Arthur Dr.	–	$1,000	City	Inspect Annually
O15	Additional culverts and swales at S. 15th Ave. north of E. Ryan Rd.	$ 218,000	--	City	6
O16	Additional culvert at 15th Ave. south of E. Ryan Rd.	$ 75,000	–	City	10
O17	Reconstruct road and add culverts at 9000 S. Pennsylvania Ave.	City road project	–	City	14
O19A	Overflow grading south of E. Puetz Rd. east of S. Shepard Ave. Lower road and add culverts at Puetz Rd. and Nicholson Rd.	$ 304,000	--	City	4
O19A	Culvert under railroad north of Puetz Rd. and channel to Oak Creek east of Nicholson Rd.	$ 406,000	–	City	4

(1) Easement and land acquisition costs are not included.

Figure 8-1
Flood Control and Drainage Recommendations



Legend

C3	TRIBUTARY NAME
●	CULVERT
▪▪▪▪▪▪▪▪	CHANNEL OR SWALE
▲	PRESERVE NATURAL STORAGE
▭	FLOOD PROTECTION
☆	PUMPING STATION
△	STORM OUTLET MAINTENANCE
◇	DETENTION BASIN

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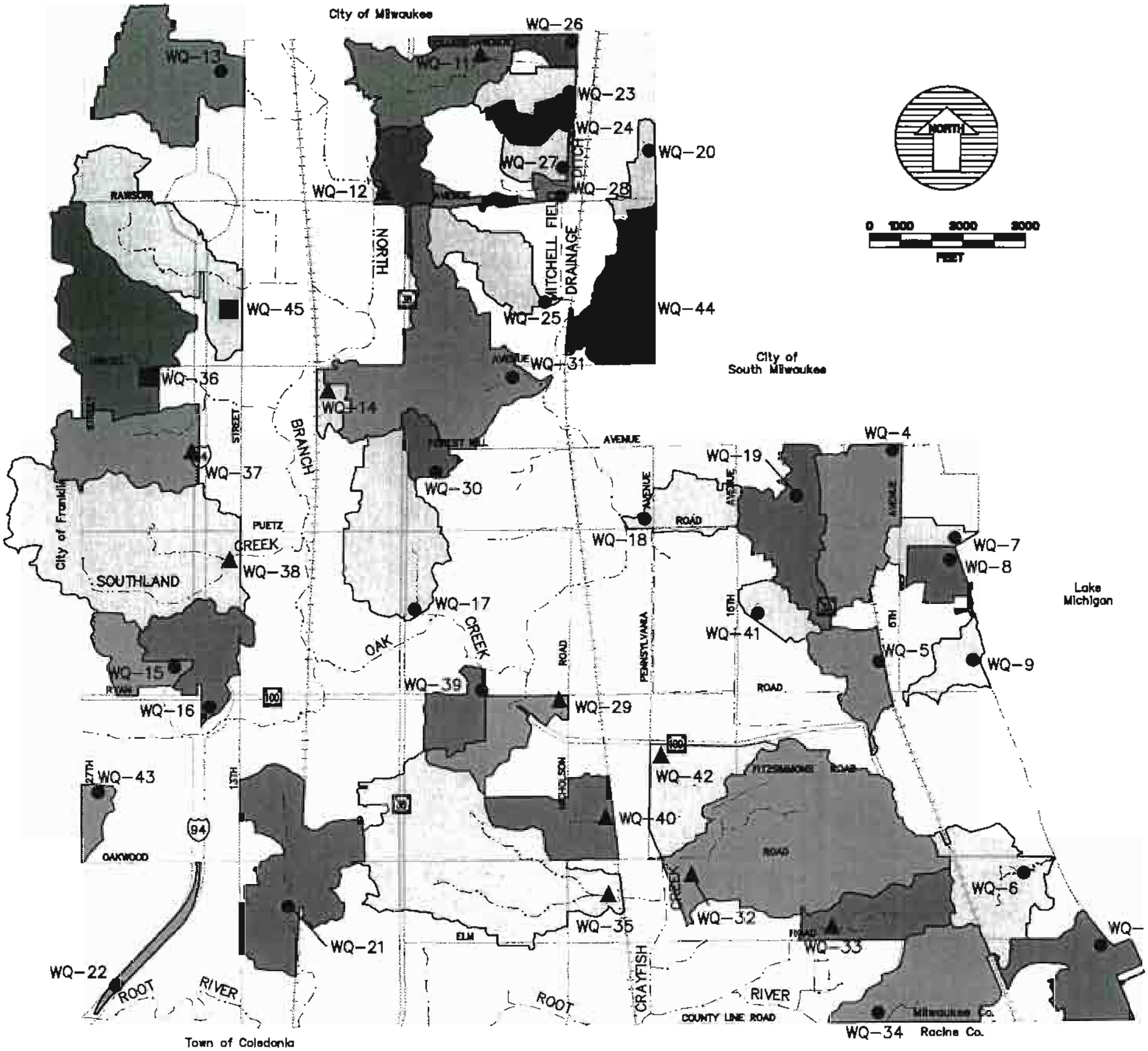
Figure 8-2
Recommended Detention Pond and Wetland Locations



Legend

- ● PROPOSED NEW OR RETROFIT WET DETENTION POND
- ▲ PROPOSED NEW OR RETROFIT WETLAND TREATMENT SYSTEM
- ■ POTENTIAL REGIONAL WATER QUALITY POND FOR NEW DEVELOPMENT

WQ–34 RECOMMENDATION NO. IN TABLE 8–3

Hey and Associates, Inc.

R. A. SMITH & ASSOCIATES, INC.

Table 8-1 Flood Control and Drainage Recommendations (continued)

Tributary Stream	Recommendation	Capital Construction Cost (1)	Annual O&M Cost	Implementing Agency	Priority
Root River	Raise E. County Line Rd. west of Nicholson Rd.	$ 384,000	–	City	18
Crayfish Creek	Evaluate raising E. Oakwood Rd.	–	–	City	19
Crayfish Creek	Evaluate raising E. Elm Rd.	–	–	City	20
C1	Rebuild storm sewer outlet and clean channel downstream of Darlene Ln.	$65,000	$1,000	City	2
C1	Culverts at S. Shepard Ave.	$ 80,000	–	City	5
C1	Culverts at E. Oakwood Rd.	$ 181,000	–	City	5
C3	Control development flows upstream of S. 11th Ave.	–	–	City	16
Total		$5,911,500	$ 49,000		

(1) Easement and land acquisition costs are not included.

Water Quality Recommendations

The suspended sediment loading from the study area, from all sources, is estimated at 8,570,000 pounds per year. Implementation of the water quality recommendations, outlined in Table 8-3 and illustrated in Figure 8-2, will result in an annual reduction of more than 3,620,000 pounds per year of suspended sediment, or 42% of the total loading. Combined with the housekeeping practices outlined in Table 8-2, the plan recommendations should reach the 50% total suspended solids reduction goal. Implementation of the High Priority recommendations results in a 27% reduction in suspended sediment loading. Implementation of the Medium Priority recommendations in addition to the High Priority items would raise the sediment reduction level to 32%.

TABLE 8-2 Water Quality Recommendations on a City Wide Basis

Recommendation	Annual Cost	Implementing Agency	Priority
Enforcement of construction site erosion control ordinances.	$30,000 to $40,000	City of Oak Creek	High
Adoption and Enforcement of a City stormwater management ordinance.	$15,000	City of Oak Creek	High
Continued support for the Milwaukee County Hazardous Response Team.	NA	City of Oak Creek	High
Conduct an information and education program on proper lawn fertilization and pesticide use, proper disposal of lawn clippings, leaf composting, proper pet waste disposal, and the need to control dumping of waste down storm sewers.	$5,000	City of Oak Creek	High
Conduct a storm sewer-stenciling program informing residents to not dump waste into storm sewers. Conduct an annual program of inspections and replace faded and worn stencils.	$2,000	City of Oak Creek School District	High
Enter discussions with the cities of Franklin and South Milwaukee to explore options for coordinating their stormwater management efforts.	NA	City of Oak Creek	High
Sweep all City streets with curbs spring and fall.	$25,000	City of Oak Creek	High
Implement a program of catch basin cleaning twice per year or when sumps are 30-40% full.	$24,000 to $45,000/yr	City of Oak Creek	High
Develop a "Business Partnership Program for Clean Water"	$5,000	City of Oak Creek	High
Total Annual Cost	**$81,000 to 112,000**		

[1] NA means "Not Available"

TABLE 8-3 Water Quality Recommendations for Targeted Subbasins

Number on Figure 2-1	Recommendation	TSS Reductions (lbs/year)	Capital Cost[1]	Annual Operation and Maintenance Cost[2]	Implementing Agency	Priority
WQ-1[4]	Street sweeping on major highways including, I-94, Ryan Rd., Howell Ave., 27th St., College Ave., Rawson Ave., Drexel Ave., Puetz Rd., and Forest Hill Ave.	334,247	$150,000	$34,800 to $92,250/yr	Milwaukee County and City of Oak Creek	Medium
WQ-2[4]	Use conservation tillage practices on agricultural fields	194,630	NA[3]	$152,320/yr	Private Landowners	Medium
WQ-3[4]	Install streambank erosion control on sites surveyed with heavy erosion. Streambank stabilization practices of rock riprap and/or soil bioengineering should be installed on approximately 9,500 feet of streambank	142,500	$427,500	$25,000/yr	City of Oak Creek	Medium
WQ-4	Install 3.24-acre wet detention basin in subbasin L1-6	90,102	$286,500	$10,740	City of Oak Creek	Medium
WQ-5	Install 1.19-acre wet detention basin in subbasin L2-7	37,653	$105,000	$4,200	City of Oak Creek	Medium
WQ-6	Install 2.07-acre wet detention basin in subbasin L5-3	106,199	$175,180	$7,030	Private	Medium
WQ-7	Install 0.82-acre wet detention basin in subbasin LG-8	67,789	$75,500	$3,020	Private	Medium
WQ-8	Install 1.17-acre wet detention basin in subbasin LG-11 (north)	73,425	$103,500	$4,140	Private	Medium
WQ-9	Install 1.22-acre wet detention basin in subbasin LG-11 (south)	78,844	$107,400	$4,300	Private	Medium
WQ-10	Install 2.99-acre wet detention basin in subbasin LG-17	283,457	$248,600	$10,000	Private	Medium
WQ-11	Install 11-acre wetland treatment system in subbasin M1-4	51,983	$49,000	$2,000	City of Oak Creek	Medium
WQ-12	Install 5.23-acre wetland treatment system in subbasin N1-2	170,268	$26,000	$1,000	City of Oak Creek	Medium
WQ-13	Install 3.58-acre wet detention basin in subbasin N2-5G	109,273	$295,900	$11,900	City of Milwaukee, City of Oak Creek & WDOT	Medium

[1] Unless noted, capital cost includes construction, engineering and contingencies. Costs do not include acquisition of land.
[2] Costs are for annual operation and maintenance for a one year period. O& M cost include annual cost of street sweeping and 4% of capital cost for O&M on detention ponds.
[3] NA means "Not Available"
[4] Not shown on Figure 2-1

TABLE 8-3 Water Quality Recommendations for Targeted Subbasins (continued)

Number on Figure 2-1	Recommendation	TSS Reductions (lbs/year)	Capital Cost[1]	Annual Operation and Maintenance Cost[2]	Implementing Agency	Priority
WQ-14	Install 1.77-acre wetland treatment system in subbasin N6-1	4,679	$19,000	$1,000	City of Oak Creek	Medium
WQ-15	Install 1.00-acre wet detention basin in subbasin O3-2	47,688	$89,900	$3,600	City of Oak Creek	Medium
WQ-16	Install 1.90-acre wet detention basin in subbasin O5-13	103,593	$161,700	$6,470	City of Oak Creek & WDOT	Medium
WQ-17	Install 3.35-acre wet detention basin in subbasin O8-13	204,032	$277,300	$11,100	City of Oak Creek	Medium
WQ-18	Install 0.82-acre wet detention basin in subbasin O18-5	27,071	$75,500	$3.020	City of Oak Creek	Medium
WQ-19	Install 1.85-acre wet detention basin in subbasin O24-6	53,062	$157,700	$6,300	City of Oak Creek	Medium
WQ-20	Install 0.67-acre wet detention basin in subbasin O25-4	34,955	$63,600	$2,550	City of Oak Creek	Medium
WQ-21	Install 17.87-acre wetland treatment system in subbasin R2-8	89,858	$76,000	$3,000	City of Oak Creek	Medium
WQ-22	Install 0.39-acre wet detention basin in subbasin RR-2	31,376	$41,300	$1,650	WDOT	Medium
WQ-23	Install 0.47-acre wet detention basin in subbasin M2-2	20,404	$47,600	$1,900	City of Oak Creek	Medium
WQ-24	Install 0.52-acre wet detention basin in subbasin M3-2	16,301	$51,600	$2,070	City of Oak Creek	Medium
WQ-25	Install 1.02-acre wet detention basin in subbasin M5-7	32,981	$91,500	$3,660	City of Oak Creek	Medium
WQ-26	Install 0.39-acre wet detention basin in subbasin MF-10	20,680	$41,300	$1,650	City of Oak Creek	Medium
WQ-27	Install 0.40-acre wet detention basin in subbasin MF-20	16,788	$41,000	$1,640	City of Oak Creek	Medium
WQ-28	Install 0.39-acre wet detention basin in subbasin MF-21	51,737	$40,900	$1,640	City of Oak Creek	Medium
WQ-29	Install 5.96-acre wetland treatment system in subbasin O11-3	25,708	$29,000	$1,200	City of Oak Creek	Medium

[1] Unless noted, capital cost includes construction, engineering and contingencies. Costs do not include acquisition of land.
[2] Costs are for annual operation and maintenance for a one year period. O& M cost include annual cost of street sweeping and 4% of capital cost for O&M on detention ponds.
[3] NA means "Not Available"

TABLE 8-3 Water Quality Recommendations for Targeted Subbasins (continued)

Number on Figure 2-1	Recommendation	TSS Reductions (lbs/year)	Capital Cost[1]	Annual Operation and Maintenance Cost[2]	Implementing Agency	Priority
WQ-30	Install 0.48-acre wet detention basin in subbasin O19-6	14,798	$48,400	$1,940	City of Oak Creek	Medium
WQ-31	Install 4.8-acre wet detention basin in subbasins O20-14&15	179,454	$392,900	$15,700	City of Oak Creek	Medium
WQ-32	Install 36.35-acre wetland treatment system in subbasin C3-14	151,447	$150,000	$6,000	City of Oak Creek	Low
WQ-33	Install 8.09-acre wetland treatment system in subbasin CB1-4	38,359	$37,000	$1,500	City of Oak Creek	Low
WQ-34	Install 1.69-acre wet detention basin in subbasin CB3-6	50,115	$144,900	$6,000	City of Oak Creek	Low
WQ-35	Install 32.71-acre wetland treatment system in subbasin CC-2	210,687	$136,000	$5,500	City of Oak Creek	Low
WQ-36	Install 19.93-acre wetland treatment system in subbasin N7-6	100,147	$85,000	$3,400	City of Oak Creek	Low
WQ-37	Install 12.13-acre wetland treatment system in subbasin N7-13	48,801	$54,000	$2,000	City of Oak Creek	Low
WQ-38	Install 31.87-acre wetland treatment system in subbasin N10-15	132,622	$136,000	$5,500	City of Oak Creek	Low
WQ-39	Install 0.83-acre wet detention basin in subbasin O10-5	27,279	$76,300	$3,050	City of Oak Creek	Low
WQ-40	Install 8.29-acre wetland treatment system in subbasin O15-4	27,371	$38,000	$1,500	City of Oak Creek	Low
WQ-41	Install 0.26-acre wet detention basin in subbasin O17-2	4,746	$30,900	$1,250	City of Oak Creek	Low
WQ-42	Install 13.17-acre wetland treatment system in subbasin O17-9	58,222	$58,000	$2,300	City of Oak Creek	Low
WQ-43	Install 0.42-acre wet detention basin in subbasin OC-447	34,236	$43,600	$1,750	City of Oak Creek	Low
WQ-44	Install 0.77-acre wet detention basin in subbasin OC-500	21,623	$71,900	$2,900	City of Oak Creek	Low
WQ-45	Install 17.89-acre wetland treatment system in subbasin N5-6	106,261	$77,300	$3,100	City of Oak Creek	Medium
Total		3,727,451	$4,935,000	$383,000 to 441,000		

[1] Unless noted, capital cost includes construction, engineering and contingencies. Costs do not include acquisition of land.
[2] Costs are for annual operation and maintenance for a one year period. O& M cost include annual cost of street sweeping and 4% of capital cost for O&M on detention ponds.
[3] NA means "Not Available"

Stormwater Ordinance

Under Wisconsin Administrative Code NR 216, communities required to acquire stormwater discharge permits must have adequate ordinances in place to control both the quantity and quality of runoff. The Wisconsin Department of Natural Resources has prepared a model ordinance that complies with the requirements of NR 216. Although the City currently has language to regulate stormwater in Chapter 14 and Chapter 17 of the Municipal, Plumbing and Zoning Code, these provisions only partially comply with the state model. A stand-alone stormwater ordinance, that meets the requirements of the state model, is provided for the City's review in Appendix D of this report.

Revisions to Floodplain Ordinance

The City should adopt the revised floodplain mapping prepared by SEWRPC for the mainstem of Oak Creek, North Branch of Oak Creek, Mitchell Field Drainage Ditch, and Southbranch Creek.

Floodways should be developed and mapped for the tributary streams.

Financing Options

Issues relating to financing of the stormwater management plan can be divided into three categories: collection and grant opportunities, borrowing options, and administrative structures. The following is a summary of the options that are available to the City of Oak Creek for the implementation of this plan.

Administrative Structures

The City of Oak Creek can implement the recommendations of this plan under two potential administrative structures: the existing City government or a special stormwater utility district.

A. City Options

The City of Oak Creek is empowered under state statute to implement all of the recommendations of this plan. All of the taxing and borrowing options discussed in this section are available. Ordinance language to allow the City to assess property taxes, special assessments and impact fees are in place. To enact user fees for stormwater management, a special ordinance would need to be adopted. Advice from a municipal attorney should be sought to understand how the City, under its current structure, can use user fees.

B. Utility Options

An alternative to the current structure of the City, which relies predominantly on property tax for revenue, is a stormwater utility formed under Chapter 66 of the state statutes. A stormwater utility is a special purpose unit of government whose sole purpose would be to provide stormwater management service. Stormwater utilities can be set up to include the entire City or only specific drainage areas with stormwater problems. Utilities operate predominantly on user fees that are charged against property based on the type of land use and percentage of stormwater generated. Stormwater utilities borrow money for capital improvements predominantly in the form of revenue bonds. The use of revenue bonds can take the burden off general obligation borrowing, which has a cap of 5% of the municipality's equalized valuation, freeing up borrowing for other municipal expenditures. Unlike property taxes, user fees collected by a stormwater utility can not be deducted on a personal income tax retum.

Due to the large cost of implementing the recommendations of this plan, it is recommended that the City of Oak Creek explore the option of forming a stormwater utility.

Collection Options and Grant Opportunities

Collection and grant opportunities available to the City of Oak Creek fall into the following categories:

A. Local Tax options

1. **Property Taxes** - Property tax is a levy on local property based on a percentage of the assessed value. The limits on property tax use by cities are established in Wisconsin Statues 66.12 (4m) and 65.07(2). Local property taxes can be used for all aspects of implementation of the stormwater management plan. The major disadvantage of the property tax is that it is based on property value, which bears little correlation to stormwater runoff. An advantage of property tax is that it can be deducted on a personal income tax return.
2. **License and permit fees** - License and permit fees are charged to cover the cost of issuance and enforcement of local ordinances. Wisconsin Statute and court-imposed rule require that license and permit fees not exceed the actual cost of issuance of the license and enforcement of the regulation (City of Milwaukee vs. Milwaukee & Suburban Transport Corp., 1959). Therefore, license and permit fees can only be used for such items as enforcement of a City's construction site erosion control and stormwater ordinance.
3. **User fees** - User fees are special charges levied to provide a specific municipal service. Treatment of stormwater is an example of a service for which a user fee can be used. User fees are usually used to pay for operation and maintenance costs. Capital improvement costs are generally covered by the levy of special assessment upon benefited property, issuance of municipal obligations, federal and state grants, or all three.

4. **Special assessments** - Special assessments are levied against property for the cost of a public work or improvement if the City can demonstrate that the improvement or work does in fact confer a special benefit or improvement on the involved property.

5. **Impact fees** - Under Wisconsin Law, cities can enact local impact fees to cover the cost of public improvement needed as the result of new growth. In addition to cash fees, the municipality can require developers to install local improvements, such as stormwater conveyance systems and detention ponds, and dedicate land for stormwater management practices. Impact fees are very useful in developing areas where cost can be born by new residents. In developing areas, such as the City of Oak Creek, impact fees can be a temporary source of revenue.

B. State Grants

1. **Urban Green Space** - This state grant program provides 50% matching grants to municipalities to provide open natural space in urban development. For stormwater management facilities developed as part of an urban green space project, the acquisition of the land may be eligible for this grant. The Urban Green Space Program is allocated $750,000 statewide per year.

2. **Local Park Aids** - This state program provides 50% matching grants for the development of public outdoor recreational facilities. For stormwater management practices developed as part of an outdoor recreational facility, the acquisition of the land may be eligible for this grant. Local Park Aids are allocated $2,500,000 statewide per year.

3. **County Conservation Aids** - This state program provides 50% matching grants for implementation of fish and wildlife management projects. If fish and wildlife habitat features were designed into a stormwater facility, such as a detention pond, these improvements may be eligible for this grant program.

4. **Nonpoint Source Pollution Abatement Program Grants** - This program provides cost share grants for the installation of nonpoint source pollution abatement practices. Water quality treatment practices are cost shared at up to 100% for engineering design, 70% for construction, and 50% for land acquisition and storm sewer rerouting. Programs for information and education, enactment and enforcement of local construction site erosion control, and stormwater management ordinances, are eligible for grants under this state program. To be eligible for this program the watercourses in the City would need to be designated as "Priority Watersheds" under Wisconsin Administrative Code NR 120. The Root River and its tributaries are a designated priority watershed. Oak Creek has been ranked in A Regional Water Quality Management Plan for Southeastern Wisconsin: An Update and Status Report (SEWRPC, Memorandum Report 93, 1995) as a high priority for designation.

C. Borrowing Options

Borrowing options for capital improvements for stormwater management fall into the following categories:

- General obligation borrowing.
- General obligation Bonds under sec. 67.05, Wisconsin Stats.
- Bonds, not general obligation under sec 67.125 Wisconsin Stats.
- Promissory notes, pursuant to sec. 67.12 Wisconsin Stats.
- Mortgage Revenue Bonds, Certificates and notes under sec. 66 006 Wisconsin Stats.
- Tax Increment financing bonds under sec. 66.46 Wisconsin Stats.

Coordination with NR 216

In the 1987 revision of the Clean Water Act, Congress redefined runoff from urban areas as an activity that would be regulated by federal pollution law. In the State of Wisconsin, the federal government delegates the enforcement of the Clean Water Act to the Wisconsin Department of Natural Resource (WDNR). To enforce the federal requirements the WDNR adopted administrative code NR 216 in October of 1994. The WDNR has designated the City of Oak under NR 216 as a municipality that is required to apply for a stormwater discharge permit. In January of 1997, the City submitted a pre-application as required under NR 216.05. A final application was submitted on February 11, 1999. A permit was issued on June 29, 2000 (Appendix G.)

Permit requirements under the NR 216 program are currently being developed by WDNR. At this time, WDNR is anticipating that during the first three years of the permit they will require communities to implement the following activities:

- Enforcement of erosion control ordinances.
- Enforcement of a stormwater management ordinance that meets the criteria of the state model.
- Enforcement of ordinances that prohibit illicit discharges to the stormwater drainage system.
- Implementation of housekeeping practices, such as street sweeping and catch basin cleaning.
- Conduct public education programs on lawn care, car washing, pet waste, and dumping of waste into the local drainage system.
- Water quality monitoring.

During the second issuance of the NR 216 permit, WDNR may require the installation of management practices to control existing sources of pollution. Implementation of the water quality recommendation outlined in this plan will help the City comply with the requirements of NR 216.

Plan Adoption and Regulatory Approval

An important first step in the plan implementation is the formal adoption of the plan by the City of Oak Creek and acceptance by Wisconsin Department of Natural Resources, Milwaukee County, and Milwaukee Metropolitan Sewerage District. The steps in the approval process are as follows:

1. Review of plan by the City's Stormwater Management Committee (SMC.)
2. Review of draft plan by City Council.
3. Public informational meetings.
    a. Mapping – development, inventory, and changes
    b. Compensatory fill regulation for flood fringe areas
    c. Detention alternatives and recommendations on water quality
    d. Skeletal system
4. Submit draft plan to the Wisconsin Department of Natural Resources for acceptance as a refinement to A Regional Water Quality Management Plan for Southeastern Wisconsin: An Update and Status Report (SEWRPC, Memorandum Report 93, 1995.)
5. Submit draft plan to Milwaukee County and the Milwaukee Metropolitan Sewerage District for acceptance.
6. Public hearing on final plan.
7. Adoption of final plan by City Council.

Public Information and Education Activities

An Information and Education (I&E) program to educate local residents as to what they can do to prevent and reduce stormwater pollution problems and drainage problems is recommended. Issues that need to be addressed by the I&E program to meet the goals of this plan include:

1. Lawn Care
    a. Reduced fertilizer use
    b. Reduced pesticide use

2. Proper disposal of lawn clippings and leaves
3. Proper disposal of pet waste
4. Reduction of dumping of waste in storm sewers
5. Reduction of lawn waste in waterways or channels
6. Use of non-galvanized rain gutters
7. Protection of wetlands

Table 8-4 outlines recommended I&E activities that could be used in the City of Oak Creek.

TABLE 8-4 I & E Plan Recommendations

I & E METHOD	ACTIVITY
Newsletters	The City of Oak Creek publishes a newsletter, the Acorn, to educate residents on local issues. This newsletter should be used to disseminate information as part of this plan.
Articles in the local newspapers	The following newspapers serve the City of Oak Creek: The Oak Creek Pictorial (weekly), and the Milwaukee Journal Sentinel (daily). The City should work with local reporters of these newspapers to include articles on stormwater related issues.
Local cable TV	A local access cable channel serves City of Oak Creek. Channel 14 on the local Time Warner Cable system is reserved for public use. Channel 14 can be used to show educational material related to implementation of this plan.
Meetings with civic groups	Meetings with the local Chamber of Commerce, Rotary Club, local scout troops, and other civic groups are recommended in order to explain the importance of housekeeping practices in maintaining good water quality is recommended.
Business Partnership for Clean Water	Waukesha County has developed a pilot program to provide a forum for local businesses to share information on controlling pollution from their own property. A pilot program was started in the City of Waukesha. The City of Oak Creek should establish a similar program. The Waukesha County Land Conservation Department can provide advice on establishing a local business partnership program.
Display at local events	The University of Wisconsin Extension has a water quality display that is available for use at local civic events and local schools.
Placement of educational material at Public Buildings	It is recommended that the City of Oak Creek have a display area for flyers located in the lobby of the City Hall and public library to display I&E materials. I&E material on lawn care, fertilizer use, pet waste, etc., developed by the University of Wisconsin Extension and Waukesha County can be displayed for public pick up.
Tours of Management Practices	Tours of management practices and pollution prevention activities are recommended for local citizens and civic leaders. Tours provide the opportunity for residents to see first hand the progress being made by the City.
Educational Signs at management practice sites	Signs to explain the purpose of stormwater management facilities can educate the public on how their dollars are being spent.
Storm Sewer Stenciling Program	To prevent the dumping of waste materials down storm drains, placement of the statement "*Dump No Waste Drains to River*" on the storm sewer inlets is recommended. A local civic or scout group could conduct this project. The University of Wisconsin Extension has material available to conduct this activity.
Educational Programs in the local schools	To help educate students, the City of Oak Creek should work with the science departments at the Oak Creek School District to develop environmental education programs that include urban stormwater. Programs such as "Project WET" and "Testing the Waters" should be explored for potential incorporation into the school curriculum.

As discussed above, the University of Wisconsin Extension has developed a series of informational brochures that can be used by the City for display at the City Hall or in the Acorn. The following is a list of some the titles that are available:

- *Car Care for Cleaner Water* (UWEXT Publication I-04-95-2M-10-S)
- *Stormwater Ponds: An Effective Way to Control Urban Runoff* (UWEXT Publication GWQ 017)
- *Symptoms and Sources of Runoff Pollution*
- *Rules of Thumb for Clean Water* (UWEXT Publication GWQ007)

- *Practical Tips for Home and Yard* (UWEXT Publication GWQ007)
- *Rethinking Yard Care*
- *Lawn Watering* (UWEXT Publication GWQ012)
- *Lawn and Garden Fertilizers* (UWEXT Publication R-09-92-20M-50-S)
- *Lawn and Garden Pesticides* (UWEXT Publication 1-07-92-10M-20-S)
- *Pet Waste and Water Quality Lawn and Garden Fertilizers*
- *Brown Water Green Weeds: Familiar Signs of Nonpoint Source Pollution* (UWEXT Publication 1-06-92-15M-35-S)

Copies of the above publications can be obtained by contacting the University of Wisconsin Extension.

Appendix

A

Glossary

BACKWATER: The increase in elevation of the water surface on the upstream side of a bridge, culvert, other hydraulic structure, object, or deposit above that which would occur in the absence of the structure, object, or deposit.

BATHYMETRY: Measurement of the depth of large bodies of water.

BEST MANAGEMENT PRACTICE (BMP): The most effective, practical measures to control nonpoint sources of pollutants that runoff from land surfaces.

BIOCHEMICAL OXYGEN DEMAND (BOD): A measure of the amount of oxygen consumed in the biological processes that break down organic matter in water. BOD5 is the biochemical oxygen demand measured in a five day test. The greater the degree of pollution, the higher the BOD5.

BUFFER STRIPS: Areas of grass or other erosion-resisting vegetation between disturbed areas and a stream or lake.

CHANNEL: A natural or artificial watercourse with definite bed and banks to confine and conduct the normal flow of water.

CHECK DAM: A log, rock, or gabion structure placed perpendicular to a stream to enhance aquatic habitat; reduce water velocities; promote sediment deposition; and enhance infiltration.

DESIGN STORM: A rainfall event of specific return frequency and duration (e.g., a storm with a 2-year frequency of occurrence and 24-hour duration) that is used to calculate the runoff volume and peak discharge rate.

DETENTION: A basin designed for the storage of storm runoff which is used to decrease the peak discharge rates, and provide gravity settling of pollutants and sediment.

DETENTION TIME: The amount of time it takes for water to flow through a detention basin.

DEVELOPMENT: Any artificial change to improved or unimproved real estate, including, but not limited to, the construction of buildings, structures or accessory structures; the construction of additions or substantial improvements to buildings, structures or accessory structures; the placement of buildings or structures; mining, dredging, filling, grading, paving, excavation or drilling operations; and the storage, deposition or extraction of materials.

EROSION: A wearing away of land by the action of natural forces such as wind or water.

EUTROPHIC: Designating a body of water in which the increase of mineral and organic nutrients has reduced the dissolved oxygen, producing an environment that favors plant over animal life.

EXFILTRATION: The downward movement of runoff through the bottom of an infiltration basin into the soil.

FLOOD or FLOODING: A general and temporary condition of partial or complete inundation by water of normally dry land areas caused by:

a) The overflow or rise of inland waters;

b) The rapid accumulation or runoff of surface waters from any source;

FLOOD FREQUENCY: The probability of a flood occurrence. A flood frequency is generally determined from statistical analyses. The frequency of a particular flood event is usually expressed as occurring, on the average, once in a specified number of years or as a percent (%) chance of occurring in any given year.

Note: For example, a 100-year flood event is expected to occur, or be expected, on the average of once in every 100 years, or which has a 1% chance of occurring, or being exceeded, in any given year. Any particular flood event could, however, occur more frequently than once in any given year.

FLOODPLAIN: For a given flood event, that area of land adjoining a watercourse that will be covered temporarily by water.

FLOOD STAGE PROFILE: A graph of flooding condition water surface elevation versus distance along a river or stream. The profile may correspond to a historic flood event or an event of a specified recurrence interval.

FOREBAY: An extra storage area provided near an inlet of a detention basin to trap incoming sediments before they accumulate in the basin.

FREEBOARD: The vertical distance from the design water surface to the point at which flood damage would occur. Freeboard is a safety factor intended to accommodate the possible effect of unpredictable obstructions, such as ice buildup and debris blockage, that could increase stages above the design water surface.

GABIONS: Rock-filled wire baskets used to protect and stabilize the bottom and side walls of channels.

GREEN STRIPS: See buffer strip.

GROUNDWATER: Underground water-bearing areas, generally within the boundaries of a watershed, which fill internal passageways of porous geologic formations (aquifers) with water which flows in response to gravity and pressure. Often used as the source of water for communities and industries.

HABITAT: The environment best suited for plants or animals to thrive naturally and grow.

HEAVY METALS: Metals present in municipal and industrial wastes that may pose long-term environmental hazards if not properly disposed. Heavy metals can contaminate ground and surface waters, fish, and other food stuffs. The metals of most concern are; arsenic, barium, cadmium, chromium, copper, lead, mercury, selenium, and zinc.

HYDRAULICS: Study of physical behavior of water as it flows within sewers and channels; on floodplains, under and over bridges, culverts, dams, and control structures; and through detention/retention facilities, lakes and reservoirs.

HYDROGRAPH: A graph showing for a given point on a stream, drainage basin, or a lake the discharge, stage (depth), velocity, or other property of water with respect to time.

HYDROLOGY: Study of the physical behavior of water; from its occurrence as precipitation, to its entry into streams, detention/retention facilities, lakes, and reservoirs, and its return to the atmosphere via evaporation.

IMPERVIOUS AREA: Impermeable surfaces, such as pavement or rooftops, which prevent the infiltration of water into the soil.

INFILTRATION: The downward movement of surface water from the surface into the subsoil. The infiltration capacity may be expressed in terms of inches/hour.

INVERT ELEVATION: The bottom elevation of a pipe, orifice, or spillway.

LOAD: The total amount of materials or pollutants reaching a given location.

LOW FLOW CHANNEL: A small channel constructed within a larger channel that is designed to carry low runoff flows and/or baseflow directly without detention.

MANNING ROUGHNESS COEFFICIENT: A dimensionless coefficient used in the Manning's equation to account for frictional losses in steady uniform flow.

NATIONAL GEODETIC VERTICAL DATUM (NGVD): Elevations referenced to mean sea level datum, 1929 adjustment.

NONPOINT SOURCE POLLUTION (NSP): Pollution whose sources cannot be traced to a single point, such as a municipal or industrial wastewater treatment plant discharge pipe. Nonpoint sources include eroding farmland and construction sites, urban streets, and barnyards. Pollutants from these sources reach water bodies in runoff.

OUTFALL: The outlet of a sewer, drain, or pipe where runoff is discharged into a watercourse.

PEAK DISCHARGE: The maximum instantaneous rate of flow during a storm, referenced to a specific design storm event.

PERMANENT POOL: The portion of a pond or infiltration basin which is below the elevation of the lowest point on the outlet structure.

PHOSPHORUS: A nutrient that, when reaching lakes in excess amounts, can lead to over fertile conditions.

PRIORITY WATERSHED (WDNR Definition): A drainage area about 100,000 acres in size selected to receive Wisconsin Fund money to help pay the cost of controlling nonpoint source pollution.

RECURRENCE INTERVAL: The average time interval, usually in years, between the occurrence of a flood or other hydrologic event of a given magnitude or larger. The inverse of recurrence interval is the probability of occurrence, in any year, of a flood equaling or exceeding a given magnitude. For example, a flood that would be equaled or exceeded on the average of once in 100 years would have a recurrence interval of 100 years and a 1 percent probability of occurring or being exceeded in any year.

RELEASE RATE: The rate of discharge in volume per unit time from a detention facility.

RETENTION: The holding of runoff in a basin without release, except by means of evaporation or infiltration.

RETROFIT: To install a new BMP, or improve an existing BMP, in a previously developed area.

RIPRAP: A combination of large stone, rock, or cobbles used to line channels, stabilize banks, and prevent erosion.

RISER: A vertical pipe or box extending up from the bottom of a pond that is used to control the discharge from the pond.

RUNOFF: Water resulting from precipitation that flows over the ground surface and outlets into watercourses and streams. Runoff can collect pollutants from air or land and carry them to receiving waters.

SCOUR: The clearing and digging action of flowing water.

SEDIMENT: Soil particles suspended in and carried by surface water as a result of erosion.

SHEET FLOW: Runoff which flows over the ground surface as a thin, even layer, not concentrated in a channel.

SOIL GROUP, HYDROLOGIC: A classification of soils by the Natural Resource Conservation Service into four runoff potential groups. The groups range from A soils, which are very permeable and produce little runoff, to D soils, which are not very permeable and produce much more runoff.

SOIL BIOENGINEERING: Technology of using plant materials as the main structural component in systems designed to control slope failures, surface erosion, and streambank erosion.

STAGE: Elevation of the water surface above a given datum.

STORAGE: Depressions, basins, or other areas that normally stand empty or partially empty, but fill during storms to hold runoff and reduce downstream flow rates.

STORM SEWERS: A system of sewers that collect and transport rain and snow runoff. In areas that have separated sewers, such stormwater is not mixed with sanitary sewage.

STORMWATER MANAGEMENT: Public policy and actions taken to control stormwater runoff associated with development within an urbanizing watershed in order to prevent the occurrence of, or an increase in, flood damage potential. It includes, but is not limited to, development of stormwater runoff data, flood profiles and enactment and administration of ordinances regulating land use in a watershed.

SUSPENDED SOLIDS (SS): Small particles of solid pollutants suspended in water.

SWALE: A natural depression, or wide shallow waterway, used to temporarily store, route, or filter runoff.

TIME OF CONCENTRATION: The time required for surface runoff from the most remote point in a watershed to reach the watershed outlet.

TOXIC: An adjective that describes a substance which is poisonous, or can kill or injure a person or plants and animals upon direct contact or long-term exposure (also, see toxic substance).

TOXIC SUBSTANCE: A chemical, or mixture of chemicals, which through sufficient exposure, or ingestion, inhalation of assimilation by an organism, either directly from the environment or indirectly by ingestion through the food chain, will, on the basis of available information cause death, disease, behavioral or immunologic abnormalities, cancer, genetic mutations, or development of physiological malfunctions, including malfunctions in reproduction or physical deformations, in organisms or their offspring.

UNDERDRAIN: Perforated pipes installed on the bottom of an infiltration basin, or sand filter, which are used to collect and remove excess runoff.

WASTE: Used or unwanted materials, water, or refuse resulting from manufacturing processes, commercial activities, and residential land use.

WATER SURFACE PROFILE: A graphical representation showing the elevation of the water surface of a watercourse for all locations along a reach of river or stream at various frequency storm flows. A water surface profile of the regional flood is used in regulating floodplain areas.

WATERSHED: The entire area of land contributing surface runoff to a particular watercourse or body of water.

WETLANDS: Those areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support a variety of vegetative or aquatic life. Wetland vegetation requires saturated or seasonally saturated soil conditions for growth and reproduction. Wetlands generally include swamps, marshes, bogs, and similar areas.

Appendix

B

Hydrologic-Hydraulic Models Provided to City

Numerous computer models were compiled during the preparation of this stormwater management plan. The models are input files to computer programs. The models listed below were provided to the City for use in evaluating changes in the drainage system of the City.

O14-2HF	Oak Creek Tributary O14; future L.U., 2-hour duration.
O17-2HCK	Oak Creek Tributaries O16, O17 and O18a; 1995 L.U., 2-hour duration.
O17-2FCK	Oak Creek Tributaries O16, O17 and O18a; future L.U., 2-hour duration.
O18-2HR	Oak Creek Tributary O18; 1995 L.U., 2-hour duration.
O18-2HF	Oak Creek Tributary O18; future L.U., 2-hour duration.
O19-2HR	Oak Creek Tributary O19; 1995 L.U., 2-hour duration.
O19-2FHR	Oak Creek Tributary O19; future L.U., 2-hour duration.
O2022-2H	Oak Creek Tributaries O20, O21, and O22; 1995 L.U., 2-hour duration.
O2022F2H	Oak Creek Tributaries O20, O21, and O22; future L.U., 2-hour duration.
O23-252H	Oak Creek Tributaries O23, O24, and O25; 1995 L.U., 2-hour duration.
O23-252F	Oak Creek Tributaries O23, O24, and O25; future L.U., 2-hour duration.
R13-6-2H	Root River Tributaries R1, R3, R4, R5, and R6; 1995 L.U., 2-hour duration.
R13-6F2H	Root River Tributaries R1, R3, R4, R5, and R6; future L.U., 2-hour duration.
R2-2A2HR	Root River Tributaries R2 and R2a; 1995 L.U., 2-hour duration.
R2-2AF2H	Root River Tributaries R2 and R2a; future L.U., 2-hour duration.
R2-2HDET	Root River Tribs. R2 & R2a; evaluation of detention in R2-8; 1995 L.U.
R2-2DETF	Root River Tribs. R2 & R2a; evaluation of detention in R2-8; future L.U.

32-3(2-1).xp	System 32-3; 2-year rainfall, 1-hour duration, 1995 land use.
32-4(10-1).xp	System 32-4; 10-year rainfall, 1-hour duration, 1995 land use.
32-4(2-1).xp	System 32-4; 2-year rainfall, 1-hour duration, 1995 land use.
32-5(10-1).xp	System 32-5; 10-year rainfall, 1-hour duration, 1995 land use.
32-5(2-1).xp	System 32-5; 2-year rainfall, 1-hour duration, 1995 land use.
32-6(10-1).xp	System 32-6; 10-year rainfall, 1-hour duration, 1995 land use.
32-6(2-1).xp	System 32-6; 2-year rainfall, 1-hour duration, 1995 land use.
32-7(10-1).xp	System 32-7; 10-year rainfall, 1-hour duration, 1995 land use.
32-7(2-1).xp	System 32-7; 2-year rainfall, 1-hour duration, 1995 land use.
33-1(10-1).xp	System 33-1; 10-year rainfall, 1-hour duration, 1995 land use.
33-1(2-1).xp	System 33-1; 2-year rainfall, 1-hour duration, 1995 land use.
33-2(10-1).xp	System 33-2; 10-year rainfall, 1-hour duration, 1995 land use.
33-2(2-1).xp	System 33-2; 2-year rainfall, 1-hour duration, 1995 land use.
33-3(10-1).xp	System 33-3; 10-year rainfall, 1-hour duration, 1995 land use.
33-3(2-1).xp	System 33-3; 2-year rainfall, 1-hour duration, 1995 land use.
33-4(10-1).xp	System 33-4; 10-year rainfall, 1-hour duration, 1995 land use.
33-4(2-1).xp	System 33-4; 2-year rainfall, 1-hour duration, 1995 land use.
33-5(10-1).xp	System 33-5; 10-year rainfall, 1-hour duration, 1995 land use.
33-5(2-1).xp	System 33-5; 2-year rainfall, 1-hour duration, 1995 land use.
33-6(10-1).xp	System 33-6; 10-year rainfall, 1-hour duration, 1995 land use.
33-6(2-1).xp	System 33-6; 2-year rainfall, 1-hour duration, 1995 land use.
33-7(10-1).xp	System 33-7; 10-year rainfall, 1-hour duration, 1995 land use.
33-7(2-1).xp	System 33-7; 2-year rainfall, 1-hour duration, 1995 land use.
33-8(10-1).xp	System 33-8; 10-year rainfall, 1-hour duration, 1995 land use.
33-8(2-1).xp	System 33-8; 2-year rainfall, 1-hour duration, 1995 land use.
33-9(10-1).xp	System 33-9; 10-year rainfall, 1-hour duration, 1995 land use.
33-9(2-1).xp	System 33-9; 2-year rainfall, 1-hour duration, 1995 land use.
33-10(10-1).xp	System 33-10; 10-year rainfall, 1-hour duration, 1995 land use.
33-10(2-1).xp	System 33-10; 2-year rainfall, 1-hour duration, 1995 land use.
33-11(10-1).xp	System 33-11; 10-year rainfall, 1-hour duration, 1995 land use.
33-11(2-1).xp	System 33-11; 2-year rainfall, 1-hour duration, 1995 land use.
33-12(10-1).xp	System 33-12; 10-year rainfall, 1-hour duration, 1995 land use.
33-12(2-1).xp	System 33-12; 2-year rainfall, 1-hour duration, 1995 land use.
33-13(10-1).xp	System 33-13; 10-year rainfall, 1-hour duration, 1995 land use.
33-13(2-1).xp	System 33-13; 2-year rainfall, 1-hour duration, 1995 land use.
33-14(10-1).xp	System 33-14; 10-year rainfall, 1-hour duration, 1995 land use.
33-14(2-1).xp	System 33-14; 2-year rainfall, 1-hour duration, 1995 land use.
33-1510-1).xp	System 33-15; 10-year rainfall, 1-hour duration, 1995 land use.
33-15(2-1).xp	System 33-15; 2-year rainfall, 1-hour duration, 1995 land use.
36-1(10-1).xp	System 36-1; 10-year rainfall, 1-hour duration, 1995 land use.
36-1(2-1).xp	System 36-1; 2-year rainfall, 1-hour duration, 1995 land use.
36-2(10-1).xp	System 36-2; 10-year rainfall, 1-hour duration, 1995 land use.
36-2(2-1).xp	System 36-2; 2-year rainfall, 1-hour duration, 1995 land use.
36-3(10-1).xp	System 36-3; 10-year rainfall, 1-hour duration, 1995 land use.
36-3(2-1).xp	System 36-3; 2-year rainfall, 1-hour duration, 1995 land use.

OC-459 THROUGH –461.DAT	SLAMM input file for named subbasin.
OC461B AND 461C.DAT	SLAMM input file for named subbasin.
OC-462 THROUGH 464.DAT	SLAMM input file for named subbasin.
OC465A AND 465B.DAT	SLAMM input file for named subbasin.
OC-466 THROUGH –480.DAT	SLAMM input file for named subbasin.
OC-495 THROUGH –498.DAT	SLAMM input file for named subbasin.
OC-498B.DAT	SLAMM input file for named subbasin.
OC498C.DAT	SLAMM input file for named subbasin.
OC499A AND 499B.DAT	SLAMM input file for named subbasin.
OC-500.DAT	SLAMM input file for named subbasin.
R1-1 THROUGH –5.DAT	SLAMM input file for named subbasin.
R2-1 THROUGH –9.DAT	SLAMM input file for named subbasin.
R2A-1 THROUGH –5.DAT	SLAMM input file for named subbasin.
R3-1.DAT	SLAMM input file for named subbasin.
R4-1.DAT	SLAMM input file for named subbasin.
R5-1 THROUGH –5.DAT	SLAMM input file for named subbasin.
R6-1 THROUGH –3.DAT	SLAMM input file for named subbasin.
RR-1 THROUGH –11.DAT	SLAMM input file for named subbasin.
MADISON.PPD	SLAMM file containing the particulate and filterable residue (dissolved solids) concentrations for each source area and for several pollutants.
MADISON.PRR	SLAMM particulate residue delivery file.
MADISON.PSC	SLAMM particulate residue (suspended solids) description files.
MADISON.RSV	SLAMM runoff coefficients file.
MSCALC64.EXE	SLAMM executable file.
RAIN83.RAN	1983 rainfall data for use in SLAMM (representative of average year).
README.DOC	Reconciliation of various model runs with results summary in Microsoft Word format.
REC-WQ-TRTMT-BASINS-FINAL.XLS	Water quality treatment basins analysis in Excel spreadsheet format.
RESULTS-FINAL.XLS	Final SLAMM results summary in Excel spreadsheet format.
SLAMM-INPUT-SUM.XLS	SLAMM input data summary in Excel spreadsheet format.

* SLAMM output files ".OUT" included for all ".DAT" files.

Appendix

C

Cost Estimating Guidelines

Introduction

The purpose of this appendix is to state the assumptions and establish the unit costs used to prepare the estimate of construction costs for altemative and recommended improvements.

General Conditions

Construction costs presented in this report reflect late 1998 conditions. Capital constructions cost estimates include a contingency, and engineering and administrative fees. The contingency was calculated as 20 percent of the construction cost. Engineering and administrative fees were calculated as 15 percent of the construction cost.

These costs are preliminary budget level costs (+30 percent to –5 percent) and have been prepared from the information available at the time of the estimate. Final costs will depend on the actual labor and material costs, competitive market conditions, final project design, implementation schedule, and other variable factors. With the passage of time, inflation may be expected to increase costs.

Construction costs are determined, to a large degree, by the size of the project, the construction market, and the availability of materials at the time the project is bid. The following are the sources for unit construction costs shown on Table C-1:

- R. A. Smith & Associates, Inc. Projects
- Department of Transportation Construction Projects
- Hey and Associates, Inc. Projects
- Engineering News – Record (ENR)

Costs for land acquisition necessary to implement improvements are highly dependent on the specific location, amount of land required, and property boundaries. The City of Oak Creek provided the unit cost as a typical cost for the type of land anticipated to be acquired for these projects.

Specific Construction Conditions

1. Costs incorporate allowances for the proximity of residential areas to the construction area and the difficult access to the channel.

2. Concrete and reinforced concrete box conduit costs assume access by trucks to the channel from the channel banks along the various study reaches.

3. Reasonable attempts will be made to retain as many of the existing trees and bushes as possible during construction.

4. Construction will be during dry season to minimize problems associated with flow in the various channels.

5. Costs do not include provisions for extreme soil conditions such as bedrock removal or muck or peat conditions.

Water Quality Management Costs

Costs for water quality management practices were derived from the report Cost of Urban Stormwater Pollution Control Measures published by the Southeastern Wisconsin Regional Planning Commission (SEWRPC, 1991). The SEWRPC costs were updated from 1991 to 1998 dollars by using an inflation factor of 1.2 obtained from the publication *Engineering News Record*.

Summary of Unit Costs

Item	Units	Unit Cost
Earthwork Excavation---Channel	CY	$15
Earthwork Excavation—Pond	CY	$10
Pond Outlet Pipe w/ Riprap	EA	$5,000
Culvert/Storm Sewer Removal	LF	$100
24" through 36" Culverts	LF	$300
48" Culvert	LF	$330
60" Culvert	LF	$360
66" Culvert	LF	$375
6'W x 4'H & 10'W x 3'H Box Culverts	LF	$2,000
8'W x 5'H Box Culvert	LF	$2,100
10'W x 5'H Box Culvert	LF	$2,200
30"-36" Storm Sewer	LF	$250
48" Storm Sewer	LF	$280
Railroad Casing	LF	$500
Excavation Including Haul	CY	$15
Compact Road & Foreslope Material	Ton	$6
Re-ditching	LF	$10
Compacted Road Base	Ton	$9
Pavement Removal & Replacement	SY	$15
Restoration (topsoil, seed, fert., & mulch)	SY	$5
Erosion Matting	SY	$2
Stormwater Pumping Station	EA	$500,000
Land Acquisition	Acre	$15,000
Tree & Brush Removal	2% of other costs	
Utility Relocations	2% of other costs	
Erosion Control	2% of other costs	
Contingency	20% of other costs	
Engineering	15% of other costs	

Appendix

D

Stormwater Management Ordinance

For the City of Oak Creek

Draft

Prepared by Hey and Associates, Inc.

DRAFT

STORM WATER MANAGEMENT ORDINANCE FOR THE CITY OF OAK CREEK

Prepared by Neal O'Reilly
Vice President Water Resources Planning
Hey and Associates, Inc.

DRAFT
STORM WATER MANAGEMENT ORDINANCE FOR THE CITY OF OAK CREEK

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AN ORDINANCE TO CREATE CHAPTER TWENTY SIX OF THE MUNICIPAL CODE OF THE CITY OF OAK CREEK RELATING TO THE CONTROL OF STORM WATER RUNOFF

The City Council of the City of Oak Creek does hereby ordain that Chapter ________ of the Municipal Code of the City of Oak Creek is created to read as follows:

CHAPTER ________
STORM WATER RUNOFF

S. 01. AUTHORITY

(1) This ordinance is adopted by the City of Oak Creek under the authority granted by s. 62.234 Wis. Stats. This ordinance supersedes all conflicting and contradictory storm water management regulations previously enacted under s. 62.23, Wis. Stats. Except as specifically provided for in s. 66.234 Wis. Stats., s. 66.23, Wis. Stats. applies to this ordinance and to any amendments to this ordinance.

(2) The provisions of this ordinance are deemed not to limit any other lawful regulatory powers of the same governing body.

(3) The City of Oak Creek hereby designates the City Engineer to administer and enforce the provisions of this ordinance.

(4) The requirements of this ordinance do not pre-empt more stringent storm water management requirements that may be imposed by WPDES Storm Water Permits issued by the Department of Natural Resources under s. 283.33 Stats.

S. 02. FINDINGS OF FACT

(1) The City of Oak Creek finds that uncontrolled storm water runoff from land development activity has a significant impact upon water resources and the health, safety, and general welfare of the community, and diminishes the public enjoyment and use of natural resources. Specifically, uncontrolled storm water runoff can:

(a) degrade physical stream habitat by increasing streambank erosion, increasing streambed scour, diminishing groundwater recharge, and diminishing stream base flows;

(b) diminish the capacity of lakes and streams to support fish, aquatic life, recreational, and water supply uses by increasing the export of nutrients and other urban pollutants;

(c) alter wetland communities by changing wetland hydrology and by increasing pollutant loads;

(d) reduce the quality of groundwater by increasing pollutant loading;

(e) threaten public health, safety, property, and general welfare by overtaxing storm sewers, drainageways, and other minor drainage facilities;

(f) threaten public health, safety, property, and general welfare by increasing major flood peaks and volumes;

(g) undermine flood plain management efforts by increasing the incidence and levels of flooding.

S. 03. PURPOSE AND INTENT

(1) PURPOSE. The purpose of this ordinance is to set forth storm water requirements and criteria which will prevent and control water pollution, and diminish the threats to public health, safety, welfare, and aquatic life due to runoff of storm water from development or redevelopment.

(2) INTENT. The City of Oak Creek recognizes that the preferred method of addressing storm water management problems and needs is through the preparation of comprehensive storm water management plans for logical subwatershed areas which are designed to meet the purpose and intent of this ordinance. Accordingly, the standards for onsite storm water management measures set forth in Section 07 do not apply in areas where such plans have been prepared and approved by the City of Oak Creek. In those areas for which approved storm water management plans have been prepared, all land development activities will include storm water management measures set forth in those approved storm water management plans. It is the general intent of the City of Oak Creek to achieve its purpose through:

(a) managing long-term, construction site erosion and post-construction storm water discharges from land development activities;

(b) providing two options for developing storm water management requirements including: 1) application of generic requirements in this ordinance on a site-by-site basis in areas for which no approved storm water management plan exists; and 2) implementation of management practices set forth in the City of Oak Creek Storm Water Management Master Plan or any other detailed storm water management plan approved by the City.

S. 04. DEFINITIONS

(1) "Administering authority" means the governmental employee, or a regional planning commission empowered under s. 62.23 Wis. Stats., designated by the City of Oak Creek to administer this ordinance.

(2) "Agricultural land use" means use of land for planting, growing, cultivating, and harvesting of crops for human or livestock consumption, and pasturing or yarding of livestock.

(3) "Business day" means a day which the offices of the City Engineer are routinely and customarily open for business.

(4) "Cease and desist order" means a court issued order to halt land developing activity that is being conducted without the required permit.

(5) "Commercial land use" means use of land for the retail or wholesale of goods or services.

(6) "Common plan of development or sale" means all lands included within the boundary of a certified survey or subdivision plat created for the purpose of development or sale of property where multiple separate and distinct land developing activity may take place at different times and on different schedules.

(7) "Control measure" means a practice or combination of practices to control erosion and attendant pollution.

(8) "Control plan" means a written description of the number, locations, sizes, and other pertinent information of control measures designed to meet the requirements of this ordinance submitted by the applicant for review and approval by the City of Oak Creek.

(9) "Critical duration storm" means that storm that produces the highest peak rate of runoff. To determine the critical duration storm a series of rainfall depths and durations are run in an iterative process until the highest peak is found.

(10) "Design rainfall event" means a discrete hypothetical rainstorm characterized by a specific duration, temporal distribution, rainfall intensity, return frequency, and total depth of rainfall.

(11) "Detention basin" means a pond designed to store water after a rainstorm which releases the runoff water at a controlled rate.

(12) "Discharge volume" means the quantity of runoff discharged from the land surface as the result of a rainfall event.

(13) "Division of land" means the creation of four or less parcels or building sites of one or fewer acres from one parcel.

(14) "Drainage Easement" means a legal agreement to allow water to flow across a piece of property. The easement establishes specific requirements for activities that can and can not take place in the easement zone.

(15) "Erosion" means the detachment and movement of soil, sediment or rock fragments by water, wind, ice, or gravity.

(16) "Extra-territorial" means the unincorporated area within 3 miles of the corporate limits of a first, second, or third class city or village.

(17) "Fee in lieu" means a payment of money to the City of Oak Creek in place of meeting all or part of the storm water performance standards required by the ordinance.

(18) "Gross aggregate area" means the total area, in acres, of all land located within the property boundary containing the land development activity.

(19) "Groundwater enforcement standard" means a numerical value expressing the concentration of a substance in groundwater which is adopted under s. 160.07 Wis. Stats., and s. NR 140. 10 or s. 160.09 Wis. Stats, and s. NR 140.12.

(20) "Groundwater preventive action limit" means a numerical value expressing the concentration of a substance in groundwater which is adopted under s. 160.15 Wis. Stats., and s. NR 140.10, 140.12, or 140.20.

(21) "Irrevocable letter of credit" means an agreement with a bank or other institution to pay money or extend credit to honor the terms of the permit with the City of Oak Creek.

(22) "Impervious surface" means a surface through which rainfall does not infiltrate. "Rooftops," "sidewalks," "parking lots," and "street surfaces" are examples of impervious surfaces.

(23) "Infiltration" means the process by which rainfall or surface runoff percolates or penetrates into the underlying soil.

(24) "Landowner" means any person holding title to or having an interest in land.

(25) "Land user" means any person operating, leasing, renting, or having made other arrangements with the landowner by which the landowner authorizes use of his or her land.

(26) "Land development activity" means any activity which changes the volume or peak flow discharge rate of rainfall runoff from the land surface, or means the construction of buildings; roads; parking lots; paved storage areas; and similar facilities—excluding agricultural land use.

(27) "Land disturbing construction activity" means any man-made change of the land surface including removing vegetative cover; excavating; filling; and grading, but not including agricultural land uses such as planting, growing, cultivating and harvesting of crops; growing and tending of gardens; harvesting of trees; and landscaping modifications.

(28) "Local municipality" means a town, county, village, or city.

(29) “Low flow channel” means a small channel located within a waterway used to concentrate flow during small storms. The purpose of a low flow channel is to maintain adequate water depth for aquatic organisms and needed scour velocities to prevent sediment buildup.

(30) "Maintenance agreement" means a legal document that is filed with the County Register of Deeds as a property deed restriction and which provides for long-term maintenance of storm water management practices.

(31) "Maintenance Bond" means a bond, which guarantees that the permit holder will perform needed maintenance outlined in the permit. The bond protects the City against loss due to the inability or refusal of the permit holder to perform to the conditions of the permit.

(32) “Major drainage systems” means a drainage system of open channels and overland flow paths that carry storm water during large rainfall events, typically with greater than a 10-year recurrence interval.

(33) “Minor drainage system” are those components of the drainage system designed to carry small rainstorms. The minor drainage system is typically made up of roadside ditches and storm sewers.

(34) "Natural wetlands" means an area where water is at, near, or above the land surface long enough to be capable of supporting aquatic or hydrophytic vegetation and which has soils indicative of wet conditions. These wetlands include existing, mitigation, and restored wetlands.

(35) "Non-storm discharge" means a discharge to the storm sewer system created by some process other than the runoff of rain.

(36) "Non-structural measure" means a practice, technique, or measure to reduce the volume, peak flow rate, or pollutants in storm water that does not require the design or installation of fixed storm water management facilities.

(37) "Off-site" means located outside the property boundary described in the permit application for land development activity.

(38) "Other than residential development" means development of the following land uses: commercial; industrial; government and institutional; recreation; transportation; communication; and utilities.

(39) "On-Site" means located within the property boundary described in the permit application for the land development activity.

(40) "Peak flow discharge rate" means the maximum rate at which a unit volume of storm water is discharged.

(41) "Performance Bond" means a bond which guarantees that the permit holder will perform to the terms of the agreement. The bond protects the City against loss due to the inability or refusal of the permit holder to perform to the conditions of the permit.

(42) "Performance security" means a performance bond, maintenance bond, surety bond, irrevocable letter of credit, or similar guarantees submitted to the City Engineer by the permit holder to assure that requirements of the ordinance are carried out in compliance with the storm water management plan.

(43) "Permit" means a written authorization made by the City of Oak Creek to the applicant to conduct land development activities.

(44) "Permit administration fee" means a sum of money paid to the City of Oak Creek by the permit applicant for the purpose of recouping the expenses incurred by the authority in administering the permit.

(45) "Pervious surface" means a surface that infiltrates rainfall during a large portion of the design rainfall event. Well-managed lawns, fields and woodlands are examples of pervious surfaces.

(46) "Post-construction storm water discharge" means any storm water discharged from a site following the completion of land disturbing construction activity and final site stabilization.

(47) "Post-development condition" means the extent and distribution of land cover types anticipated to occur under conditions of full development that will influence rainfall runoff and infiltration.

(48) "Pre-development condition" means the extent and distribution of land cover types present before the initiation of land development activity, assuming that all land uses prior to development activity are managed in an environmentally sound manner.

(49) "Pre-treatment" means the treatment of storm water prior to its discharge to the primary storm water treatment practice in order to reduce pollutant loads to a level compatible with the capability of the primary practice.

(50) "Residential development" means that which is created to house people, including the residential dwellings as well as all attendant portions of the development including lawns, driveways, sidewalks, garages, and access streets. This type of development includes single family, multi-family, apartment, and trailer parks.

(51) “Retention pond” is a detention basin designed to have no surface water discharge.

(52) "Runoff" means the rainfall, snowmelt, or irrigation water flowing over the ground surface.

(53) "Site" means the entire area included in the legal description of the land on which the land disturbing or land development activity is proposed in the permit application.

(54) "Site restriction" means any physical characteristic which limits the use of a storm water best management practice as prescribed in the latest edition of the Wisconsin Storm Water Manual (WDNR).

(55) "Stop work order" means an order issued by the office of the City Engineer that requires that all construction activity on the site be stopped.

(56) "Storm water management plan" means a document that identifies what actions will be taken to reduce storm water quantity and pollutant loads from land development activity to levels meeting the performance standards of Section 07 of this ordinance.

(57) "Storm water runoff" means that portion of the precipitation falling during a rainfall event that runs off the surface of the land and into the natural or artificial conveyance or drainage network.

(58) "Structural measure" means source area practices, conveyance measures, and end-of-pipe treatment that are designed to control storm water runoff pollutant loads, discharge volumes, and peak flow discharge rates.

(59) "Surety Bond" means a guaranty provided by a bonding company to pay the City for loss due to the inability or refusal of the permit holder to perform to the conditions of the permit.

(60) "Type II Storm" is a theoretical rainfall storm distribution developed by the Natural Resources Conservation Service (NRCS) to represent typical storms experienced in the Midwest. The storm distribution is found in NRCS Technical Report TR55.

(61) "Wet detention pond" is a detention basis with a permanent pool of water, often designed to trap particulate pollutants.

(62) "Wetland functional value" means the type, quality, and significance of the ecological and cultural benefits provided by wetland resources, such as: flood storage; water quality protection; groundwater recharge and discharge; shoreline protection; fish and wildlife habitat; floral diversity; aesthetics; recreation; and education.

(63) "Wisconsin Pollution Discharge Elimination System (WPDES) Storm Water Permit" means a permit issued by the Wisconsin Department of Natural Resources under s. 283.33 Stats. that authorizes the point source discharge of storm water to waters of the State.

S. 05. APPLICABILITY AND JURISDICTION

(1) APPLICABILITY. This ordinance applies to land development and redevelopment activities which meet the applicability criteria specified in this section. The ordinance also applies to land development activities that are smaller than the minimum applicability criteria if such activities are part of a larger common plan of development

or sale that meets any of the following applicability criteria, even though multiple separate and distinct land development activities may take place at different times on different schedules.

(a) Residential land development with a gross aggregate area of 5 acres or more;

(b) Residential land development with a gross aggregate area of at least 3 acres, but less than 5 acres, if there are at least 1.5 acres of impervious surfaces;

(c) Land development or redevelopment, other than a residential land development, with a gross aggregate area of 1.5 acres or more, or any nonresidential land development which creates impervious area of 0.5 acres or more.

(d) Land development and redevelopment activities, regardless of size of the development, which in the opinion of the City of Oak Creek are likely to result in storm water runoff which exceeds the capacity of the existing drainage facilities or receiving body of water, which causes undue channel erosion, which increases water pollution by scouring or the transportation of particulate matter, or which endangers downstream property or public safety.

(2) JURISDICTION. This ordinance applies to land development and redevelopment, and land disturbing activities within the boundaries of the City of Oak Creek.

(3) EXEMPTIONS. This ordinance does not apply to the following activities:

(a) Land development activities conducted or contracted for by any state agency, as defined under s. 227.01(1) Wis. Stats., but also including the office of district attorney.

S. 06. DESIGN CRITERIA, STANDARDS AND SPECIFICATIONS

(1) All best management practices required to comply with this ordinance shall meet the design criteria, standards and specifications in the latest edition of the Wisconsin Storm Water Manual as published and amended from time-to-time by the State of Wisconsin Department of Natural Resources. Design criteria, standards and specifications for best management practices not contained in the Wisconsin Storm Water Manual shall not be permitted unless approved by the City of Oak Creek.

(2) Unless prior authorization is given by the City Engineer, the following methods shall be used for making hydrologic calculations and for designing storm water management practices to meet the requirements of this ordinance:

(a) All hydrologic and hydraulic design calculations required under this section shall be based on the principles of the SCS curve method document entitled "Urban Hydrology for Small Watersheds" (Technical Release 55) published by Natural Resources Conservation Service (NRCS), United States Department of Agriculture, June 1992, or other methods acceptable to the City Engineer. Computer models that may be used include:

- U. S. Army Corps of Engineers HEC-1.
- Natural Resources Conservation Service TR-20.
- Natural Resources Conservation Service TR-55.
- Illinois State Water Survey ILLUDAS.
- U. S. EPA's SWMM

S. 07. STORM WATER MANAGEMENT STANDARDS

(1) DRAINAGE SYSTEM REQUIREMENT.

The developer shall install all the storm drainage facilities indicated on the plans required in Subsection 09 of this ordinance necessary to serve, and resulting from, the phase of the land development.

(a) A drainage system shall be designed and constructed by the developer to provide for the proper drainage of the surface water of the land division and the drainage area of which it is a part.

(b) Lots shall be laid out so as to provide positive drainage away from all buildings, and individual lot drainage shall be coordinated with the general storm drainage pattern for the area.

(c) Any storm water drainage system will be separate and independent of any sanitary sewer system. Storm sewers, where utilized, shall be designed in accordance with all governmental regulations, and a copy of design computations for engineering capacities shall accompany plans submitted by the petitioners engineer for the final plat.

(d) Storm water drainage systems shall be designed to utilize the natural drainage and storage capabilities of the site to the fullest extent practicable. Storm water drainage systems shall be designed to provide an economical gravity flow drainage system.

(e) Storm water drainage systems shall be designed to utilize the collector and land access streets as open runoff channels during major storm events without flooding adjoining building sites. The streets will be supplementary to the minor storm water drainage system.

(f) Bridges and Culverts. All new and replacement culverts and bridges over waterways shall be designed so as to accommodate, according to the categories listed below, the designated flood event without over topping the related roadway or railway track:

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

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

c. Freeway and expressway: a 100-year recurrence interval flood discharge.

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

The depth of flow over the top of minor, collector, and arterial streets and highways shall not exceed six inches during the 100-year recurrence interval flood discharge.

Bridges and culverts shall be designed to facilitate fish passage through elimination of hydraulic drops, maintenance of low flow channels, and minimization of excess stream enclosures.

(g) Street Drainage. All streets shall be provided with an adequate storm drainage system. The street storm drainage system shall serve as the minor drainage system and shall be designed to carry street, adjacent land and building storm water drainage. Storm water shall not be permitted to be run into the sanitary sewer system within the proposed subdivision. In order to provide an acceptable level of access to property and traffic service, the drainage system shall be designed to provide two clear lanes of moving traffic on arterial streets and one 10-foot lane for moving traffic on collector and land access streets during the 10-year critical duration storm. Temporary accumulations of storm runoff from ponding or flowing water, in or near minor system components, shall be permitted during events beyond the ten year providing such accumulations do not encroach on any traffic lane of any collector or arterial street, nor be more than 6-inches deep as measured at the centerline of any local street.

(h) Off-Street Drainage. The design of the off-street major drainage system shall include the entire watershed affecting the land division and shall be extended to a watercourse or ditch adequate to receive the storm drainage. When the drainage system is outside of the street right-of-way, the developer shall make provisions for providing an easement pursuant to Subsection 07(2) of this ordinance, to provide for the future maintenance of said system.

(i) Drainage Piping Systems. Unless otherwise approved by the City Engineer, all drainage piping of twelve (12) inches diameter and greater in street rights-of-way shall be constructed of Class III (3) reinforced concrete pipe. Piping materials outside of rights-of-way shall be subject to approval of the City Engineer.

(j) Agricultural Drains. Agricultural drain tiles which are disturbed during construction shall be restored, reconnected or connected to public storm drainage facilities.

(k) Open Channel Systems. Where open channels are utilized in either the minor or major drainage system, they shall be designed so as to minimize maintenance requirements. Drainage easements, in lieu of dedications, shall be utilized to accommodate open channels provided with adequate access by the City for maintenance of drainage capacity. Side slopes shall not be steeper than a three-to-one (3: 1) slope unless approved by the City Engineer.

Major drainageways should be designed with low flow channels to maintain increased stream velocity to reduce sedimentation in the stream channels and accompanying nuisance vegetation.

(l) Protection of Drainage Systems. The developer shall adequately protect all ditches to the satisfaction of the City Engineer. Open channels shall be seeded, sodded or ripraped based upon recommendations made in the Wisconsin Construction Site Handbook, WDNR, 1990.

(2) DRAINAGE EASEMENTS.

Where a land division is traversed by a watercourse, drainageway, channel or stream:

(a) There shall be provided a storm water easement or drainage right-of-way conforming substantially to the lines of such watercourse and such further width or construction, or both, as will be adequate for the purpose and as may be necessary to comply with this Section; or

(b) The watercourse, drainageway, channel or stream may be relocated in such a manner that the maintenance of adequate drainage will be assured. When channels are relocated, a storm water easement or drainage right-of-way conforming to the lines of the relocated watercourse, and such further width for construction, or both, will be provided. For state designated navigable streams, such relocations shall only be in accord with a permit issued by the Wisconsin Department of Natural Resources; or

(c) Wherever possible, drainage shall be maintained in an easement by an open channel with vegetated banks and adequate width for maximum potential volume flow. In all cases, such easements shall be wide enough to convey the 10-year critical duration storm for the minor drainage system, and the 100-year critical duration storm for the major drainage system. The drainage easement under all circumstances shall not be less than thirty (30) feet in width.

(3) STORM WATER DISCHARGE QUANTITY. Unless otherwise provided for in this ordinance, all land development activities subject to this ordinance shall establish on-site management practices to control the peak flow rates of storm water discharged from the site. Infiltration of storm water runoff from driveways, sidewalks, rooftops, and landscaped areas shall be incorporated to the maximum extent practical, as defined by the City Engineer, to provide volume control in addition to control of peak flows.

On-site management practices shall be used to meet the following minimum performance standards:

[Note: the City has two options for managing the quantity of surface water runoff. One is to match per and post peak discharges. However, it should be noted that this method while generally used by most municipalities has been show to allow increases in downstream flood elevations. The second option is only allow a maximum discharge equivalent to the current 2 and 100-year flood flow. Both options are presented below for the City's consideration.]
[***Peak Control Option***]

(a) The peak flow rates of storm water runoff from the development shall not exceed the pre-development flows calculated for the series of design storms specified in s.07(3)(b). Pre-development conditions are specified in s.07(3)(c). Discharge velocities and duration's must be non-erosive to discharge locations, outfall channels, and receiving streams. Overland conveyance must be provided for discharges from the development that exceed the capacity of the drainage system.

(b) At a minimum, the 24-hour, Type II, 2-, 10-, and 100-year rainfall events shall be used in comparing peak flow discharge rates for pre-development and post-development conditions.

(c) Pre-development conditions for land developing activities shall assume a "good" level of land management. When the Natural Resource Conservation Service TR-55 Method is used to calculate peak flow discharge rates and runoff volumes for the pre-development condition, NRCS curve numbers shall not exceed the following for the given soil hydrologic groups. When other methods for computing runoff are used, they shall assume a comparable pre-development condition.

Soil Hydrologic Group:	A	B	C	D
NRCS Curve Number for Meadow:	30	58	71	78
NRCS Curve Number for Woodland:	30	55	70	77

[***Maximum Discharge Option***]

(a) The peak discharge rate from the site shall not exceed the 0.04 cubic feet per second (cfs) for the 2-year event, and 0.15 cfs for the 100-year event .

(4) STORM WATER DISCHARGE QUALITY. Unless otherwise provided for in this ordinance, all land development activities subject to this ordinance shall establish on-site management practices to control the quality of storm water discharged from the site. On-site management practices shall be used to meet the following minimum standard:

(a) Storm water discharges shall be treated to remove, on an average annual basis, a minimum of 80% of the total suspended solids load. To achieve this level of control, storm water practices shall be designed to accommodate, at a minimum, the runoff resulting from 1.5-inches of rainfall during a 4-hour period and control particulates which are 5-microns or larger in size.

(b) Storm water discharges shall be pre-treated prior to infiltration to prolong the life of the infiltration practice and to prevent discharge of storm water pollutants at concentrations that will result in exceedances of groundwater preventive action limits or enforcement standards established by the Department of Natural Resources in NR 140 Wisconsin Administrative Code.

(c) Storm water ponds and infiltration devices shall not be located closer to water supply wells than indicated below without first notifying the City Engineer:

1. 100 feet from a well serving a private water system or a transient, non-community public water system;

2. 1,200 feet from a well serving a municipal public water system, a non-municipal public water system, or a non-transient non-community public water system;

3. the boundary of a recharge area to a wellhead identified in a wellhead area protection plan.

(5) DISCHARGE TO WETLANDS. Wetlands shall be protected from the damaging modifications and adverse changes in runoff quality and quantity associated with new developments. To protect the quality of wetlands in the City of Oak Creek the following criteria will be followed:

(1) Increased volumes of storm water shall not be discharged to high quality wetlands classified as Category III wetlands in the <u>City of Oak Creek Storm Water Master Plan</u>. Category I wetlands have vegetation and wildlife communities that can not tolerate any discharge of sediment or pollutants, and can not tolerate any changes in water levels.

(2) Untreated storm water shall not be discharged to wetlands classified as Category II wetlands in the <u>City of Oak Creek Storm Water Master Plan</u>. Category II wetlands have vegetation and wildlife communities that cannot tolerate discharges of sediment or pollutants without becoming degraded. Discharges of treated storm water is allowed to Category II wetlands provided that inundation of the vegetation is for periods of less than one week.

(3) Discharge of pretreated storm water is allowed to wetlands classified as Category I wetlands identified in the <u>City of Oak Creek Storm Water Master Plan.</u> Category I wetlands have vegetation that is not impacted by the discharge

of pollutants or impacted by changing water levels. Category I wetlands can be used for storm water storage provided the water is pretreated for sediment removal, and that no dredging in the wetland takes place.

(6) EXCEPTIONS. The requirements for on-site storm water management practices established in Sections 07 (3,4) are not applicable in areas which are determined by the City Engineer to be covered by an approved storm water management plan, which was developed and approved as an alternative storm water management planning approach to carrying out on-site measures consistent with the purpose and intent of this ordinance. In such cases, the recommendations of the approved storm water management plan shall be applied either through the installation of storm water management provisions recommended to be included on the development site being considered and/or through the payment of a fee as set forth in s. 07 (7). These minimum requirements may also be waived in whole or in part by the City Council upon written request of the applicant, provided that at least one of the following conditions applies:

(a) Provisions are made to manage storm water by an off-site facility. This requires that the off-site facility is in place, is designed and adequately sized to provide a level of storm water control that is equal to or greater than that which would be afforded by application of the standards of this ordinance.

(b) The City Engineer finds that meeting the minimum on-site management requirements is infeasible due to space or site restrictions.

(7) FEE IN LIEU OF ON-SITE STORM WATER MANAGEMENT PRACTICES. Where the City waives all or part of the minimum on-site storm water management requirements under s.07 (3,4), or where the waiver is based on the provision of adequate storm water facilities provided by the City of Oak Creek downstream of the proposed development, the applicant shall be required to pay a fee in an amount determined in negotiation with the City Council. In setting the fee for land development projects, the City Council shall consider an equitable distribution of the cost of land, engineering design, construction, and maintenance as set forth in Section 66.55 of the Wisconsin Statutes.

(8) GENERAL CONSIDERATIONS FOR ON-SITE AND OFF-SITE STORM WATER MANAGEMENT MEASURES. The following considerations shall be observed in managing storm water runoff.

(a) Natural topography and land cover features such as natural swales, natural stream channels, flood plain, natural depressions, native soil infiltrating capacity, and natural groundwater recharge areas shall be preserved and used, to the extent possible, to meet the requirements of this section.

(b) Emergency overland flow for all storm water facilities shall be considered to prevent exceeding the capacity of downstream drainage facilities and prevent endangerment of downstream property or public safety.

S. 08. PERMITTING REQUIREMENTS AND PROCEDURES

(1) PERMIT REQUIRED. No landowner or land operator may undertake a land development activity subject to this ordinance without receiving a permit from the City Engineer prior to commencing the proposed activity.

(2) PERMIT APPLICATION AND FEE. Unless specifically excluded by this ordinance, any landowner or operator desiring a permit shall submit to the City Engineer a permit application made on a form provided by the City Engineer for that purpose.

(a) Unless otherwise excepted by this ordinance, a permit application must be accompanied by the following in order that the permit application be considered by the City Council: a storm water management plan; a maintenance agreement; any payment of "fees in lieu," as provided for under s. 07(7); and a non-refundable permit administration fee.

(b) The storm water management plan shall be prepared to meet the requirements of s. 09 of this ordinance, the maintenance agreement shall be prepared to meet the requirements of s. 10 of this ordinance, and fees shall be those established by the City of Oak Creek as set forth in s. 12 of this ordinance.

(3) REVIEW AND APPROVAL OF PERMIT APPLICATION. The City Engineer shall review any permit application that is submitted with a storm water management plan, maintenance agreement, and the required fee. The following approval procedure shall be used:

(a) Within 30 business days of the receipt of a complete permit application, including all documents as required by s. 09, the City Engineer shall inform the applicant in writing whether the application, plan, and maintenance agreement are approved or disapproved. The City Engineer shall base the decision on requirements set forth in s. 06, s. 07, and s. 09 of this ordinance.

(b) If the storm water permit application; plan; and maintenance agreement are approved, the City Engineer shall issue the permit.

(c) If the storm water permit application; plan; or maintenance agreement are disapproved, the City of Oak Creek shall detail in writing the reasons for disapproval.

(d) If additional information is submitted, the City Engineer shall have 30 business days from the date the additional information is received to inform the applicant that the plan and maintenance agreement are either approved or disapproved.

(4) PERMIT CONDITIONS. All permits issued under this section of the Ordinance shall be subject to the following conditions, and holders of permits issued under this ordinance shall be deemed to have accepted these conditions. The City Engineer may suspend or revoke a permit for violation of a permit condition, following written notification to the permittee. An action by the City Engineer to suspend or revoke the permit may be appealed in accordance with s. 14 of this ordinance.

(a) Compliance with the permit does not relieve the permit holder of the responsibility to comply with other applicable federal, state, and local laws and regulations.

(b) The permit holder shall design, install, and maintain all structural and nonstructural storm water management measures in accordance with the approved storm water management plan, maintenance agreement, and the permit.

(c) The permit holder shall notify the City Engineer at least three (3) business days before commencing any work in conjunction with the storm water management plan, and within three (3) business days upon completion of the storm water management practices. If required as a special condition, the permit holder shall make additional notification according to a schedule set forth by the City Engineer so that practice installations can be inspected during construction.

(d) Completed structural storm water management practices must pass a final inspection to determine if they are in accordance with the approved storm water management plan and ordinance. The City Engineer shall notify the permit holder in writing of any changes required in such practices to bring them into compliance with the conditions of the permit. The practice installation required as part of this ordinance shall be certified as built by a licensed professional engineer.

(e) The permit holder shall notify the City Engineer prior to any modifications he or she intends to make to an approved storm water management plan. The City Engineer may require that the proposed modifications be submitted for approval prior to incorporation into the storm water management plan and execution.

(f) The permit holder shall maintain all storm water management practices specified in the approved storm water management plan until the practices either become the responsibility of the City of Oak Creek, or are transferred to subsequent private owners as specified in the approved maintenance agreement.

(g) The permit holder authorizes the City to perform any work or operations necessary to bring storm water management measures into conformance with the approved storm water management plan, and to charge such costs against any performance bond posted for the project or a special assessment pursuant to Wisconsin Statutes Section 66.60.

(h) The permit holder shall provide a one-year written guarantee from the accepted date on all facilities dedicated to the City and installed as part of the storm water plan and accepted by the City of Oak Creek.

(i) If so directed by the City Engineer, the permit holder shall repair and restore, at the permit holder's own expense, all damage to municipal facilities and drainageways caused by storm water runoff, where such damage is caused by activities that are not in compliance with the approved storm water management plan.

(j) The permit holder shall permit property access to the City Engineer for the purpose of inspecting the property for compliance with the approved storm water management plan and the permit.

(k) Where a storm water management plan involves changes in direction, or increases in peak rate and/or total volume of runoff from of a site, the City Council shall require the permittee to make appropriate legal arrangements with adjacent property owners concerning the prevention of endangerment to downstream property or public safety.

(l) The permit holder is subject to the enforceable actions detailed in s.13 of the storm water management ordinance if the permit holder fails to comply with the terms of the permit.

(5) PERMIT DURATION. Permits issued under this section shall be valid from the date of issuance through the date the City Engineer provides written notice to the permit holder that all storm water management practices have passed the final inspection required under Permit Condition (d).

S. 09. STORM WATER MANAGEMENT PLANS

(1) PLAN REQUIREMENTS. The storm water management plan required under s. 08(2) of this ordinance shall contain any such information the City Engineer may need to evaluate the environmental characteristics of the area affected by land development activity, the potential impacts of the proposed development upon the quality and quantity of storm water discharges, the potential impacts upon water resources and drainage utilities, and the effectiveness and acceptability of proposed storm water management measures in meeting the performance standards set forth in this ordinance. Unless specified otherwise by this ordinance, storm water management plans shall contain, at a minimum, the following information.

(a) Name, address, and telephone number for the following or their designees: landowner; developer; project engineer for practice design and certification; person(s) responsible for installation of storm water management practices; person(s) responsible for maintenance of storm water management practices prior to the transfer, if any, of maintenance responsibility to another party.

(b) A proper legal description of the property proposed to be developed referenced to the U.S. Public Land Survey system or to block and lot numbers within a recorded land subdivision plat.

(c) Pre-development site conditions, including:

1. One or more site maps at a scale of not less than 1 inch equals 50 feet. The site maps shall show the following: site location and legal property description; predominant soil types and hydrologic soil groups; existing cover type and condition; topographic contours not to exceed two-foot contour interval; topography and drainage network including enough of the contiguous properties to show runoff patterns onto, through, and from the site; watercourses that may affect or be affected by runoff from the site; flow path and direction for all storm water conveyance sections, including time of travel and time of concentration applicable to each; watershed boundaries used in determinations of peak flow discharge rates and discharge volumes from the site; lakes, streams, wetlands, channels, ditches, and other watercourses on and immediately adjacent to the site; limits of the 100-year flood plain; location of wells located within 1,200 feet of storm water detention ponds, infiltration basins, or infiltration trenches; delineation of wellhead protection areas pursuant to NR 811.16 Wis. Admin. Code.

2. Computations of the peak flow discharge rates and discharge volumes from each discharge point in the development. At a minimum, computations must be made for the following 24-hour, Type II storms: 2-, 10-, and 100-year. All major assumptions used in developing input parameters shall be clearly stated. The areas used in making the calculations shall be clearly cross-referenced to the required map(s).

(d) Post-development site conditions, including:

1. Explanation of the provisions to preserve and use natural topography and land cover features to minimize changes in peak flow runoff rates and volumes to surface waters and natural wetlands.

2. Explanation of any restrictions on storm water management measures in the development area imposed by wellhead protection plans and ordinances.

3. One or more site maps at a scale of not less than 1 inch equals 50 feet showing: proposed pervious land use including vegetative cover type and condition; impervious land use including all buildings, structures, and pavement; proposed topographic contours not to exceed two feet; proposed drainage network including enough of the contiguous properties to show runoff patterns onto, through, and from the site; locations and dimensions of drainage easements; locations of

maintenance easements specified in the maintenance agreement; flow path and direction for all storm water conveyance sections, including time of travel and time of concentration applicable to each; location and type of all storm water management conveyance and treatment practices, including the on-site and off-site tributary drainage area; location and type of conveyance system that will carry runoff from the drainage and treatment practices to the nearest adequate outlet such as a curbed street, storm drain, or natural drainage way; watershed boundaries used in determinations of peak flow discharge rates and discharge volumes; any changes to lakes, streams, wetlands, channels, ditches, and other watercourses on and immediately adjacent to the site.

4. Computations of the peak flow discharge rates and discharge volumes from each discharge point in the development including analysis of the capacity of downstream drainage conveyance systems. At a minimum, computations must be made for the following storms: 2-, 10-, and 100-year 24-hour, Type II, storm. All major assumptions used in developing input parameters shall be clearly stated. The areas used in making the calculations shall be clearly cross-referenced to the required map(s).

5. Detailed investigations of soils and groundwater required for the placement and design of storm water management measures.

6. Design computations and all applicable assumptions for storm water conveyance (open channel, closed pipe) and storm water treatment practices (sedimentation type, filtrations, infiltration-type) as needed to show that practices are appropriately sized and capable of meeting the discharge performance standards of this ordinance.

7. Detailed drawings including cross-sections and profiles of all permanent storm water conveyance and treatment practices.

(e) A storm water plan construction schedule.

(f) A maintenance plan developed for the life of each storm water management practice including the required maintenance activities and maintenance activity schedule.

(g) Cost estimates for the construction, operation, and maintenance of each storm water management practice.

(h) Other information as required by the City Engineer to determine compliance of the proposed storm water management measures with the provisions of this ordinance.

(2) EXCEPTIONS. The City Engineer may prescribe alternative submittal requirements for applicants seeking an exemption to on-site storm water management performance standards under s. 07 (6) of this ordinance.

S. 10. MAINTENANCE

(1) MAINTENANCE AGREEMENT REQUIRED. The maintenance agreement required for storm water management practices under s. 06 and s. 07 of this ordinance shall be an agreement between the City and the permittee. The agreement or recordable document shall be recorded with the County Register of Deeds so that it is binding upon all subsequent owners of land served by the storm water management practices.

(2) AGREEMENT PROVISIONS. The maintenance agreement shall contain the following provisions:

(a) Identify the responsible party for maintenance of the storm water management practices.

(b) The responsible party shall maintain storm water management practices in accordance with the storm water practice maintenance provisions contained in the approved storm water management plan submitted under s.09 of this ordinance.

(c) The City Engineer is authorized to access the property to conduct inspections of storm water practices as necessary to ascertain that the practices are being maintained and operated in accordance with the approved storm water management plan.

(d) A schedule for regular maintenance of each aspect of the property's storm water management system.

(e) That if the City Engineer notifies the party designated under the maintenance agreement of maintenance problems which require correction, the specified corrective actions shall be taken within a reasonable time frame as set by the City Engineer.

(f) If the responsible party does not perform the required corrections in the specified time, the City is authorized to perform the corrected actions identified in the inspection report. The City shall assess the landowner for the cost of such work. The cost of such work shall be assessed against the property as a special assessment pursuant to Wisconsin Statutes Section 66.60.

(g) Identification of the storm water facilities, design components, and designation of the drainage area served by the facilities.

S. 11. FINANCIAL GUARANTEE

(1) The City may require the submittal of a financial guarantee, the form and type of which shall be acceptable to the City. The financial guarantee shall be in an amount determined by the City to be the estimated cost of construction and the estimated cost of maintenance during the period which the designated party in the maintenance agreement has maintenance responsibility.

Conditions for the release of the financial guarantee are as follows:

(a) The financial guarantee shall be released in full or part as the components of the approved storm water management plan are completed and the practice installation has been certified as built by a licensed professional engineer.

(b) The City Engineer must approve any portion of the plan dedicated to the City.

(c) The financial guarantee minus any costs incurred by the City of Oak Creek to conduct required maintenance, shall be released at such time that the responsibility for practice maintenance is passed on to another private entity, via an approved maintenance agreement, or to the City of Oak Creek.

S. 12. FEE SCHEDULE

(1) The fees referred to in other sections of this ordinance shall be established by the City Council and may from time to time be modified by resolution. A schedule of the fees shall be available for review in the office of the City Engineer and Clerk. Fees shall not be required of departments, boards, municipalities, commissions, public offices and corporations as defined under Chapter 32.01 of the Wisconsin State Statutes.

S. 13. ENFORCEMENT AND PENALTIES

(1) Any land development activity initiated after the effective date of this ordinance by any person, firm, association, or corporation subject to the ordinance provisions shall be deemed a violation unless conducted in accordance with said provisions.

(2) The City Engineer shall notify the responsible owner or operator personally or by certified mail of any non-complying land development activity. The notice shall describe the nature of the violation, remedial actions needed, a schedule for remedial action, and additional enforcement action which may be taken.

(3) Upon receipt of written notification from the City Engineer, the permit holder shall correct work that does not comply with the storm water management plan or other provisions of this permit. The permit holder shall make corrections as necessary to meet the specifications and schedule set forth by the City Engineer in the notice.

(4) If the violations to this ordinance are likely to result in damage to adjacent properties, the City may enter the land and take emergency actions necessary to prevent damage to adjacent properties. The costs incurred by the City plus interest and legal costs shall be billed to the owner of title of the property.

(5) The City Engineer is authorized to post a stop work order on all land development activity in violation of this ordinance, or to request the City Attorney to obtain a cease and desist order from a court of competent jurisdiction.

(6) The City Engineer may revoke a permit issued under this ordinance for non-compliance with ordinance provisions.

(7) Any permit revocation or stop work order shall remain in effect unless retracted in writing by the City Engineer.

(8) Any cease and desist order shall remain in effect unless retracted by a court of competent jurisdiction.

(9) The City Engineer is authorized to refer any violation of this ordinance, or of a stop work order or cease and desist order issued pursuant to this ordinance, to the City Attorney for the commencement of further legal proceedings.

(10) Any person, firm, association, or corporation issued a written notice under s. 13(2) who does not comply with the provisions of this ordinance shall be subject to a court ordered forfeiture of not less than 50 dollars nor more than 500 dollars per offense, together with the costs of prosecution. Each day that the violation exists shall constitute a separate offense.

(11) Every violation of this ordinance is a public nuisance. Compliance with this ordinance may be enforced by injunctional order at the suit of the City of Oak Creek pursuant to s. 66.119 Stats. It shall not be necessary to prosecute for forfeiture before resorting to injunctional proceedings.

(12) When the City Engineer determines that the holder of a permit issued pursuant to this ordinance has failed to follow practices set forth in the Storm Water Management Plan submitted and approved pursuant to s. 08 of this ordinance, or has failed to comply with schedules set forth in said Storm Water Management Plan, and has received a written notice under s. 13 (2), the City Engineer or a party designated by the City Engineer may enter upon the land and perform the work or other operations necessary to bring the condition of said lands into conformance with requirements of the approved plan. The City Engineer shall keep a detailed accounting of the costs and expenses of performing this work. These costs and expenses shall be deducted from any performance or maintenance bond posted pursuant to s. 11 of this ordinance. Where such a bond has not been established, or where such a bond is insufficient to cover these costs, the costs and expenses shall be entered on the tax roll as a special assessment pursuant to Section 66.60 of the Wisconsin Statutes.

S. 14. APPEALS

(1) The City Council shall hear and decide appeals where it is alleged that there is error in any order, decision or determination made by the City Engineer in administering this ordinance.

(2) Upon appeal, the City Council may authorize variances to the storm water management plan and from the provisions of this ordinance which are not contrary to the public interest and the intent of this ordinance, and where, owing to special conditions, a literal enforcement of the ordinance will result in unnecessary hardship or practical difficulty.

(3) TIME OF APPEAL. Appeals to the City Council by any aggrieved person affected by any decision of the City Engineer must be made within 30 days of the decision.

S. 15. SEVERABILITY

(1) If any section, clause, provision or portion of this ordinance is judged unconstitutional or invalid by a court of competent jurisdiction, the remainder of the ordinance shall remain in force and not be affected by such judgment.

S. 14. EFFECTIVE DATE

(1) This ordinance shall be in force and effect from and after its adoption and publication. The above and foregoing ordinance was duly adopted by the City Council of the City of Oak Creek on the [number] day of [month], [year].

Approved:

Attested:

Published on: [day, month, year]

Appendix

E

NR216 Stormwater Permit

For the City of Oak Creek

WISCONSIN
DEPT. OF NATURAL RESOURCES

State of Wisconsin \ DEPARTMENT OF NATURAL RESOURCES

Tommy G. Thompson, Governor
George E. Meyer, Secretary
Gloria L. McCutcheon, Regional Director

Southeast Regional Headquarters
2300 N. Dr. ML King Drive, PO Box 12436
Milwaukee, Wisconsin 53212-0436
Telephone 414-263-8500
FAX 414-263-8606
TDD 414-263-8713

CITY OF OAK CREEK
ENGINEERING DEPARTMENT
JUL 03 2000
RECEIVED

REF: 3400

CERTIFIED MAIL
RETURN RECEIPT REQUESTED

Mr. Dale Richards, Mayor
City of Oak Creek
8640 S. Howell Avenue
Oak Creek, WI 53154

SUBJECT: WPDES Permit Issuance No. WI-S049905-1

Dear Mayor Richards:

Thank you for the City Oak Creeks' assistance in developing the attached Wisconsin Pollutant Discharge Elimination System (WPDES) Permit. The conditions of the attached permit were determined using the permit application, information from your WPDES permit file, other information available to the Department, comments received during the public notice period, and applicable Wisconsin Administrative Codes. All discharges from the City of Oak Creek's Municipal Separate Storm Sewer System, and actions or reports relating thereto shall be in accordance with the terms and conditions of this permit.

This permit requires the periodic submittal of program proposals and contains specific compliance dates.

The Department has the authority under ss. 160 and 283, Stats., to establish effluent limitations, monitoring requirements, and other permit conditions for discharges to groundwater and surface waters of the State. The Department also has the authority to issue, reissue, modify, suspend or revoke WPDES permits under s. 283, Stats., and has adopted Wis. Adm. Code Chapters NR 200, NR 203, NR 205, and NR 216 under this authority.

To challenge the reasonableness of or necessity for any term or condition of the attached permit, s. 283.63, Stats, and ch. NR 203, Wis. Adm. Code require that you file a verified petition for review with the Secretary of the Department of Natural Resources within 60 days of the date of this letter. This notice is provided pursuant to s. 227.48, Stats.

Sincerely,

Craig D. Helker
Permit Coordinator, Southeast Region

Dated: 6/29/2000

cc: Mr. Philip Beirermeister, P.E.
Mr. Eric Rortvedt
WT/2
DOT
SER

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GENERAL DESCRIPTION AND PURPOSE OF THE WPDES STORM WATER PERMIT FOR THE CITY OF OAK CREEK

The City of Oak Creek owns and operates a municipal separate storm sewer system that discharges to the Oak Creek, Root River, and Lake Michigan. Discharges from storm sewer systems may consist of runoff from rain events or snow melt and fluids from spills or illicit connections. Pollutants of concern found in storm sewer system discharges include organic materials, suspended solids, metals, nutrients, bacteria, pesticides, fertilizer, and traces of toxic materials.

This WPDES permit will regulate discharges from the City's municipal separate storm sewer system in accordance with s. 283, Wis. Stats. and ch. NR 216, Wis. Adm. Code. The permit requirements are intended to reduce the quantity of pollutants discharged from the municipal separate storm sewer system. Major components of the permit include a storm water management program to address pollutant sources, monitoring of storm water discharges, enforcement of ordinances, and an annual report to summarize and assess compliance with permit requirements.

PERMIT TO DISCHARGE UNDER THE WISCONSIN POLLUTANT DISCHARGE ELIMINATION SYSTEM

In compliance with the provisions of Chapter 283, Wisconsin Statutes,

THE CITY OF OAK CREEK

is permitted to discharge storm water from

ALL PORTIONS OF THE CITY OF OAK CREEK'S MUNICIPAL SEPARATE STORM SEWER SYSTEM

owned or operated by the permittee listed above to the following waters of the state:

OAK CREEK
ROOT RIVER
LAKE MICHIGAN

in accordance with the storm water management program and other conditions set forth in this permit.

This permit will become effective on the date of signature.

This permit to discharge shall expire at midnight, June 30, 2005.

To retain authorization to discharge after this expiration date, an application shall be filed for reissuance of this permit in accordance with the requirements of Chapter NR 216, Wis. Adm. Code, at least 180 days prior to this expiration date.

State of Wisconsin Department of Natural Resources
For the Secretary

By ______________________
Peter C. Wood, P.E.
Water Resources Engineer

6/29/00
Date of Signature

EFFECTIVE DATE: July 1, 2000 EXPIRATION DATE: June 30, 2005

SPECIAL CONDITIONS

A. APPLICABILITY

(1) PERMITTED AREA: This permit covers all areas within the jurisdiction of the City of Oak Creek that contribute to discharges from the municipal separate storm sewer system owned or operated by the City of Oak Creek. Municipal separate storm sewer system means a conveyance or system of conveyances designed or used for the collection or conveyance of storm water. These include, but are not limited to; storm sewers, roads with drainage systems, municipal streets, catch basins, inlets, curbs, gutters, ditches, constructed channels or storm drains.

(2) AUTHORIZED DISCHARGES: This permit authorizes storm water point source discharges to waters of the State from the municipal separate storm sewer system in the permitted area. This permit also authorizes the discharge of storm water commingled with flows contributed by process wastewater, non-process wastewater, and storm water associated with industrial activity, provided the discharges are regulated by other WPDES permits or are discharges which are not illicit discharges as provided in Section E. (6)(a).

(3) WATER QUALITY STANDARDS: This permit specifies the conditions under which storm water can be discharged to waters of the State for the purpose of achieving water quality standards contained in chs. NR 102 though NR 105, Wis. Adm. Code. For the term of this permit, compliance with water quality standards will be addressed by the following:

a) Adherence to the general narrative-type storm water discharge limitations described in Subsection (4).

b) Implementation of the best management practices of the City of Oak Creek's storm water management program described under Section E. (5).

c) Specific numeric effluent limitations may be included in subsequent permits when procedures applicable to establishing such limits for storm water discharges are promulgated.

(4) GENERAL STORM WATER DISCHARGE LIMITATIONS: The City of Oak Creek may not discharge from the municipal separate storm sewer system the following substances in amounts that adversely effect receiving water quality or aquatic life:

a) Solids that may settle to form putrescent or otherwise objectionable sludge deposits.

b) Oil, grease, and other floating material that form noticeable accumulations of debris, scum, foam, or sheen.

c) Color or odor that is unnatural and to such a degree as to create a nuisance.

d) Toxic substances in amounts toxic to aquatic life, wildlife, or humans.

e) Nutrients conductive to the excessive growth of aquatic plants and algae to the extent that such growths are detrimental to desirable forms of aquatic life, create conditions that are unsightly, or are a nuisance.

f) Any other substances that may impair, or threaten to impair, beneficial uses of the receiving water.

SPECIAL CONDITIONS

A. APPLICABILITY (cont.)

(5) INDIVIDUAL RESPONSIBILITIES: The City of Oak Creek is responsible for:

a) Compliance with conditions of this permit relating to discharges from those portions of the municipal separate storm sewer system where it is the owner or operator.

b) Storm water management program implementation, as required by this permit, on portions of the City draining to the municipal separate storm sewer system where it is the owner or operator.

c) All other activities required by this permit.

SPECIAL CONDITIONS

B. APPLICATION DEFICIENCIES

(1) LEGAL AUTHORITY: The City of Oak Creek shall demonstrate the ability to meet the legal authority requirements of NR 216.06(1). Accordingly, The City of Oak Creek shall:

(a) Submit a legal opinion demonstrating the ability of the City of Oak Creek to control the contribution of pollutants to the municipal separate storm sewer system from storm water discharges associated with industrial activity.

(b) Establish an ordinance that prohibits illicit connections/discharges to the municipal separate storm sewer system.

The legal opinion and ordinance shall be submitted to the Department by October 1, 2001.

(2) STORM SEWER MAP: The City of Oak Creek shall submit a revised storm sewer system map at a scale of 1 inch equals 500 feet. The revised map shall include the following features in addition to the features found on the map submitted to the Department with the permit application:

a) Identification of major outfalls as defined in s. NR 216.06(2)(c), Wis. Adm. Code.

b) Identification of structural storm water controls with contributing drainage areas of 5 acres or greater.

c) Identification of landfills found in the Registry of Waste Disposal Sites in Wisconsin, SW-108-93 (WDNR, 1993).

d) Identification of swale conveyances with culverts that are 24-inch diameter or greater.

The revised storm sewer system map shall be submitted to the Department by March 31, 2001.

SPECIAL CONDITIONS

C. POLLUTANT LOADING CALCULATION

(1) STORM WATER DISCHARGES: The City of Oak Creek shall calculate the event mean concentration and the annual pollutant loadings from each major outfall and the cumulative discharge of all known municipal separate storm sewer outfalls.

(2) POLLUTANT DATA TO REPORT: The City of Oak Creek shall develop a summary of pollutant loading data for the parameters indicated in Table A and for any other significant pollutants identified by the City of Oak Creek or the Department.

(3) PROCEDURES: Event mean concentrations and pollutant loadings shall be calculated by modeling analysis equivalent in accuracy to the Source Loading and Management Model (SLAMM).

As required in Section G. (4)(h), a summary of the pollutant loading data and a description of the procedures used shall be submitted with the annual report due March 31, 2001.

Table A - Parameters for Pollutant Loading Calculations

Total Suspended Solids
Total Dissolved Solids
COD
BOD_5
Total Kjeldahl Nitrogen
Nitrate + Nitrite Nitrogen
Ammonia Nitrogen
Dissolved Phosphorus
Total Phosphorus
Total Copper
Total Lead
Total Zinc

SPECIAL CONDITIONS

D. MONITORING REQUIREMENTS

(1) CITY OF OAK CREEK CHARACTERIZATION OF STORM WATER MONITORING PROGRAM: The City of Oak Creek shall monitor representative outfalls to characterize the quality of storm water discharges from the municipal separate sewer system.

(a) The City of Oak Creek shall submit a monitoring program proposal that identifies the following:

1. Purpose and goals of the monitoring program.

2. Number of rainfall events that will be sampled within the term of the permit.

3. Location of sampling point(s).

4. Parameters that the samples will be analyzed for.

5. Type of sampling equipment that will be used.

(b) Samples must be analyzed for the parameters listed in Table B. However, the parameter list may be reduced with Department approval.

The monitoring program proposal shall be submitted to the Department by March 31, 2002.

The City of Oak Creek shall implement the monitoring program when Department approval is obtained.

(2) ALTERNATIVE DATA SOURCES: Monitoring done by the Department or others may be used as a source of data to meet some of the City of Oak Creek's monitoring program needs as described in Subsection (1).

(3) SAMPLING EXEMPTION: If the City of Oak Creek is unable to collect samples due to adverse climatic conditions, the City shall describe why samples could not be collected in the annual report. An exemption from the monitoring requirements shall be given for just cause. However, this does not relieve the City of Oak Creek of complying with the monitoring requirements when weather conditions allow sampling.

SPECIAL CONDITIONS

Table B - Monitoring Parameters for Storm Water Characterization

Alkalinity
Ammonia Nitrogen
Antimony
Beryllium
BOD_5
Chloride
COD
Color
Cyanide
Dissolved Phosphorus
Fecal Coliform
Fecal Streptococcus
Hardness as $CaCO_3$
Mercury
Nitrate + Nitrite Nitrogen
Odor
Oil & Grease
PAHs
Pesticides
PH
Silver
Thallium
Total Arsenic
Total Cadmium
Total Chromium
Total Copper
Total Dissolved Solids
Total Kjeldahl Nitrogen
Total Lead
Total Nickel
Total Phenols
Total Phosphorus
Total Selenium
Total Suspended Solids
Total Zinc
VOCs

SPECIAL CONDITIONS

E. STORM WATER MANAGEMENT PROGRAM

(1) MAXIMUM EXTENT PRACTICABLE: The City of Oak Creek shall limit, to the maximum extent practicable, the discharge of pollutants its municipal separate storm sewer system.

(2) MANAGEMENT AREA EXPANSION: The City of Oak Creek shall implement the storm water management program in all new areas added to the municipal separate storm sewer system. Implementation shall be done as expeditiously as practicable and may follow a phased schedule.

(3) PROGRAM RESOURCES: The City of Oak Creek shall provide adequate finances, staff, equipment, and support capabilities to implement their storm water management program. Public participation is encouraged in planning and reviews.

(4) CITY OF OAK CREEK STORM WATER MANAGEMENT MASTER PLAN: The City of Oak Creek shall complete the Storm Water Management Master Plan and submit the Plan to the Department.

The Storm Water Management Master Plan shall be submitted to the Department by March 31, 2001.

(5) CITY OF OAK CREEK MANAGEMENT PROGRAM: To address the requirements in this section, the City of Oak Creek shall implement or participate in the following storm water management program best management practices:

(a) Maintenance activities and schedules for source area controls and structural best management practices for the City of Oak Creek:

1. Catch Basins

WHAT DO WE DO WITH WASTE

- All catch basins shall be cleaned as needed.
- Cleanings from catch basins shall be stored and disposed of in a manner consistant with Part II, Section A. (9).
- A proposal for increasing catch basin cleaning frequency shall be submitted. The proposal shall include a catch basin inventory and identification of catch basins located in critical areas. The minimum acceptable catch basin cleaning frequency is once per year.

The catch basin cleaning frequency proposal shall be submitted to the Department by March 31, 2001.

2. Sweeping of Streets with Curbs

WINTER AS WEATHER PERMITS

- Major roadways shall be swept at least once per month.
- Residential areas shall be swept at least twice per year.
- Disposal of street sweepings shall be in a manner consistent with Part II, Section A. (9).
- A proposal for increasing street sweeping frequency shall be submitted. The minimum acceptable street sweeping frequency is twice per month in critical areas and once per month in all other areas.

The street sweeping frequency proposal shall be submitted to the Department by March 31, 2001.

SPECIAL CONDITIONS

E. STORM WATER MANAGEMENT PROGRAM (cont.)

(5) CITY OF OAK CREEK MANAGEMENT PROGRAM: (cont.)

3. Structural Control Maintenance

- Mowing: City owned/operated detention basins and swales shall be mowed at least once per year. If possible, cut material should be removed.
- Inspections: City owned/operated detention basins shall be inspected quarterly, with maintenance provided as needed to ensure proper operation.
- Sediment: City owned/operated detention basins and swales shall be inspected annually for sediment buildup. Accumulated sediment shall be removed when the design efficiency is compromised. All sediment removed shall be managed in a manner consistent with Part II, Section A. (9).
- Records: Records of all inspections and maintenance performed on storm water management facilities shall be kept.

4. Roadway Maintenance

- A summary of the current road salting practices used by the City shall be submitted.
- Salt storage shall be in a manner consistent with Part II, Section A. (9).

The road salting practices summary shall be submitted to the Department by March 31, 2001.

(b) The City of Oak Creek shall develop, implement, and enforce controls on discharges from areas of new development and redevelopment after construction is completed. This requirement shall be addressed by establishment of a storm water management ordinance.

The storm water management ordinance shall be established by October 1, 2001.

(c) All flood management projects conducted by the City of Oak Creek shall include an assessment of water quality impacts.

(d) The City of Oak Creek shall evaluate all City owned/operated structural flood control devices to determine the feasibility of implementing retrofit devices to provide pollutant removal from storm water.

The evaluations shall be completed and a summary report submitted to the Department by March 31, 2002.

(e) The City of Oak Creek shall implement a program to promote the management of streambanks and shorelines by riparian landowners to minimize erosion, and restore or enhance the ecological values of the waterway. This requirement shall be addressed by enforcement of the City of Oak Creek Shoreland Wetland Zoning Ordinance. In addition, the City of Oak Creek shall include educational information on shoreland protection in the City newsletter at least once per year.

SPECIAL CONDITIONS

E. STORM WATER MANAGEMENT PROGRAM (cont.)

(6) ILLICIT CONNECTION/DISCHARGE PROGRAM: The City of Oak Creek shall develop and implement a program to identify and remove illicit connections and discharges into the municipal separate storm sewer system. Accordingly, the City of Oak Creek shall:

WIB. Doc, PA.

(a) Submit a program proposal that includes the following:

1. A protocol for conducting initial field screening at all major outfalls and on-going field screening during the term of the permit.

   - Field screening analysis shall include visual observation and grab sampling in accordance with s. NR 216.07 (3), Wis. Adm. Code.

   - Field screening points shall be located where practicable at the farthest manhole or other accessible location downstream in the system.

   - Consideration shall be given to hydrological conditions, drainage area, population density, traffic density, age of structures or buildings, and land use.

2. Procedures for investigating areas of the municipal separate storm sewer system that, based on the results of field screening or other information, indicate a reasonable potential for containing illicit discharges, illicit connections, or other sources of non-storm water. The following are not considered illicit discharges unless identified by either the City of Oak Creek or the Department as a significant source of pollutants to waters of the state:

   - Water line flushing
   - Landscape irrigation
   - Diverted stream flows
   - Uncontaminated ground water infiltration
   - Uncontaminated pumped ground water
   - Discharges from potable water sources
   - Foundation drains
   - Air conditioning condensate
   - Irrigation water
   - Lawn watering
   - Individual residential car washing
   - Flows from riparian habitats and wetlands
   - Dechlorinated swimming pool water
   - Street wash water
   - Fire fighting

3. Procedures to eliminate illicit connections or discharges following detection.

4. Controls to limit infiltration of leakage from municipal sanitary sewers into the municipal separate storm sewer system.

The illicit connection/discharge program proposal shall be submitted to the Department by March 31, 2003.

The illicit connection/discharge program shall be implemented when Department approval is obtained.

SPECIAL CONDITIONS

E. STORM WATER MANAGEMENT PROGRAM (cont.)

(7) INDUSTRIAL/HIGH RISK RUNOFF PROGRAM: The City of Oak Creek shall develop and implement a program to identify, monitor, and address pollutants in storm water discharges from industrial facilities and other high risk sites as defined in s. NR 216.07(7)(c), Wis. Adm. Code. Accordingly, the City of Oak Creek shall submit a program proposal that includes the following:

(a) A monitoring program for storm water discharges associated with industrial facilities and other high risk sites.

- Within the term of this permit, the City of Oak Creek shall concentrate on industrial facilities and other high risk sites located within the critical basins identified in the Draft Storm Water Management Master Plan for the City of Oak Creek (February 4, 1999).

- Monitoring data collected by a WPDES permitted facility may be used and is available from the Department.

(b) A strategy for conducting inspections and implementing control measures.

The industrial/high risk runoff program proposal shall be submitted to the Department by March 31, 2003.

The industrial/high risk runoff program shall be implemented when Department approval is obtained.

(8) CONSTRUCTION SITE RUNOFF: The City of Oak Creek shall reduce pollutants in storm water runoff from construction sites through the implementation and maintenance of source area controls and structural best management practices. This requirement shall be addressed by enforcement of the City of Oak Creek Construction Site Erosion Control Ordinance.

(9) INFORMATION AND EDUCATION PROGRAM: The City of Oak Creek shall develop and implement an information and education program. Accordingly, the City of Oak Creek shall submit a program proposal that includes the following:

(a) An information/education program to promote reduction of pollutants associated with the application of pesticides, herbicides, and fertilizer.

(b) An information/education program to promote management of materials that may pollute storm water, including; used oil, toxic materials, yard waste, lawn care, and car washing.

(c) An information/education program for construction site operators.

(d) An information/education program to promote the public reporting of the presence of illicit discharges, spills, or water quality impacts associated with discharges from municipal separate storm sewers.

The information and education program proposal shall be submitted to the Department by March 31, 2002.

The information and education program shall be implemented when Department approval is obtained.

SPECIAL CONDITIONS

E. STORM WATER MANAGEMENT PROGRAM (cont.)

(10) SPILLS PROGRAM: The City of Oak Creek shall prevent, contain, and respond to spills that may discharge into the municipal separate storm sewer system. This requirement shall by addressed by enforcement of the City of Oak Creek ordinances related to spills and cooperation with the Milwaukee Hazardous Response Team.

(11) PROGRAM REVISIONS: If necessary, the City of Oak Creek shall revise the storm water management program during the term of the permit in accordance with the following:

(a) The City of Oak Creek may revise the storm water management program after the Department approves the revision. The program may be revised without prior Department approval if the revision is in accordance with the following:

1. The revision adds a component to the approved storm water management program. The City of Oak Creek shall provide a description of the added component in the annual report.

2. The revision replaces an ineffective or unfeasible best management practice specifically identified in the storm water management program with an alternate best management practice. The City of Oak Creek shall submit a written request to the Department to replace a best management practice. Unless the Department issues a written denial, the replacement shall be considered approved and may be implemented 60 days from submittal of the request. Such written requests to the Department shall include the following information:

- Explanation of why the initial best management practice is ineffective or unfeasible.

- Expectations on the effectiveness of the replacement best management practice.

(b) The Department may require the City of Oak Creek to revise the storm water management program. However, the City of Oak Creek shall have an opportunity to propose alternative program revisions to meet the objective of the request. The Department may require revisions for the following reasons.

1. To address adverse impacts on receiving water quality caused by discharges from the municipal separate storm sewer system.

2. To include other conditions to comply with ch. NR 216, Wis. Adm. Code, or any new State or Federal requirements that may be promulgated in the future.

(c) Department approval of revisions or requests for revisions to the storm water management plan is the authority for incorporation of the revision into the permit, until the permit can be modified or reissued in accordance with the procedures in s. 283.53, Wis. Stats.

SPECIAL CONDITIONS

F. ASSESSMENT OF CONTROLS

(1) ANNUAL REVIEW: The City of Oak Creek shall conduct an annual review of the storm water management program in conjunction with preparation of the annual report required in Section G. The assessment of the effectiveness of the storm water management program, including both structural and non-structural practices, shall consist of the following:

(a) A review of the monitoring program data for a direct measurement of the effect of management practices on storm water quality.

(b) An estimate of expected reductions in pollutant loadings discharged from the municipal separate storm sewer system. This shall include an estimate of the pollutant loading reductions attributed to each major component of the storm water management program. Pollutant loading reductions for some storm water management practices can be assessed by indirect measurements. At minimum, the following activities shall be documented:

1. Volume of used oil collected.

2. Number and type of illicit connections found and eliminated.

3. Number of enforcement actions taken.

4. Number of educational activities undertaken.

5. Number of sewer inlets stenciled.

6. Mass of leaves collected, sediment captured from street sweeping, sediment removed from catch basins, and sediment removed from structural controls.

7. Number of construction site erosion control permits issued.

8. Number of new development storm water permits issued.

(c) Identification of known impacts of storm water controls on both surface water and groundwater quality.

(d) Identification of any storm water management program (Section E.) revisions needed to reduce the discharge of pollutants to the maximum extent practicable, meet applicable water quality standards, and comply with permit requirements.

SPECIAL CONDITIONS

G. ANNUAL REPORT

(1) PURPOSE: The information provided in the annual report shall be used to determine progress on implementation of the storm water management program and compliance with the conditions in the permit.

(2) INDIVIDUAL RESPONSIBILITIES: The City of Oak Creek is responsible for content of the report relating to the portions of the municipal separate storm sewer system for which it is responsible.

(3) CERTIFICATION: A properly authorized representative of the City of Oak Creek (as defined in Part II, Section A. (19)) shall sign and certify the annual report and include a statement or resolution that the City of Oak Creek governing body or delegated representatives have reviewed or been appraised of the content of the annual report.

(4) CONTENTS: An annual report for each calendar year shall be submitted by March 31 of the next year. The first annual report, covering the period from the date of permit issuance until December 31, 2000, is due March 31, 2001. The report shall include the following:

(a) The status of implementing the storm water management program (Section E.) and compliance with any schedules contained in the permit.

(b) An updated storm sewer system map that includes any new outfalls, structural controls, or other note worthy changes.

(c) A summary describing the number and nature of enforcement actions, inspections, public education programs, spill responses, and any other activities in the storm water management program (Section E.) that have measurable results.

(d) A summary of revisions made to the storm water management program (Section E.) in accordance with Section E. (11).

(e) Proposed revisions to the storm water management program (Section E.)

(f) A summary of the monitoring data required in Section D. for the reporting year.

(g) Proposed revisions to the storm water monitoring program (Section D.).

(h) A summary of the pollutant loading calculations required in Section C.

(i) A summary of the assessment of controls required in Section F.

(j) A fiscal analysis which includes the following:

1. The annual expenditures for the previous year with a breakdown of expenses for the major elements of the storm water management program.

2. The budget for the current year with a breakdown of the planned expenses for the major elements of the storm water management program.

(k) Identification of water quality improvements or degradation.

(5) PUBLIC REVIEW: The general public and interest groups shall be encouraged to review and comment on the annual report.

SPECIAL CONDITIONS

H. REPORTING REQUIREMENTS AND COMPLIANCE SCHEDULE

(1) REPORTING: The annual report required under Part I Section G, and reports required by General Conditions (2) and (3) of Part II shall be signed by the City Engineer or the duly authorized representative having overall responsibility for the storm water management program. A signed copy of the annual report and other required reports shall be submitted to the Department Office listed below:

Wisconsin Department of Natural Resources
Sturtevant Service Center
9531 Rayne Road
Sturtevant, WI 53177

(2) COMPLIANCE SCHEDULE: Refer to General Condition (2) of Part II for compliance schedule reporting requirements. The City of Oak Creek shall achieve compliance with the following permit special conditions contained in Part I in accordance with the following schedule:

Action to be Taken	Reference	Due Date
• Legal Opinion and Illicit Connection Ordinance	B.(1)	10/1/01
• Storm Sewer Map Changes	B.(2)	3/31/01
• Pollutant Loading Calculations	C.(1)	3/31/01
• Monitoring Program Proposal	D.(1)	3/31/02
• Storm Water Management Master Plan Submittal	E.(4)	3/31/01
• Catch Basin Cleaning Proposal	E.(5)(a)1	3/31/01
• Street Sweeping Proposal	E.(5)(a)2	3/31/01
• Road Salt Summary	E.(5)(a)4	3/31/01
• Storm Water Management Ordinance Established	E.(5)(b)	10/1/01
• Evaluation of Structural Flood Control Devices	E.(5)(d)	3/31/02
• Illicit Connection/Discharge Program Proposal	E.(6)(a)	3/31/03
• Industrial/High Risk Runoff Program Proposal	E.(7)	3/31/03
• Information and Education Program Proposal	E.(9)	3/31/02
• First Annual Report	G.(4)	3/31/01
• Second Annual Report	G.(4)	3/31/02
• Third Annual Report	G.(4)	3/31/03
• Fourth Annual Report	G.(4)	3/31/04
• Fifth Annual Report	G.(4)	3/31/05
• Reapplication for Municipal Storm Water Discharge Permit		10/1/04

GENERAL CONDITIONS
PART II

A. CONDITIONS

The conditions in s. NR 205.07(1) and NR 205.07(3), Wis. Adm. Code, are included by reference in this permit. The City of Oak Creek shall be responsible for meeting these requirements. Some of these requirements are outlined below in paragraph (1) through (19). Requirements not specifically outlined below can be found in s. NR 205.07(1) and NR 205.07(3), Wis. Adm. Code.

(1) DUTY TO COMPLY: The City of Oak Creek shall comply with all conditions of the permit. Any permit noncompliance is a violation of the permit and is grounds for enforcement action, permit revocation or modification, or denial of a permit reissuance application.

(2) COMPLIANCE SCHEDULES: Reports of compliance or noncompliance with interim and final requirements contained in any compliance schedule of the permit shall be submitted in writing within 14 days after the schedule date, except that progress reports shall be submitted in writing on or before each schedule date for each report. Any report of noncompliance shall include the cause of noncompliance, a description of remedial actions taken, and an estimate of the effect of the noncompliance on the City of Oak Creek's ability to meet the remaining schedule dates.

(3) NONCOMPLIANCE NOTIFICATION:

(a) Upon becoming aware of any permit noncompliance which may endanger public health or the environment, the City of Oak Creek shall report this information by a telephone call to the Department within 24 hours. A written report describing the noncompliance shall be submitted to the Department within 5 days after the City became aware of the noncompliance. The Department may waive the written report on a case-by-case basis based on the oral report received within 24 hours. The written report shall contain a description of the noncompliance and its cause; the period of noncompliance, including exact dates and times; the steps taken or planned to reduce, eliminate, and prevent reoccurrence of the noncompliance; and if the noncompliance has not been corrected, the length of time it is expected to continue.

(b) Reports of any other noncompliance not covered under General Conditions (2), (3)(a), or (5) shall be submitted with the annual report required in Part I, Section H. The reports shall contain all the information listed in General Condition (3)(a).

(4) DUTY TO MITIGATE: The City of Oak Creek shall take all reasonable steps to minimize or prevent any adverse impact on the waters of the state resulting from noncompliance with the permit.

(5) SPILL REPORTING: The City of Oak Creek shall notify the Department, in accordance with ch. NR 158, Wis. Adm. Code, in the event of a spill or accidental release of hazardous substances which results in a discharge of pollutants into waters of the state.

(6) PROPER OPERATION AND MAINTENANCE: The City of Oak Creek shall at all times properly operate and maintain all facilities and systems of treatment and control which are installed or used by the City to achieve compliance with the conditions of the permit and the storm water management plan.

(7) BYPASS: The City of Oak Creek may temporarily bypass storm water treatment facilities if necessary for maintenance, or due to runoff from a storm event which exceeds the design capacity of the treatment facility, or during an emergency.

GENERAL CONDITIONS
PART II

A. CONDITIONS (cont.)

(8) DUTY TO HALT OR REDUCE ACTIVITY: Upon failure or impairment of best management practices identified in the storm water management program, the City of Oak Creek shall, to the extent practicable and necessary to maintain permit compliance, modify or curtail operations until the best management practices are restored or an alternative method of storm water pollution control is provided.

(9) REMOVED SUBSTANCES: Solids, sludges, filter backwash or other pollutants removed from or resulting from treatment or control of storm water shall be stored and disposed of in a manner to prevent any pollutant from the materials from entering the waters of the state, and to comply with all applicable Federal, State, and Local regulations

(10) ADDITIONAL MONITORING: If the City of Oak Creek monitors any pollutant more frequently than required by the permit, using test procedures specified in ch. NR 219, Wis. Adm. Code, the results of that monitoring shall be recorded and reported in accordance with this chapter. Results of this additional monitoring shall be included in the calculation and reporting of the data submitted in the annual report.

(11) INSPECTION AND ENTRY: The City of Oak Creek shall allow an authorized representative of the Department, upon the presentation of credentials, to:

(a) Enter upon the City of Oak Creek's premises where a regulated facility or activity is located or conducted, or where records are required under the conditions of the permit.

(b) Have access to and copy, at reasonable times, any records that are required under the conditions of the permit.

(c) Inspect at reasonable times any facilities, equipment (including monitoring and control equipment), practices or operations regulated or required under the permit.

(d) Sample or monitor at reasonable times, for the purposes of assuring permit compliance, any substances or parameters at any location.

(12) DUTY TO PROVIDE INFORMATION: The City of Oak Creek shall furnish the Department, within a reasonable time, any information which the Department may request to determine whether cause exists for modifying, revoking or reissuing the permit or to determine compliance with the permit. The City shall also furnish the Department, upon request, copies of records required to be kept by the City.

(13) RECORDING OF RESULTS: For each monitoring measurement or sample taken, the City of Oak Creek shall record the following information.

(a) Date, exact place, method and time of sampling or measurements.

(b) Individual who performed the sampling or measurements.

(c) Date the analysis was performed.

(d) Individual who performed the analysis.

(e) Analytical techniques or methods used.

(f) Results of the analysis.

GENERAL CONDITIONS
PART II

A. CONDITIONS (cont.)

(14) PROPERTY RIGHTS: The permit does not convey any property rights of any sort, or any exclusive privilege. The permit does not authorize any injury or damage to private property or an invasion of personal rights, or any infringement of federal, state or local laws or regulations.

(15) DUTY TO REAPPLY: If the City of Oak Creek wishes to continue an activity regulated by the permit after the expiration date of the permit, the City of Oak Creek shall apply for a new permit.

(16) OTHER INFORMATION: Where the City of Oak Creek becomes aware that it failed to submit any relevant facts in a permit application or submitted incorrect information in a permit application or in any report to the department, it shall promptly submit such facts or correct information to the department.

(17) RECORDS RETENTION: The City of Oak Creek shall retain records of all monitoring information, including all calibration and maintenance records and all original strip chart recordings for continuous monitoring instrumentation, copies of all reports required by the permit, and records of all data used to complete the application for the permit for a period of at least 3 years from the date of the sample, measurement, report or application. The Department may request that this period be extended by issuing a public notice to modify the permit to extend this period.

(18) PERMIT ACTIONS: As provided in s. 283.53, Wis. Stats., after notice and opportunity for a hearing the permit may be modified or revoked and reissued for cause. If the City of Oak Creek files a request for a permit modification, revocation or reissuance, or a notification of planned changes or anticipated noncompliance, this action by itself does not relieve the City of any permit condition.

(19) SIGNATORY REQUIREMENT: All applications, reports or information submitted to the Department shall be signed for by a ranking elected official, or other person authorized by them who has responsibility for the overall operation of the municipal separate storm sewer system and storm water management program activities regulated by the permit. The representative shall certify that the information was gathered and prepared under their supervision and based on inquiry of the people directly under their supervision that, to the best of their knowledge, the information is true, accurate, and complete.

Appendix F

Stream Maintenance

Introduction

Without routine and proper maintenance, stream channels can become choked with sediment, debris, and vegetation, resulting in the loss of hydraulic capacity. During storm events, channels without proper maintenance may not function as designed, causing unnecessary flooding and property damage. However, improper maintenance can result in the loss of valuable fish and wildlife habitat, cause streambank and shoreline erosion, and result in the loss of aesthetic values of the stream corridor. The purpose of this appendix is to provide guidance on proper stream and pond maintenance. The appendix will be broken into the following sections:

- Jurisdictions for stream maintenance
- Emergency maintenance
- Preventive maintenance
- Control of nuisance wildlife species

Jurisdictions for Stream Maintenance

Within the City of Oak Creek, several parties have over lapping jurisdiction with regards to stream channel maintenance. The parties include the Wisconsin Department of Natural Resources (WDNR), Wisconsin Department of Transportation (WDOT), Milwaukee Metropolitan Sewerage District (MMSD), Milwaukee County Highway Department, Milwaukee County Department of Parks, City of Oak Creek, and private landowners. The following outlines the jurisdiction of each of the parties:

<u>Wisconsin Department of Natural Resources (WDNR)</u>

Under the Wisconsin State Constitution all navigable water are held in public trust for the enjoyment of all people of the state. The protection of navigable water is governed in Wisconsin under the "Public Trust Doctrine", a set of statutes and case law. The state agency responsible for administrating the Public Trust Doctrine is the Wisconsin Department of Natural Resources (WDNR). Chapter 30 of the state statute regulates activities in navigable streams. Many activities regarding stream maintenance require WDNR permits. Sections of Chapter 30 that effect channel maintenance are outlined in Table F-1. The role of WDNR in stream channel maintenance is primarily a regulatory one. WDNR can provide technical assistance through their fish, wildlife, and water resource staff in the area of habitat protection.

TABLE F-1 Sections of Wisconsin Statue Chapter 30 That Regulate Channel Maintenance

Section	Activity
Section 30.123	Bridge construction and maintenance permits.
Section 30.125	Cutting of weeds in navigable waters.
Section 30.16	Removal of obstructions to navigation.
Section 30.19	Enlargement and protection of waterways.
Section 30.195	Changes of stream courses.
Section 30.20	Removal of material from beds of navigable waters.

Before any work in a navigable stream, the sponsor should contact the WDNR office in Milwaukee located at 2300 North Dr. Martin Luther King Drive. The WDNR can be reached by telephone at (414) 263-8500.

<u>The Milwaukee Metropolitan Sewerage District</u>

The Milwaukee Metropolitan Sewerage District is charged under Section 66.89 of the Wisconsin Statutes with maintaining a sanitary sewerage system for the metropolitan area of Milwaukee. As part of their authority, MMSD is authorized under Section 66.894 (8) of the Wisconsin Statutes to conduct "River and Stream Alterations" to protect the community from surface or drainage water. In <u>A Stormwater Drainage and Flood Control Policy Plan for the Milwaukee Metropolitan Sewerage District</u> (SEWRPC, 1986), MMSD has identified stream channels that they have taken jurisdiction with regards to stream maintenance. Channels in the City of Oak Creek include the mainstem of Oak Creek, Oak Creek North Branch, unnamed tributary in Section 9, T5N, R22E, and the Root River.

MMSD does have the authority to conduct maintenance on steams under their jurisdiction. Routine maintenance conducted by MMSD, on channels for which they have jurisdiction, includes removal of over grown vegetation, fallen trees, and debris that are blocking the movement of stormwater runoff. Requests for stream maintenance can be directed to MMSD during regular office hours at (414) 272-5100. After-hour emergencies can be reported to MMSD at (414) 282-7200.

<u>Milwaukee County Highway Department</u>

The Milwaukee County Highway Department is responsible for maintenance of all state, federal and County Highways in the City of Oak Creek. State and federal highways in the City include Interstate 94, STH 100 (Ryan Road), STH 36 (S. Howell Ave.), STH 41 (S. 27th Street), CTH ZZ (W. College Ave.), and CTH BB (W. Rawson Ave.). The County is responsible for the removal of blockages in culverts and bridges located in the highway right-of-way.

Milwaukee County Department of Parks

Milwaukee County Department of Parks is a major landowner on the mainstems of Oak Creek and the Root River. Major County land on stream channels includes the Oak Creek and Root River Parkways. As a landowner, the County Parks Department has the authority to maintain and protect their property from the damages caused by blocked streams. The county can remove debris from the channel to prevent flooding. Other activities that result in any change to the stream channel require WDNR permits outlined above.

City of Oak Creek

Under Wisconsin municipal law, the City of Oak Creek is authorized to conduct public works projects that protect property from the damages from stormwater runoff. The City is authorized to conduct stream maintenance projects such as dredging, removal of debris, and installation of bank stabilization measures. When working in navigable streams under the jurisdiction of WDNR, permits from the state must be acquired before conducting any work.

Private Landowners

Private landowners have the right to maintain and protect their property from the damages caused by blocked streams. A private landowner can remove debris from the channel to prevent flooding. Other activities that result in any change to the stream channel require WDNR permits outlined above.

Emergency Maintenance

During storm events, sediment and debris located in the floodplain can be moved by flowing water. When these materials become lodged in structures such as bridges and culverts, or form jams in the stream channel, they can block the flow of water causing water levels to rise. In severe situations, water levels can rise to elevations above normal flood stages, causing property damage, and threats to human safety. To respond to emergency situations, an emergency response procedure needs to be in place.

During emergency events it is important that response is quick to prevent property damage. A system should be established to assure that the proper authority is informed of the potential emergency. A resident that notices an emergency situation should contact the City of Oak Creek Fire Department at (414)-570-5600. The use of the 911 emergency number should be reserved only for life threatening events. The Fire Department will contact the appropriate responsible agency. A contact system for after hour emergencies should be established with each of the responsible agencies.

Preventive Maintenance

Stream Channels

Stream Survey

In 1995, R. A. Smith and Associates, Inc. conducted a survey of all of the streams in the City of Oak Creek. The survey was conducted to identify areas of active erosion, sediment buildup, and vegetation and debris blockage. The results of the survey results were summarized on a 1" = 1000' scale map of the city. The map is available for review at the City of Oak Creek Engineering Department.

Streambank Erosion

Streambank erosion can be a source of material that can clog channels. During the 1995 stream survey, 26 sites with active erosion were identified. The erosion areas had a cumulative length of approximately 9,500 lineal feet. It is recommended that the eroding areas be stabilized by rock riprap and/or soil bioengineering. The stabilization should be conducted using the technical guidelines outlined in Chapter 16 of the Natural Resources Conservation Service Engineering Manual.

Much of the past streambank stabilization has been conducted with rock riprap. The rock toe could be enhanced by the use of native vegetation on the upper bank. Table F-2 summarizes a list of native plants that could be used to enhance the streambank stabilization efforts.

TABLE F-2 Potential Forbs and Grasses for Use in Streambank Stabilization

Big Bluestem Grass	Swamp Milkweed
New England Aster	Panicled Aster
Canada Bluejount Grass	Shooting Star
Spotted Joe-Pye Weed	Northern Bedstraw
Bottle Gentain	Stargrass
Blue Flag (Wild Iris)	Switch Grass
Downy Phlox	Mountain Mint
Black-eyed Susan	Indian Grass
Prairie Cordgrass	Meadowrue
Culver's Root	Marsh Blue Violet
Golden Alexanders	Turk's-Cap Lily

Source: University of Wisconsin Extension, 1994

The installation of 9,500 feet of streambank stabilization is estimated at $45 per lineal foot, or $427,500. Annual operation and maintenance cost for the stabilization is estimated at $25,000 per year. Control of the identified streambank erosion is estimated to reduce annual sediment input to City of Oak Creek waterways by 142,500 pounds per year.

Removal of stream blockages

Many sections of the various stream channels in the City of Oak Creek are blocked with sediment, vegetation, and debris. These blockages can reduce the capacity of local streams to carry stormwater. Table F-3 summarizes the type and number of blockages identified during a survey conducted in 1995 by R. A. Smith and Associates, Inc.

TABLE F-3 Types and Number of Stream Blockages in the City of Oak Creek

Blockage Type	Number Sites Found in 1995
Debris Dams	21
Damaged culverts	21
Vegetation blockage (brush)	26
Vegetation blockage (cattails)	3
Vegetation blockage (reed canary grass)	9
Vegetation blockage (trees)	20
Sediment (light) (1 to 9 inches)	8
Sediment (medium) (10 to 16 inches)	9
Sediment (heavy) (17 inches plus)	11
Total Number of Blockages	**128**

Source: R. A. Smith and Associates, Inc. 1995

The City of Oak Creek should conduct an annual survey to identify serious blockages in the stream channel and update the 1995 R. A. Smith survey. Vegetation and debris blockages can be removed by the City of Oak Creek, MMSD, or riparian landowner without the need for a state or federal permits, provided the material is removed from the waterway. Dredging of sediment buildup in navigable streams can only be conducted with appropriate permits from the Wisconsin Department of Natural Resources and the U. S. Army Corps of Engineers.

Control of Nuisance Wildlife Species

Several wildlife species have become nuisances in urban areas and are associated with the urban drainage system. Two species that have become the biggest problems are Beavers and Canadian Geese. The following section outlines the advantages and disadvantages of some of the available control techniques.

Beaver Control

Beaver, like many species of wildlife, is considered good or bad depending upon whom you talk to. Some people enjoy and appreciate beaver while others consider beaver to be destructive. At times, beaver can cause hydraulic problems in streams by the building of dam structures that impede the flow of water. The potential damages will vary depending on the use of the land that is flooded.

Beavers have litters averaging four young each spring. Therefore, it is likely that the beaver population will grow as the families spread out colonizing new areas. It is therefore recommended that the City of Oak Creek conduct an annual inspection program to assure that beaver dams are not causing flow problems on local streams.

The following is an overview of beaver control options. Additional information on beaver control is available from the WDNR through Publication WM-007-96 REV, available at any WDNR office.

Landscaping

The landscaping of property can discourage beaver colonization. Beavers build dams to provide protection of their young. The dam is constructed of trees and mud. Beaver rarely cut down large pines or massive older trees; they prefer willow, poplar, alder and birch trees. Avoiding these preferred trees in a landscaping plan can discourage beaver from using the property as a harvesting site for their dams.

Physical Barriers

To prevent the cutting of trees, physical barriers can be used. Heavy wire mesh, heavy gauge hardware cloth, or tar paper will discourage beaver from cutting and gnawing trees along shorelines. The protective material should extend up three-feet from the base of the tree. Mesh size should be less than 1-inch in order to be effective. The wire mesh or hardware cloth can be secured by wiring the ends together. Tar paper can be held in place with twine or wire. This protection is effective and inexpensive if few trees are involved.

Chemical Repellents

There are several commercially available repellents that discourage deer and rodents from chewing plants. Although none are specifically registered for beaver, many will work. Specific products that can be used on trees and shrubs include: ROPEL, DEER AWAY, MILLER'S HOT SAUCE, and thiram products such as BONIDE RABBIT-DEER REPELLENT, NOTT'S CHEW-NOTT, GUSTAFSON 42-S, and WILBUR-ELLIS SCAM 42-S. The above products are available through local garden supply stores.

Undermining of Dams

Placement of pipes in the beaver dam structure can be used to lower the water level to prevent high water damage. At times the beaver will adapt to the lower water level and coexist with the neighboring property. Other times the change in water level will cause the beaver to move to another location. WDNR has several designs of "beaver pipes" that can be used. A design brochure is available at the local WDNR office.

Removal of Beaver Dams and Lodges

Removal of beaver dams, and the lodge is generally the last option recommended by WDNR because of the difficulty and expense involved. Often new beavers will re-colonize an area where a beaver dam and lodge have been removed, making this solution temporary. Removal can be done by physically dismantling of the structures or by blasting. A landowner or their neighbor can remove a dam that is causing damage without any permit from the state. Only a licensed blaster can do blasting. To obtain a list of licensed blasters you should contact the Wisconsin Department of Commerce. Hiring a blaster with beaver experience is recommended.

Removal of a beaver lodge is allowed under state law. However, blasting of an active lodge is not allowed. Blasting of inactive lodges is allowed, but only with a WDNR permit.

Trapping

Trapping is an option to permanently remove the beaver. Both live traps and traps that kill are available. A landowner can trap on their own property. If live traps are used, they must be placed 100 yards from a building devoted to human occupancy without the owners consent. Live beaver can be transferred to WDNR owned property without a permit from the WDNR. Beaver should be placed on private property only with the permission of the landowner. Companies that manufacture live traps include:

Tomahawk Live Trap Company (715)-453-3550

Hancock Trap Company (605)-673-4128

National Live Trap Corporation (715)-453-2249

Shooting

Shooting of beaver is not an option in the City of Oak Creek. City ordinance prohibits the discharge of firearms anywhere in the City.

Geese Control

Canadian Geese are an important waterfowl species. However, in recent years geese numbers in urban settings have increased. Geese feed on plant material and have a preference for turf lawns. With the establishment of urban detention ponds for flood storage and water quality treatment, the number of geese in suburban areas has been growing. In park settings and on residential lawns people have complained about the droppings and to a lesser extent the feathers that are left behind during annual molting. Several methods have been tried to control geese populations. The following is a discussion of the methods used and the success and failure.

Control of Feeding

Many residents enjoy the feeding of geese in park like settings. It provides an opportunity to interact with wildlife up close and personal. People feed geese bread, popcorn, and various grains. Many communities have attempted to control geese populations by controlling public feeding. Studies have shown that this form of direct feeding is not the primary reason that geese locate in an area. Primary sources of food such as turf lawns are a more important factor in choosing a feeding site. Most feeding ordinances, while providing some sense of accomplishment to local units of government, have done little to control geese populations.

Hazing Using Loud Sound

Hazing geese using sounds such as music, blasts and other loud noise have generally been unsuccessful in the long term. Experience has shown the geese quickly adapt to the sound. When the geese realize that the sound does not represent a physical threat, they return to the area.

Hazing Using Decoys Predators

Placing decoys of predators of geese has also been shown not to be successful. Placement of decoys such as owls and hawks have been shown to only work for short periods of time. Again the geese realize that the decoy does not represent a physical threat and return to the area. Geese have been observed feeding just below an owl decoy even though an owl is a known predator of geese.

Placement of Physical Barriers along Shorelines

Geese, if they have a preference, like to land in the water versus on land. Geese are more maneuverable in the water than on land. A water landing provides the bird an opportunity to observe the surrounding area for predators before it enters the land. Once an area is surveyed, the bird prefers to walk out of water over a gentle slope. Placement of physical barriers to the bird, preventing easy access to walking out of the water, can discourage their numbers. Geese cannot easily bend down and maneuver under obstructions. Placement of a wire or string about one-foot off the ground can act as a fence to prohibit geese movement. This technique has been used successfully in wetland restoration projects to keep geese out of freshly planted areas. A concern in a public park area is that the low fence could act as a hazard for small children who could easily trip over the barrier. With the barrier's placement close to the water edge, the potential for serious injury is too great for this technique to be recommended in public areas.

Placement of thick vegetation such as emergent wetland plants or shrubs along the pond edge have been shown to be successful in reducing geese populations. As discussed above, geese prefer to walk out of the water on a gentle slope. A mowed lawn provides easy access for the birds. Emergent wetland vegetation such as cattails or bull rush acts as a physical barrier to easy geese movement. Geese are timid birds with a great deal of fear of being near areas where predators, such as raccoons, can hide out. Geese tend to avoid areas of tall grass and shrubs. The more area of a pond edge in tall grass and shrubs, the smaller the geese population will be. Therefore, creative landscaping of the pond edge in varying covers can help control the number of geese.

Hazing using Trained Dogs

Recently the golf course industry has been using trained dogs to haze geese away from fairways and ponds. The specially trained dogs do not attack the birds but scatter them through chasing and barking. The use of dogs is most effective before the birds begin to nest. A daily hazing by the dog will force the birds to find a more secure location to nest. The Silver Spring Golf Course in Menomonee Falls, Wisconsin, has been successfully using a dog for hazing for the past several years. The cost of a trained geese dog can cost up to several thousand dollars.

Hazing by Swans

Mute swans have been used to haze geese with good success. During matting the male is very aggressive to any geese located within site of the nest site. A pair of swans will control geese on a pond up to 3 acres in size. For larger ponds, more than one pair can be used, provided there is some type of natural barrier that will prevent the two pairs from seeing each other, thus allowing them to establish separate territories. Special swans with clipped wings are used for the hazing process. Unlike geese, swans spend most of their time in the water, preventing problems with droppings. The swans eat predominately grain provided by the owners. Swans can be both purchased and rented. The cost of a matting pair is approximately $4,200. A Midwest source for mute swans is D. R. Church Landscaping located at 17950 W. HWY 173, Wadsworth, Ill 60083.

Chemical Repellants

A new product on the market is Rejex-it®. Rejex-it® is made from a chemical used as an artificial grape flavor in food. Geese do not like the taste of the product. When sprayed on their food source, the turf lawn, the geese are supposed to leave the area. The chemical does not harm the geese. Re-application of the product every 2 to 3-weeks is necessary. Due to the newness of the product, experience is limited. The product is available from Martinson-Nocholls Inc., Mentor, Ohio.

Control of Purple Loosestrife

The plant species purple loosestrife exists in various locations the City of Oak Creek. Purple Loosestrife is an exotic plant from Eurasia that has no natural enemy in the United States (Fumiss, 1995 and 1996). Purple loosestrife typically exists where there are moist conditions, such as; marshes, wetlands, ditches, streambanks, stormwater retention ponds, and canals (Water Hauler's Bulletin, 1992). The plant can tolerate a wide range of environmental conditions and appears only to be sensitive to light conditions (Fumiss, 1995 and 1996). Seed dispersal occurs by movement from: wind, water, wildlife, and humans (Fumiss, 1995). Purple loosestrife is an aggressive plant that has been known to convert diverse wetland areas to monospecific loosestrife communities (Fumiss, 1995). This loss of plant diversity is a loss of food diversity for many species of fish and wildlife (Fumiss, 1995). The dense, impenetrable stands that purple loosestrife develops into are unsuitable as cover, food or nesting sites for various wetland animals, such as; ducks, geese, rails, bittems, muskrats, frogs, toads, and turtles (McIntyre, 1996). Control during early stages of infestation is important; once the infestation becomes large, control is difficult. Manual control of a small cluster of plants is possible. Pull or dig out the plant before early August, when it flowers and produces seeds. Dry and then burn the plants if possible.

Unsuccessful control measures include water level manipulation, mowing, and fire. There are three groups of successful control measures; hand pulling, chemical control, and biological control.

The Missouri Department of Conservation states that up to 100 plants are best eliminated by hand pulling, and this should be done early in the flowering season (prior to August, WDNR, 1995) to avoid scattering seeds in the removal process. However, this may not be a permanent solution since plants can re-sprout even from a small part of a root or stem (Maia, 1996). The Wisconsin Department of Natural Resources (WDNR) recommends pulling small plants in loose soil, however acknowledges that it is difficult to remove older (larger) plants by pulling. The Virginia Natural Heritage Program recommends bagging the plants at the site, so that fragments are not dropped along the exit route, and then burning the plants. WDNR recommends drying the plants and then proper disposal.

Chemical treatment would consist of treating purple loosestrife with Rodeo, whose active ingredient is glyphosate. The WDNR has published a fact sheet on this chemical and requires a permit to use it in the state. This chemical is approved for use over water in the state of Wisconsin. A short summary of the fact sheet follows.

> *Rodeo will kill a broad spectrum of plants including grasses, sedges, broadleaved plants, and woody species. The chemical prevents the plant from making the necessary proteins for growth. Any contractor hired to perform the treatment must be certified by the Wisconsin Department of Agriculture, Trade, and Consumer Protection (DATCP). An effective method of treatment is cutting the plants and painting the cut stems with a 50% concentrated solution of Rodeo. This method is more labor intensive, but will preserve other native plant species in the area.*

In addition, biological control of purple loosestrife is currently being researched by many agencies in the United States and Canada. Researchers are studying several insects, both leaf eaters and root miners. Various insects researched are the natural enemy of purple loosestrife and were imported from Europe. Research by the WDNR began in 1994, and reports that these insects are dependent on purple loosestrife and are not a threat to other plants. Currently the insects are only approved for research in Wisconsin, and the WDNR is not distributing the insects for public use. The WDNR also reports that effective biological control may take as long as decades to be observed. However, this is more of a long term solution to the purple loosestrife problem, whereas hand-pulling and chemical control are short term solutions that may have to be repeated on a regular basis to maintain control of the plant.

Appendix

G

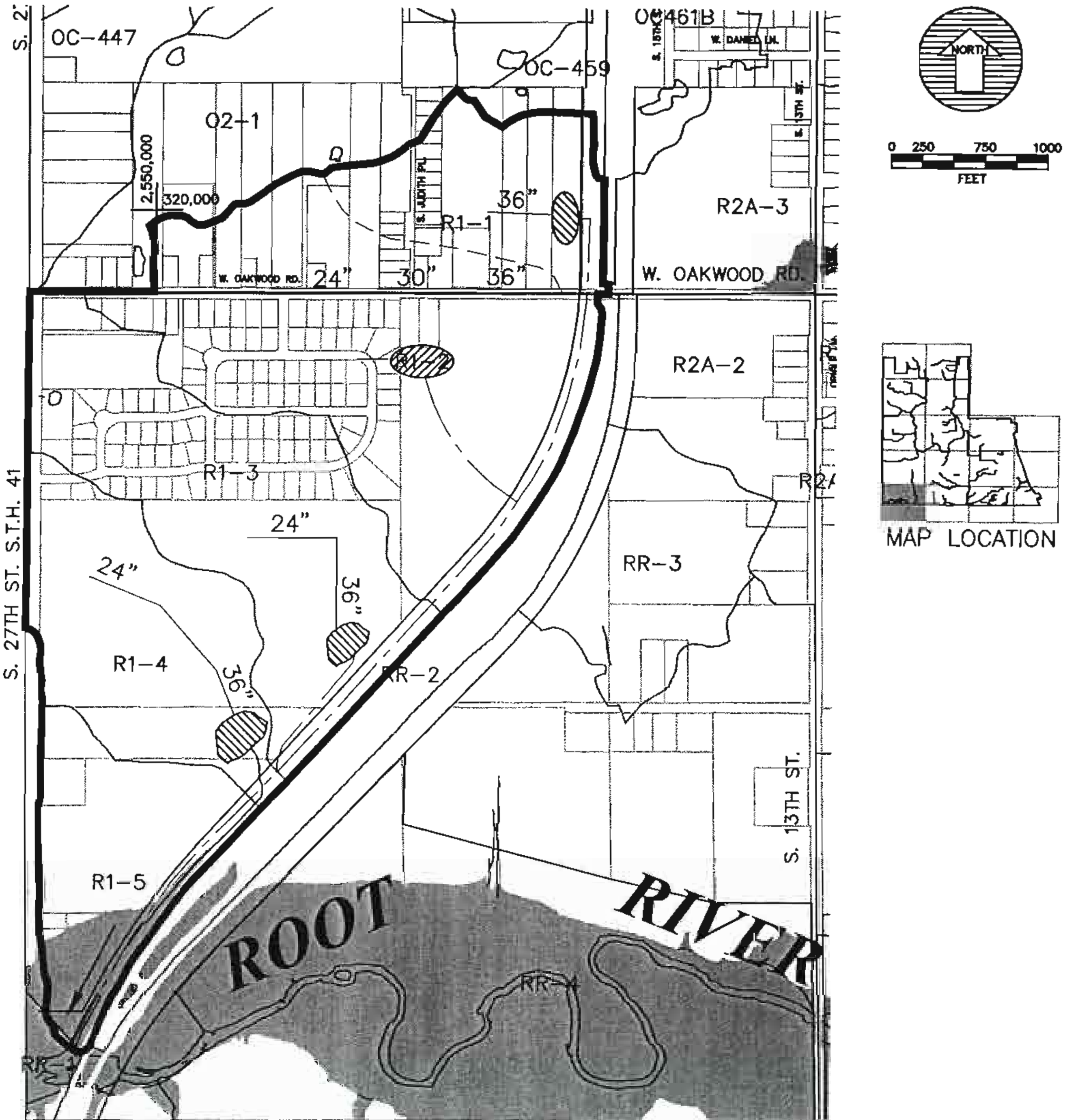
Skeletal System Plans

The alternatives discussed in Chapter 6 addressed the known and anticipated flooding and drainage problems in the City. Alternative stormwater management approaches are also possible for large tracts of developable land. Examples of such skeletal system designs for two subwatershed areas are provided in Figure G-1 and Figure G-2. These system plans are appropriate to demonstrate possible configurations of proposed storm sewers and detention basins that could be incorporated with the existing drainageways and floodplains. The type of development and the applicable City criteria would determine the need for detention and the required storage volume at the time of development. The specific design of stormwater conveyance and detention components would also be highly dependent on the size and configuration of parcels to be developed at the time the system is designed and constructed.

The R1 subwatershed, shown in Figure G-1, is approximately 300 acres in size and has five subbasins. Development exists in the upper portions of several subbasins and significant developable land is available. The Tributary R1 system plan illustrates how proposed storm sewer systems would follow existing drainage patterns and discharge to the existing open channel drainageway along IH-94. Detention basins at the outfall of each storm system would be used to limit increases in peak flows in accordance with the City ordinance.

The CB1 subwatershed, shown in Figure G-2, is approximately 160 acres at E. Elm Road and has four subbasins. The two upper subbasins are fully developed and the two lower subbasins have development along Elm Road. The Tributary CB1 system plan illustrates where storm sewers and detention basins would be located to serve proposed development in the remaining open areas.

Figure G-1
Skeletal System Plan for Tributary R1



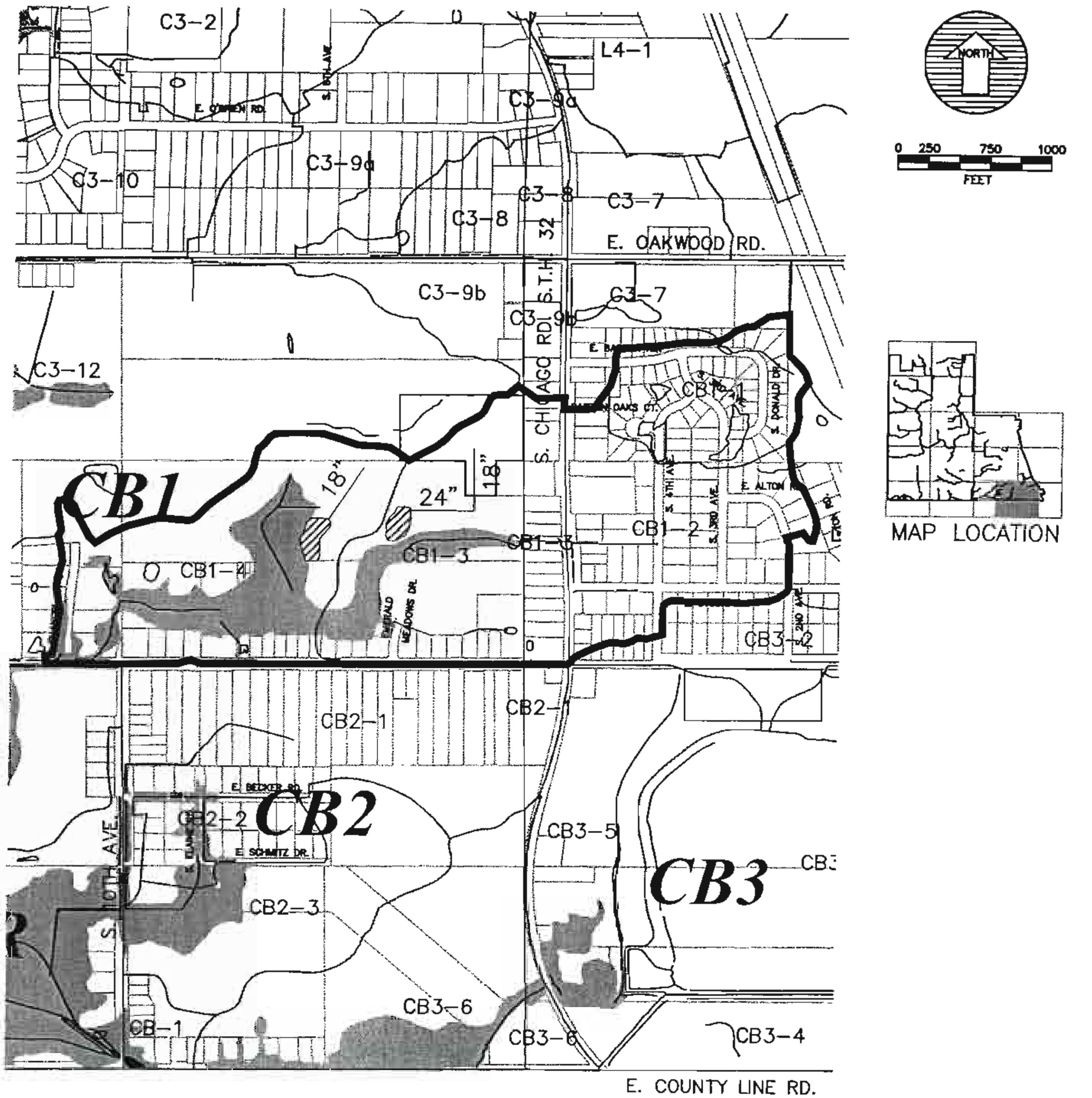
Legend

- SUBWATERSHED BOUNDARY
- SUBBASIN BOUNDARY
- CATCHMENT BOUNDARY
- MAINTAIN EXISTING DRAINAGEWAY
- 24" PROPOSED STORM SEWER WITH SIZE IN INCHES
- PROPOSED DETENTION BASIN

Hey and Associates, Inc.

R. A. SMITH & ASSOCIATES, INC.

Figure G-2
Skeletal System Plan for Tributary CB1



Legend

- SUBWATERSHED BOUNDARY
- SUBBASIN BOUNDARY
- MAINTAIN EXISTING DRAINAGEWAY
- 24" PROPOSED STORM SEWER WITH SIZE IN INCHES
- PROPOSED DETENTION BASIN

Hey and Associates, Inc.

R. A. SMITH & ASSOCIATES, INC.