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STORMWATER MANAGEMENT PLAN

FOR THE

VILLAGE OF SHOREWOOD WISCONSIN

December, 1997

Shorewood

PREPARED BY

Rust Environment & Infrastructure

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1 EXECUTIVE SUMMARY

INTRODUCTION

The Village of Shorewood is an older community which developed most of its available open land by the 1950's. Most of the development is relatively dense, though residential in nature. The dense development and associated large amount of impervious areas such as streets, roofs, parking lots, sidewalks, alleys, and driveways results in a large amount of stormwater runoff. The stormwater runoff is an area of concern for both the quantity aspects (such as flooding), and quality (i.e. nonpoint source pollution). To address the full range of stormwater issues, the Village of Shorewood undertook the development of a stormwater management plan. The Village conducted a previous flow capacity study of the combined sewer area. This study focuses on the separated sewer area of the Village.

Shorewood's stormwater management project is partially funded through the Wisconsin Nonpoint Source Water Pollution Abatement Program. This program is administered by the Wisconsin Department of Natural Resources (WDNR) and the Wisconsin Department of Agriculture, Trade, and Consumer Protection (DATCP). This stormwater management plan carries out and further refines the recommendations developed in the comprehensive priority watershed plan developed by the WDNR, DATCP, and local units of government: *A Nonpoint Source Control Plan For the Milwaukee River South Priority Watershed Project* (WDNR, 1991). In addition, erosion control concerns were addressed in Atwater Park on the shore of Lake Michigan and on the property known as the Edgewood property.

The Village is currently experiencing several minor flooding and nonpoint source pollution problems. This stormwater management plan collected the necessary data to analyze and assess the current conditions for stormwater in the Village, and also outlines recommendations to better manage stormwater. The Village of Shorewood contracted with Rust Environment & Infrastructure to conduct the stormwater management study. Rust worked with Village staff throughout the project. Village staff identified areas of concern, provided information on local conditions, and reviewed recommendations for managing stormwater.

The following objectives were defined early in the project:

- Estimate nonpoint source pollution.
- Estimate stormwater flows and volumes, to analyze the storm sewer infrastructure system for sufficient capacity.
- Analyze alternative pollution reduction methods and goals, to cost effectively achieve nonpoint source pollution reduction.
- Analyze flooding problems.
- Develop conceptual layouts of recommended Best Management Practices (BMPs), including preliminary cost estimates.
- Describe alternative mechanisms for funding stormwater management needs.

- Develop conceptual solutions to the stormwater runoff and erosion problems at Atwater Park.

- Develop recommendations for construction erosion control and for managing stormwater runoff post-development for the Edgewood Development.

SUMMARY OF PROJECT FINDINGS

- Areas were identified which contributed a disproportionate share of nonpoint source pollution. Stormwater control in these areas is critical in order to achieve significant pollution reduction in the project area. These areas consisted of commercial, institutional, industrial, multi-family, and high density residential land uses.

- Computer modeling identified 39 of the 79 modeled storm sewers as too small to accommodate the 10-year recurrence interval stormwater flow.

- Eleven funding mechanisms to finance the Village's stormwater management program were reviewed. The stormwater utility system was identified as the most fair and equitable way to fund a stormwater management program.

SUMMARY OF RECOMMENDATIONS

- Expand the Village's current catch basin cleaning monitoring program to optimize the efficiency of catch basin cleaning.

- Continue to support the existing excellent operation and maintenance program practiced by the Village Department of Public Works.

- Develop a storm sewer inspection program to detect and eliminate all non-stormwater discharges into the storm sewer system.

- Conduct the Village fall leaf pick-up using paper bags to minimize the amount of leaf litter entering the storm water stream.

- Expand article eight of the Village ordinance code to further protect surface water in the Village.

- Expand the stormwater pollution public education program to provide a public awareness of the sources of stormwater pollution and how to prevent it.

- Lease or purchase a high efficiency street sweeper for weekly sweeping of high density land uses in the project area (commercial, industrial, institutional, multi-family, and high density residential) and biweekly sweeping on other land uses in the project area.

- Install storm sewer inlet filters in parking lots and gas stations in the project area to help control petro-chemical based pollutants.

- Replace undersized storm sewers in conjunction with larger facility improvement projects, such as road reconstruction, to minimize costs and disruptions.

- Install a combination of concrete block and vegetative cover on surface erosion problem areas in Atwater Park.

- Require developer of the Edgewood Development to install stormwater control practices, such as parking lot bioswales and grass swale drainage.

Table 1-1
Recommended Nonpoint Source Control Measures Cost Estimates

Recommended Measure	Estimated Cost	Local Share	State Share	Annual Cost
High Efficiency Street Sweeper	$170,000	$73,600	$96,400	NA
Storm Sewer Inlet Filters	$27,000	$8,100	$18,900	$1,500
Atwater Park Erosion Control Measures[1]	$26,000	$7,800	$18,200	NA
Edgewood Development Stormwater Measures[1]	cost born by developer	--	--	NA
Catch Basin Cleaning Monitoring	--	--	--	--
Fall Leaf Pick-up with Paper Bags	--	--	--	--
Storm Sewer Inspection Program	--	--	--	$12,500
Public Education Program	$5,000	--	$5,000	
Total	**$228,000**	**$89,500**	**$138,500**	**$12,500**

[1] See Appendix A for details.

PROJECT BACKGROUND

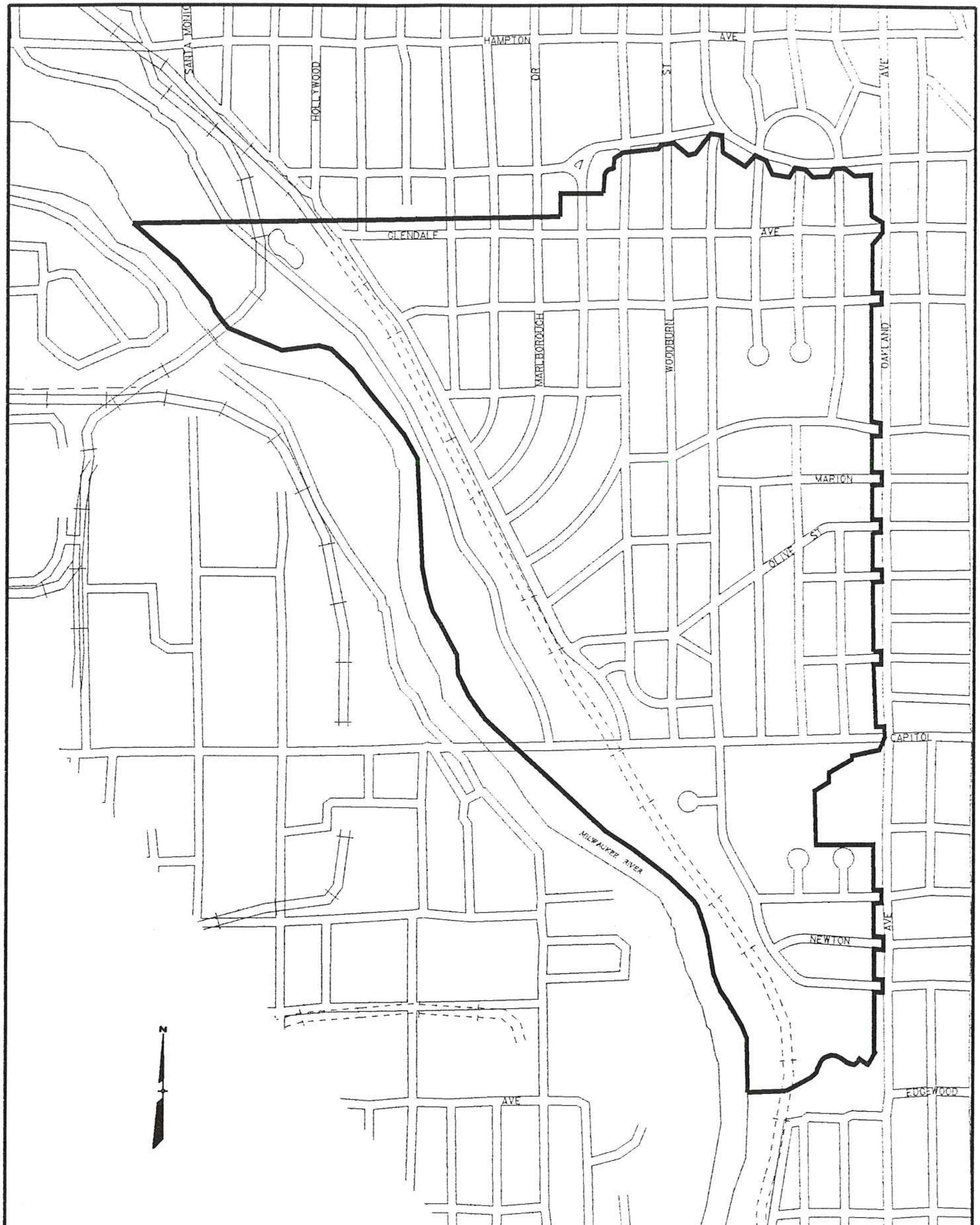
The Village of Shorewood has experienced periodic flooding of its combined sewer and separate storm sewers. A flow capacity study of the combined sewer system which identified a number of constrictions in the system was completed in 1996. This project evaluated drainage problems and identified sources of non-point source pollution in the separated sewer area of the Village. The project area is located within the Milwaukee River South Priority Watershed.

The Milwaukee River South Watershed was designated a "priority watershed" under the Wisconsin Nonpoint Source Water Pollution Abatement Program. This program is administered by the Wisconsin Department of Natural Resources (WDNR) and the Wisconsin Department of Agriculture, Trade, and Consumer Protection (DATCP) on a state level and by counties, cities and villages on a local level. The Milwaukee River South watershed encompasses an area of approximately 157 square miles in parts of Milwaukee and Ozaukee Counties. A planning level study to address the nonpoint source pollution control needs within the Milwaukee River South Watershed was completed in 1991 and resulted in the document: *A Nonpoint Source Control Plan For the Milwaukee River South Priority Watershed Project* (commonly called "the watershed plan"). This study was conducted by the WDNR; DATCP; the Ozaukee County Land Conservation Department, and the Milwaukee River South Advisory Subcommittee. Briefly, the plan:

- Identified critical sources of nonpoint pollution within the entire watershed.
- Set water resource objectives for the wetlands, streams, and lakes within the watershed.
- Established pollution reduction goals.
- Recommended a set of actions to reach the pollutant reduction goals.
- Set a budget and schedule to carry out the recommendations of the plan.

To assist in carrying out the recommendations established in the watershed plan, the Village of Shorewood received a Local Assistance Grant from the WDNR to partially fund a more detailed stormwater management plan for the drainage area described as the Shorewood separate sewer drainage area. The project area includes about 467- acres on the west side of the Village (Figure 2-1). A portion of the study area is within the City of Whitefish Bay. In addition, erosion control concerns were addressed in Atwater Park on the shore of Lake Michigan and in the Edgewood development on the southern border of the Village.

The Village of Shorewood contracted with Rust Environment & Infrastructure (Rust) to conduct the stormwater management study. This document reports on the findings of the stormwater management study for the Shorewood separate sewer drainage area.



RUST ENVIRONMENT & INFRASTRUCTURE

FIGURE 2-1

SEPARATE SEWER PROJECT AREA

VILLAGE OF SHOREWOOD
STORMWATER MANAGEMENT PLAN

PURPOSE AND OBJECTIVES

The purpose of the Stormwater Management Plan for the Shorewood separate sewer area is to move towards implementation of the recommendations set forth in the Milwaukee River South Plan. The Stormwater Management Plan for Shorewood addresses remediation of existing water quantity and quality problems, such as nonpoint source pollution, flooding, and erosion.

The objectives for the Stormwater Management Plan were based on review of the recommendations set forth in the *Nonpoint Source Control Plan For the Milwaukee River South Priority Watershed Project* and discussions within the Village/WDNR/Rust project team. As a result of the reviews and discussions, the following objectives evolved:

1. Enhance the Milwaukee River, which partially meets its designated use as set forth in the *Nonpoint Source Control Plan For the Milwaukee River South Priority Watershed Project.* For the Milwaukee River in the Village of Shorewood, the potential uses are:

   - Support a warm water sport fishery.
   - Support full body contact recreational uses.

   Achieving these important water use objectives lead to the following, more specific sub-objectives:

   A. Contribute to attainment of the pollution reduction goals set forth in the *Nonpoint Source Control Plan For the Milwaukee River South Priority Watershed Project* (page 120-124). For the Milwaukee River - Shorewood subwatershed, the plan recommends the following reductions in average annual nonpoint source pollution loads:

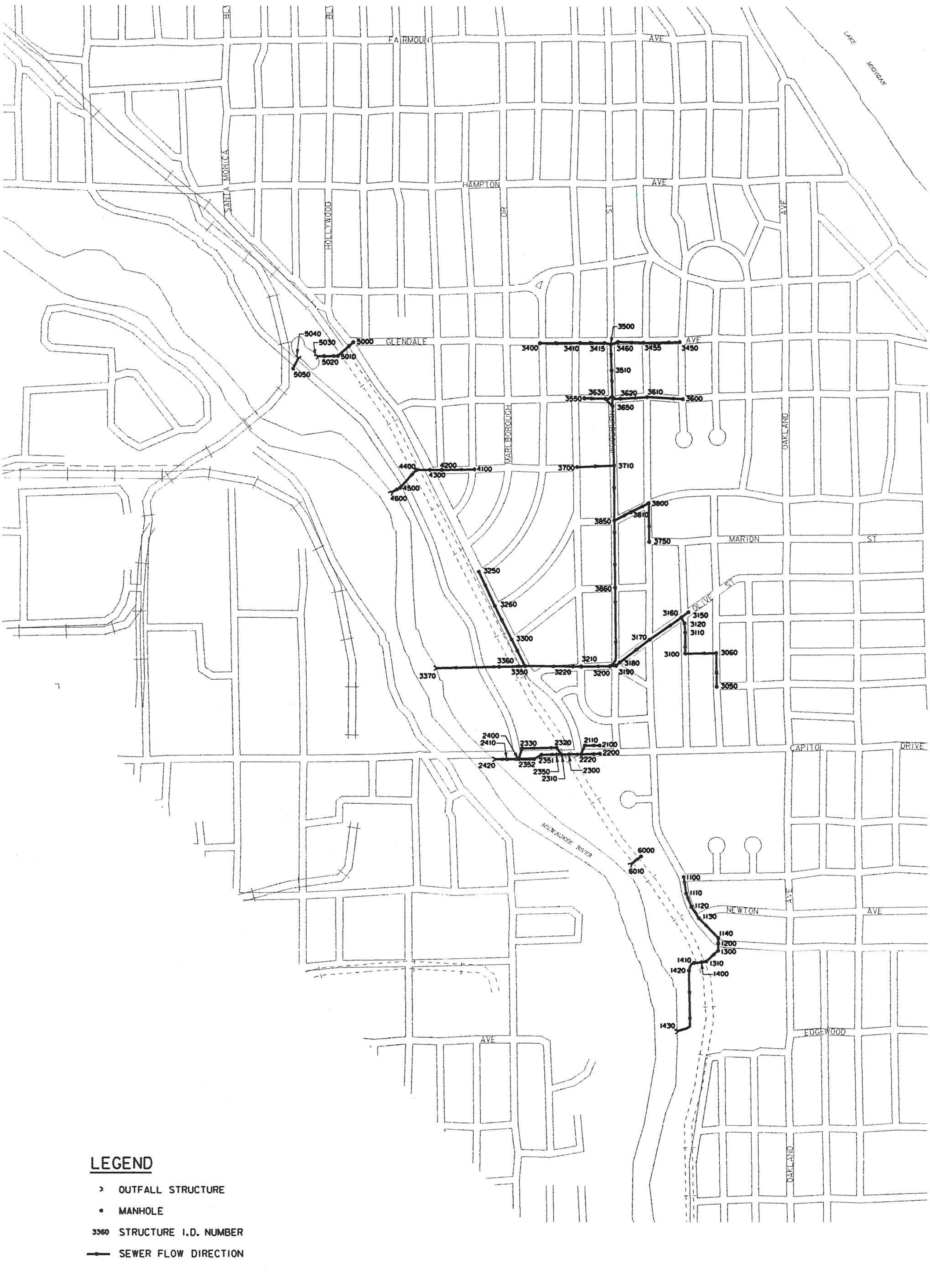
      - Sediment: 50 percent
      - Phosphorous: 50 percent - 70 percent
      - Toxic Metals: Reduce so runoff waters do not exceed state quality water standards (45 percent for lead) Lead was chosen as the "typical" toxic metal for the Shorewood study because of the current emphasis on lead pollution problems in the Milwaukee County area.

   B. Contribute to the attainment of the recommendations set forth in the regional water quality management plan, as documented in Southeastern Wisconsin Regional Planning Commission (SEWRPC) Planning Report No. 30, *A Regional Water Quality Management Plan for Southeastern Wisconsin.*

   C. Reduce negative aesthetic impacts, such as turbidity, sediment deposits, algae, litter and debris in the Milwaukee River.

2. The project will help the Village in the application process for the stormwater discharge permits (NR 216) required by the WDNR.

3. Address current flood control and drainage needs and prevention of future flooding within the watershed.



MODELED SEWERS

VILLAGE OF SHOREWOOD, WI

FIGURE 4-1

RUST ENVIRONMENT & INFRASTRUCTURE

4. Address erosion control needs at Atwater Park on the shore of Lake Michigan.

5. Address construction site erosion control needs at the Edgewood Development on the southern boundary of the Village.

6. Produce a practical and implementable plan.

SCOPE OF SERVICES

The scope of services for the Stormwater Management Plan included the following:

Project Background

- Develop a project work plan with Village staff and the WDNR.
- Determine existing land uses and soils in the project area.
- Inventory the storm sewer system for the project area.
- Survey select manhole rim and pipe invert elevations.
- Smoke test to determine whether or not the roof drains are connected to the storm sewers.
- Delineate drainage basins within the study area.
- Create a database for the land use and storm sewer information.
- Summarize existing water quality data for the Village of Shorewood and the Milwaukee River.
- Inventory and evaluate operation and maintenance procedures for the Village's stormwater management facilities.

Analyses

- Calculate peak discharge and runoff volumes for the 2-year, 10-year, 25-year and 100-year storm events.
- Recommend improvements to facilities which are unable to handle current runoff conditions.
- Estimate nonpoint source pollutant loadings were estimated for each basin and sub-basin.
- Prioritize basins for the implementation of non-structural and structure management practices.

Develop Alternatives and Recommendations

- Identify storm sewer system deficiencies and suggested repairs for flooded structures and intersections and undersized primary storm sewers.
- Recommend non-point source pollution control BMPs.
- Suggest modifications to current Village ordinances for improved stormwater management.
- Suggest improvements to the Village's existing stormwater system maintenance program.
- Develop conceptual solutions to the stormwater runoff and erosion problems at Atwater Park.
- Develop recommendations for construction erosion control and for managing stormwater runoff post-development for the Edgewood Development.
- Develop a multi-year Implementation Plan and financing strategy for the stormwater management program.

Deliverables

- Provide hard copies of this Stormwater Management Plan report, one set of 3.5" disks of reports (WordPerfect Version 6.1), hydraulic/hydrologic calculations and database, and one set of reproducible Drainage Maps to the Village.

Meetings

- Conduct four (4) progress meetings with the Village and WDNR.
- Make one formal presentation regarding the final report and recommendations of this planning process to the Village Board.

This planning investigation is intended to define systems and problems, explore a range of alternative solutions, and recommend the course of action. Implementation of facilities recommended in this report will require preparing detailed design and construction documents and obtaining WDNR permits.

3. NATURAL RESOURCES AND INFRASTRUCTURE

The geographic extent of this planning investigation includes those portions of the Village of Shorewood drained by a separate storm sewer system. This area is generally west of Oakland Avenue within the Village limits. A small area of Whitefish Bay to the north of Glendale Avenue which drains into Shorewood was included in the project area.

Discussed in this chapter are selected natural resource and infrastructure features of the project area pertinent to this planning project. Topics presented include: subbasins comprising the project area, conveyance facilities, soils, existing and future land use, precipitation, stormwater regulatory framework, and recent relevant studies,

BASINS AND SUBBASINS

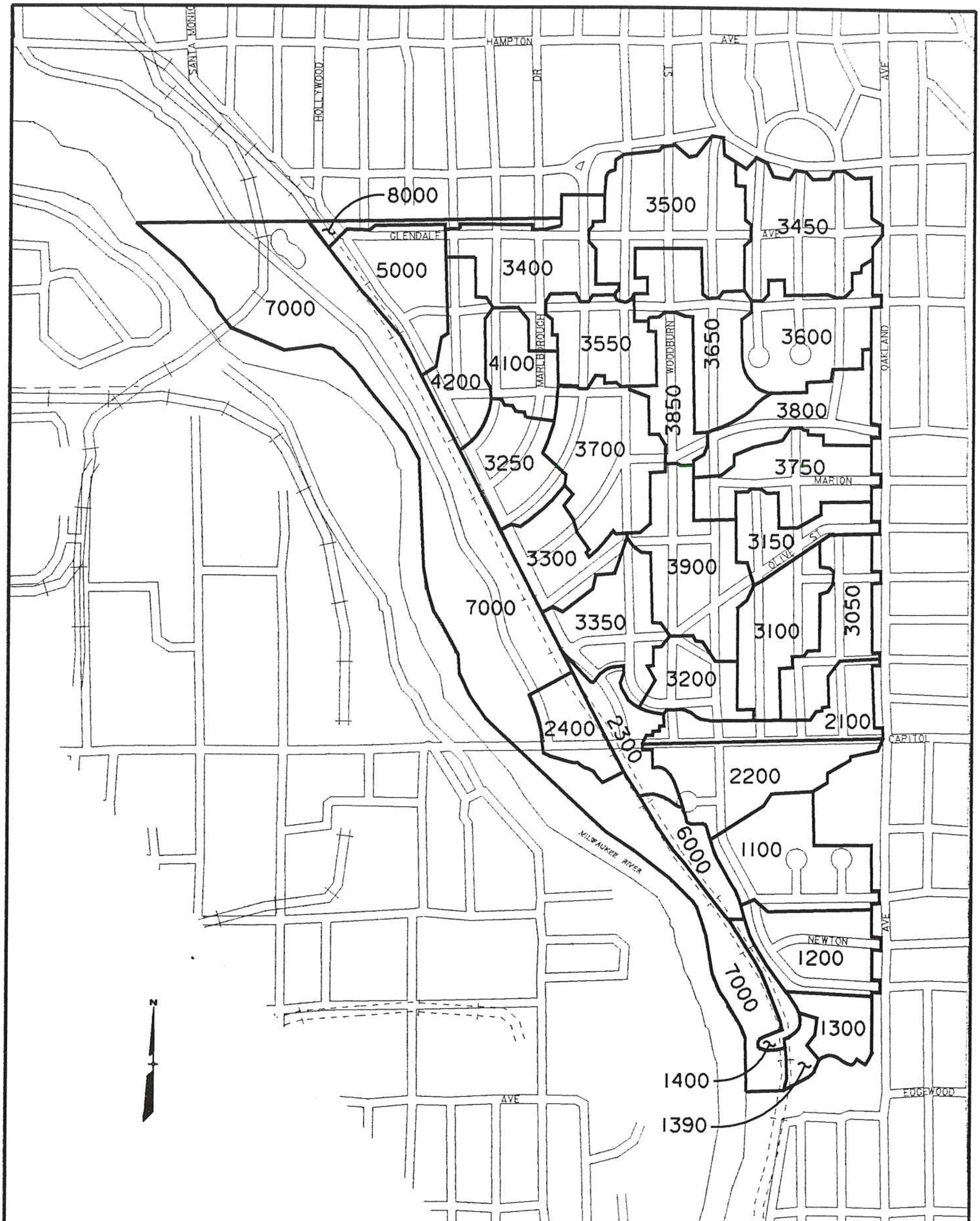
Basins are areal units which represent individual watersheds within the Village. Subbasins are smaller drainage areas within a basin. They are the basic building blocks of the hydrologic analysis. Subbasins were delineated using the 1992 two foot topographic maps for the Village, storm sewer maps, and other data supplemented with field reconnaissance. The 467-acre project area was partitioned into eight basins; six drained by storm sewers into the Milwaukee River, one draining directly into the river, and one draining north into Whitefish Bay. The basin directly draining to the Milwaukee River is 87 acres in size. The storm sewered basins ranged in size from 7.1 to 253.6 acres. Within the six drainage basins are 31 storm sewered subbasins ranging in area from 0.3 to 23.8 acres. The average size of these subbasins is 12.2 acres. Basin and subbasin boundaries are shown in Figure 3-1.

Elevations within the project area vary from about 685 feet above mean sea level in the northeastern portions to approximately 590 feet above mean sea level along the Milwaukee River in the extreme southwest for a total relief of 105 feet. The majority of the project area above the Milwaukee River floodplain is relatively flat with 1 - 5 percent slopes. The slopes going down to the Milwaukee River are rather steep with slopes in the range of 15 - 50 percent.

STORMWATER CONVEYANCE AND STORAGE SYSTEM

The stormwater conveyance system consists of storm sewers. The majority of rooftop downspouts are directly connected to the storm sewer system with the remaining flowing onto yards and driveways.

The existing and proposed storm sewer and storage system determines the route by which stormwater and its pollutants moves from the land surface through the watershed to the Milwaukee River. The system also effects flow velocity and discharge as well as localized flooding due to drainage backup. Data and information on the conveyance system, particularly storm sewers and culverts, helps diagnose the cause of local flooding problems. Typically, the capacities of the larger storm sewers are critical in determining the overall drainage capacity of the sewer system. For the purposes of this project the capacity of storm sewer pipes 24 inches or greater in diameter were analyzed. Figure 4-1 shows the storm sewers which were modeled for this project. This network includes approximately 15,900 feet of pipe.



RUST ENVIRONMENT & INFRASTRUCTURE

FIGURE 3-1

SUB-BASINS OF THE PROJECT AREA

VILLAGE OF SHOREWOOD
STORMWATER MANAGEMENT PLAN

The only detention pond in the project area is Estabrook Lagoon in Estabrook Park straddling the border between Shorewood and Whitefish Bay. The southwest corner of Whitefish Bay outside of the project area also drains into this lagoon.

SOILS

The nature of soils comprising the top layer of unconsolidated material in the watershed is important partly because soil properties are a primary factor in determining the volume of runoff associated with a given rainfall. The U.S. Department of Agriculture Natural Resource Conservation Service (NRCS) classifies soils hydrologically as A, B, C, or D. Hydrologic soil Group A soils have a high infiltration capacity and low runoff potential whereas, at the other end of the spectrum, soil Group D soils have a low infiltration capacity and a high runoff potential.

The USDA NRCS soil survey for Milwaukee County does not include the Village of Shorewood as part of a detailed soil survey but does provide a general soil association map. The general soil association map indicates that the project area is primarily in the Kewaunee-Manawa association (primarily Group C soils) and that the floodplain soils are in the Fox-Casco association (primarily Group B soils). For the purposes of this project it was assumed that the soils are Group C soils, except for the soils in the Milwaukee River flood plain which were assumed to be Group B soils.

Caution must be used when characterizing the soils of an urban area from the USDA Soil Surveys. The high degree of land disturbing activities can change the soil's physical properties. Short of actually conducting soil infiltration tests in the field, however, the soil survey is the only source of information regarding infiltration rates. For implementation of site specific recommendations from this report, field measurements are necessary to properly construct the best management practices.

LAND USE

Type and distribution of land use are important elements in a water quality and flood control investigation. The type and amount of nonpoint source pollution and the volume and timing of runoff are directly influenced by land use. Although the underlying soil type, as already noted, is an important factor in determining the hydrologic/hydraulic water quantity response, the land use superimposed on that soil by urban development can markedly alter that response. Urban land use is characterized by large areas of impervious surface and, therefore, increased runoff volume and decreased runoff time. The net effect can be very large increases in peak flow, flood stages, areas of inundation, and nonpoint source pollutant generation and transport.

Existing Land Use: This information was obtained from the Village of Shorewood Land Use Map (1995), the Village Zoning Map (1983), and 1995 SEWRPC aerial photographs. Table 3-1 shows the project area's current land use by basin (a table of land uses by sub-basin is shown in Appendix C). Shorewood is characterized by a mixed land use of residential, commercial, and business. The most common land use is high density residential at 41 percent of the total land use within the project area. Park land and open space is the second most common land use (18 percent) and is concentrated in basin 7000 along the Milwaukee River direct drainage area. Medium density residential land use comprises 15 percent of the total and occurs in basins 3000 and 4000. There is little industrial land use, comprising only 2 percent of the total.

Future Land Use: Shorewood is fully developed. It is assumed that the future land use will be the same as existing land use. There is no open land available for any future development. Any further development would require removal of existing buildings.

TABLE 3-1
LAND USE AREAS
VILLAGE OF SHOREWOOD

Basin i.d.	Residential (acres)			Commercial (acres)	Institutional (acres)	Light Industrial	Open Space (acres)	Park (acres)	Total (acres)
	High Density	Med. Density	Multi-Family						
1000	24.3	0	5.7	1.3	6	0	0	5.6	42.9
2000	4.7	0	2.1	16.2	17.1	1.8	0	1.2	43.1
3000	155.3	64	11.4	7.7	12.8	0	0	2.4	253.6
4000	7.5	4.9	6.1	0	0	0	0	0.5	19
5000	0	0	14.2	0	0	0	0	0	14.2
6000	1.8	0	0	0.1	0	5.2	0	0	7.1
7000	0	0	1.3	0	2.6	2.3	4.9	76	87.1
8000	0	0.3	0	0	0	0	0	0	0.3
Total	193.6	69.2	40.8	25.3	38.5	9.3	4.9	85.7	467.3

FLOODPLAINS

Floodplains are usually defined as the area along a stream which would be inundated during a 100- year recurrence interval flood. The floodplain is not suited for development since the development would be periodically flooded. Experience has shown that development in the floodplain exacerbates the severity of the flood. Chapter NR116 of the state administrative code regulates construction in the floodplain. The floodplain along the Milwaukee River in Shorewood has not been mapped by FEMA (Federal Emergency Management Agency). Due to the steep banks and the lack of development along the river the only structure that may be a hazard in a flood is the boathouse in Estabrook Park.

PRECIPITATION

The watershed has a climate characterized by markedly different seasons with corresponding large variations in temperature and precipitation type, amount, and intensity. The primary source used to predict total rainfall amounts for this project was the SDA, Soil Conservation Service Technical Paper No. 40: "The Rainfall Frequency Atlas of the United States" (compiled by the U.S. Department of Commerce). Also, the Southeastern

Wisconsin Regional Planning Commission's (SEWRPC) Technical Report, Volume 3, No. 5 ("Development of Equations for Rainfall intensity-Duration-Frequency Relationship"), was consulted.

A number of storms were analyzed for this study to determine which storm intensity and duration resulted in the most critical peak flows for flooding conditions. Table 3-2 summarizes the storm events and precipitation amounts screened for this project.

TABLE 3-2
INTENSITY-DURATION-DEPTH RAINFALL DATA
(reported in inches)

	Recurrence Interval				
Duration	**2-Year**	**5-Year**	**10-Year**	**25-year**	**100-year**
30 minute	1.10	1.30	1.50	1.70	2.15
1-Hour	1.38	1.68	1.81	2.20	2.60
2-Hour	1.60	2.00	2.25	2.60	3.10
6-Hour	1.95	2.45	2.85	3.35	4.00
12-Hour	2.30	2.90	3.35	3.75	4.85
24-Hour	2.55	3.35	3.80	4.40	5.40

The rainfall data for pollutant loading analysis (SLAMM) came from rainfall records for the year 1981 in Milwaukee, Wisconsin. This is considered by the WDNR as a "typical" year of rainfall and is assumed to best predict the potential average runoff and pollutant loadings. The Source Load and Management Model (SLAMM) uses the 1981 rainfall year to generate the pollutant loadings for the various land uses and other conditions.

STORMWATER REGULATORY FRAMEWORK

Over the past few years, several changes have occurred in the federal, state, and local levels of government resulting in significant impacts to stormwater quality and stormwater management. Below is a summary of the major programs at each governmental level which in some way affect stormwater regulatory issues.

Federal Government

Stormwater Permit Program

In 1987, the federal government passed the amended Clean Water Act which included several regulations related to stormwater management and nonpoint source pollution control. The programs are administered by the U.S. Environmental Protection Agency (USEPA) which issued final regulations (40 CFR, part 122) in 1990 and are targeted to controlling nonpoint source pollution from municipal, industrial, and construction site runoff. The federal program directs municipalities greater than 100,000 in population to inventory, monitor, and develop plans to reduce the pollutants found in municipal runoff. The municipalities must obtain "pollution permits" to regulate the quality of their runoff. Selected industries must also obtain permits to regulate their runoff quality. Industries must monitor their runoff quality and develop Stormwater Pollution Prevention Plans (SWPPPs) in compliance with the program. Construction sites greater than 5 acres in size must develop construction erosion control plans to minimize the pollutants in runoff from these sites.

The federal program allows for the administration and regulatory authority to be delegated to states. Because the WDNR has been designated to administer this program, the Village will likely be in contact with the state, and not the federal government, regarding this program.

404 Permit Program

Section 404 of the Clean Water Act provides the authority to the federal government for administering activities which may impact navigable waters of the United States. This program is generally administered by the U.S. Army Corps of Engineers. Activities requiring a 404 permit include placing fill or dredging a navigable waterway or wetland. The permitting process is coordinated by the District Office of the WDNR (Bureau of Water Regulation and Zoning).

State Government

Stormwater Permit Program (NR 216)

In Wisconsin, the State's WDNR has taken on the responsibility to carry out the federal stormwater management program (40 CFR, part 122). The WDNR has developed an administrative code to implement the program (commonly referred to as "NR 216"). One element of this program is the municipal stormwater discharge permit program.

In August of 1996, the Village of Shorewood, along with 22 other Southeastern Wisconsin communities, was designated to participate in the permit program. The area to be permitted in Shorewood is the project area for the plan, the separated sewer area on the west half of the Village. The permit program is a two step process. The first step is filing the preapplication information with WDNR which was filed February 2, 1997. The final application is due within 24 to 36 months after the WDNR's approval of the preapplication. The Village may apply for the permit either on their own or jointly with neighboring municipalities. Certain types of industries within the Village of Shorewood and the project area will also be affected by these rules.

Wisconsin Nonpoint Source Pollution Abatement Program (NR 120)

Because this study is partially funded through the State's Nonpoint Source Pollution Abatement Program, the Village must comply with the program's rules as defined in the administrative rules NR 120. The Village must comply with the WDNR's "core program" as described in the Priority Watershed Plan in order to accept continued funding through the priority watershed program. The core program includes requirements for: maintaining and enforcing a construction site erosion control ordinance; conducting a water quality focused information and education program; and evaluating and improving its urban "housekeeping practices."

State Wetland Permit Requirements (NR 103)

In 1991, the State of Wisconsin promulgated administrative rules (NR 103) which describes a review process to be used by WDNR for projects affecting delineated wetlands. The NR 103 process will apply to projects funded through the Wisconsin Nonpoint Source Pollution Abatement Program, if impacts on wetlands are involved. The impacts may be direct (such as constructing a structural management practice within the boundaries of the wetland) or indirect (such as changes in the hydrology of a nearby wetland). The review criteria to be used by the WDNR include: (1) is the project wetland dependent? (2) are there practical alternatives? (3) what are the impacts on wetland water quality standards? (4) what are the cumulative impacts? and (5) what are potential secondary impacts? Projects that are not wetland dependent and have practical alternatives will be denied a permit for proceeding. Applications for this permit are handled through the District Office of the WDNR (Bureau of Water Regulation).

State Water Regulation Permit (Chapter 30)

The State of Wisconsin has the authority to regulate activities that affect navigable waterways. This includes lakes, streams, and rivers within Wisconsin. Almost all waterways with a defined channel and bank are considered "navigable" if the channel carries water for a portion of the year. Projects (regardless of the funding source) that place fill in or remove fill from a waterway, or in any way impact navigation, require a permit through the "Chapter 30" process. Projects such as stream bank stabilization, dredging, or "improvements" to an existing channel likely will require this permit.

The permit application process is generally coordinated with local zoning and/or shoreland requirements. Applications for this permit are handled through the District Office of the WDNR (Bureau of Water Regulation).

Local Government

Construction Site Erosion Control Ordinance

The Village adopted a construction site erosion control ordinance (Article 3) which is based on a model ordinance developed cooperatively by the Wisconsin League of Municipalities and the WDNR. Provisions of the ordinance for construction sites include:

- The submittal of an erosion control plan to the Village from the landowner.
- The approval of the plan and issuance of a permit from the Village.
- The inspection of the construction site to check for compliance with the erosion control plan.
- Best management practices required by the ordinance shall follow the design criteria, standards, and specifications set forth in the Wisconsin Construction Site Best Management Practice Handbook published by the WDNR.

Other Stormwater Management Policies/Regulations

The Village has regulations governing leaves, grass, and refuse collection; recycling; discharge and clean-up of hazardous materials; and stormwater drainage. The refuse collection and disposal regulations (Article 6, Section 11-602) stipulates that the autumn collection of leaves will be accomplished by sucking up the leaves from loose piles on the parkways with special leaf sucking equipment. During other times of the year, yard waste other than grass clippings must be bagged in paper bags and placed at the curb for pick up. Under the recycling regulations (Article 7, Section 11-710), waste oil, lead acid batteries, and major appliances shall be brought into the Department of Public Works Yard for disposal. Village regulations for hazardous materials spills (Article 8) prohibits the spill of hazardous materials onto any public street, alley, ground, surface water, or subsurface water. Any person, firm or corporation responsible of such a spill shall take immediate action to contain and clean up the spill. The stormwater drainage regulation (Section 11-507) requires that if a given lot drains onto an adjoining property, the first lot must be connected to the storm sewer or street gutter. There are no provisions regulating the quantity or quality of stormwater runoff.

INTRODUCTION

Most people within Shorewood are more aware of street flooding problems within the Village. The purpose of the hydrologic/hydraulic analysis is to estimate the amount of runoff being generated in the study area and to determine which sewers lack the capacity to carry the runoff off the streets. The Village's storm sewer system was modeled only for existing land use conditions because the Village is fully developed.

CURRENT FLOODING PROBLEM AREAS

During discussions with Village staff, the following seven areas were identified as existing street flooding areas:

1. Intersection of Congress Street and Wilson Drive
2. Intersection of Lake Bluff Blvd. and Morris Blvd.
3. Intersection of Marion Street and Morris Blvd.
4. Intersection of Woodburn Street and Olive Street.
5. Intersection of Olive Street and Wilson Drive.
6. Capitol Drive underpass (west of Wilson Drive).
7. Morris Blvd. from Beverly Road to Menlo Blvd.

HYDROLOGIC MODELING OF URBAN AREAS

The computer model HYDRA, developed and supported by PIZER, Inc. was selected for hydrologic/hydraulic simulation of sewers in Shorewood. This model features user friendly screens for input, analysis and output functions. Information required as input to HYDRA include:

- Manhole rim and invert elevations.
- Shorewood storm sewer atlas.
- 1"=100' scale; 2-foot contour mapping.
- Field reconnaissance and survey information.
- Design storm precipitation.
- Land use data.
- Hydrologic soil information.
- Street conditions.
- Hydrologic sub-basin delineations.

Using this data, HYDRA simulates hydrology and hydraulics in the following manner:

- Using the 1"=100' topo maps, the Village was divided into sub-basins, as shown in Figure 3-1. Using land use data, soil type, and slope, the hydrologic parameters for each sub-basin were developed.

- A rainfall hyetograph (a pattern of rainfall intensity over time) is applied to each sub-basin in the watershed and the corresponding sub-basin hydrograph (a pattern of stormwater flow versus time) is generated for each sub-basin. For any given hyetograph, each sub-basin has a unique hydrograph based on sub-basin characteristics such as area, slope, soil type, and land use.

- The drainage system in the Village of Shorewood is curb and gutter with storm sewers. Roof drains are directly connected to the storm sewers. The park areas drain primarily via overland flow and channels to the Milwaukee River. Sewers with a 24-inch diameter and larger were modeled. Figure 4-1 shows the modeled sewers.

- The model routes the sub-basin hydrographs through the Village's storm sewer system adding additional hydrographs from successive sub-basins as the flow moves through the system. Hydrographs are added at manholes and the cumulative process continues on downstream ending at six different outfall locations along the Milwaukee River.

A sensitivity analysis of rainfall was conducted. The sensitivity analysis varied the runoff distributions, recurrence intervals, and durations was conducted. A rainfall hyetograph based on the Huff First Quartile distribution (Huff, 1967) was selected as being the most appropriate for the Village of Shorewood. Furthermore, the sensitivity analysis indicated that the 1-hour duration storm for recurrence intervals ranging from two to 100 years produced the most critical conditions regarding potential flood conditions. Therefore, the design storms used in preparing the Shorewood Stormwater Management Plan are all of 1-hour duration, are based on the Huff First Quartile distribution, and have recurrence intervals varying from two to 100 years.

Two, 10-, 25-, and 100-year, 1-hour design storms were applied to each sub-basin to determine the stormwater system conveyance and storage capacity under a wide range of conditions. The number of inlets within each sub-basin was determined using the Shorewood storm sewer atlas. A flow of 1.5 cubic feet per second (cfs) was allowed in at each inlet. When the sub-basin runoff exceeded the 1.5 cfs per inlet, the remaining runoff would remain on the street and would enter the system when the runoff rate was lower than 1.5 cfs per inlet. This analysis matched reported storm conditions as indicated by Village staff. A summary of the 10-year, 1-hour analysis by sub-basin is shown in Table 4-1.

Existing hydraulic conditions of the conveyance system were modeled to identify undersized elements of the stormwater system, that is, sewers with inadequate capacities to carry the stormwater runoff. This was done to address the flood control objective of this plan. Identification and prioritization of the most critical deficiencies lead to recommendation of remedial actions.

IDENTIFICATION OF STORMWATER CONVEYANCE SYSTEM CAPACITY

The Concept of Hydrologic/Hydraulic Adequacy

As discussed above, HYDRA was used to simulate the hydrologic/hydraulic behavior of the Shorewood storm sewer system under existing land use conditions. These simulations identified existing inadequacies in storm sewers. Before presenting the results of the analyses, hydrologic/hydraulic adequacy (or inadequacy) of storm sewers were defined.

Storm sewers are typically considered to be adequate if they convey flows for the design rainfall without causing objectionable surface flooding. The Village of Shorewood typically uses the 10-year, 1-hour rainfall event for storm sewer design. The term "10-year, 1-hour" means a rainfall amount that has a 10 percent probability of occurring or being exceeded in any one year, over a 1-hour period. For the Shorewood area, this rainfall is

TABLE 4-1
STORM SEWER ANALYSIS SUMMARY
10-YEAR, 1 HOUR RECURRANCE INTERVAL
VILLAGE OF SHOREWOOD

Sub-basin Number	Number of Inlets	Sub-basin Runoff (Cfs)	Total Flow to Sewer (Cfs)	Peak Flow on Street (Cfs)	Street Storage (Cu. Ft.)	Storage Per Inlet (Cu. Ft.)	Street Water Depth (In.)	Time on Street (Min.)
Basin 1100	14	40.5	21.0	19.5	7889	564	3.3	24
Basin 1200 (½)	10	17.2	15.0	2.2	780	78	0.5	6
Basin 1200	8	17.2	12.0	5.2	1117	140	0.8	12
Basin 1300	2	15.0	3.0	12.0	2542	1271	7.3	24
Basin 1400	2	8.9	3.0	5.9	2423	1212	7.0	30
Basin 1390	2	6.7	3.0	3.7	0	0	0.0	0
Basin 2100	12	43.9	18.0	25.9	13004	1084	6.3	42
Basin 2300	9	36.9	13.5	23.4	15858	1762	10.2	54
Basin 2200	15	47.7	22.5	25.2	13294	886	5.1	36
Basin 2400	13	15.2	19.5	0.0	0	0	0.0	0
Basin 3450	18	50.6	27.0	23.6	8423	468	2.7	24
Basin 3400	32	37.9	48.0	0.0	0	0	0.0	0
Basin 3550	10	27.7	15.0	12.7	4313	431	2.5	18
Basin 3600	14	37.1	21.0	16.1	7906	565	3.3	24
Basin 3650 (½)	8	26.7	12.0	14.7	6253	782	4.5	24
Basin 3850	4	10.7	6.0	4.7	2958	740	4.3	30
Basin 3700	19	24.1	28.5	0.0	0	0	0.0	0
Basin 3750	13	35.1	19.5	15.6	7778	598	3.5	24
Basin 3800	8	33.9	12.0	21.9	13537	1692	9.8	48

Sub-basin Number	Number of Inlets	Sub-basin Runoff (Cfs)	Total Flow to Sewer (Cfs)	Peak Flow on Street (Cfs)	Street Storage (Cu. Ft.)	Storage Per Inlet (Cu. Ft.)	Street Water Depth (In.)	Time on Street (Min.)
Basin 3650 (1/3) & 3500	24	39.9	36.0	3.9	680	28	0.2	30
Basin 3900 (½)	4	12.8	6.0	6.8	4944	1236	7.1	48
Basin 3250	10	22.2	15.0	7.2	3075	308	1.8	24
Basin 3300 (½)	6	14.0	9.0	5.0	1351	225	1.3	12
Basin 3300 (½)	8	14.0	12.0	2.0	488	61	0.4	6
Basin 3150	7	20.2	10.5	9.7	4120	589	3.4	24
Basin 3050	18	35.9	27.0	8.9	2566	143	0.8	12
Basin 3100 (½)	6	17.6	9.0	8.6	3223	537	3.1	24
Basin 3100 (½)	6	10.8	9.0	1.8	1092	182	1.1	18
Basin 3900 (½)	5	12.8	7.5	5.3	4419	884	5.1	42
Basin 3200	14	22.0	21.0	1.0	0	0	0.0	0
Basin 3350 (1/2)	5	19.2	7.5	11.7	5381	1076	6.2	30
Basin 3350 (1/2)	10	19.2	15.0	4.2	572	57	0.3	12
Basin 4100	10	14.6	15.0	0.0	0	0	0.0	0
Basin 4200	15	35.0	22.5	12.5	6660	444	2.6	18
Basin 5000	22	33.8	33.0	0.8	272	12	0.1	6
Basin 6000	8	24.9	23.6	1.3	0	0	0.0	0

calculated to be 1.81 inches over a 1-hour period. For the purpose of defining adequacy, it was determined that a storm sewer would be adequate if the sewer could carry the 10-year, 1-hour runoff without surcharging to within 1 foot of the rim elevation.

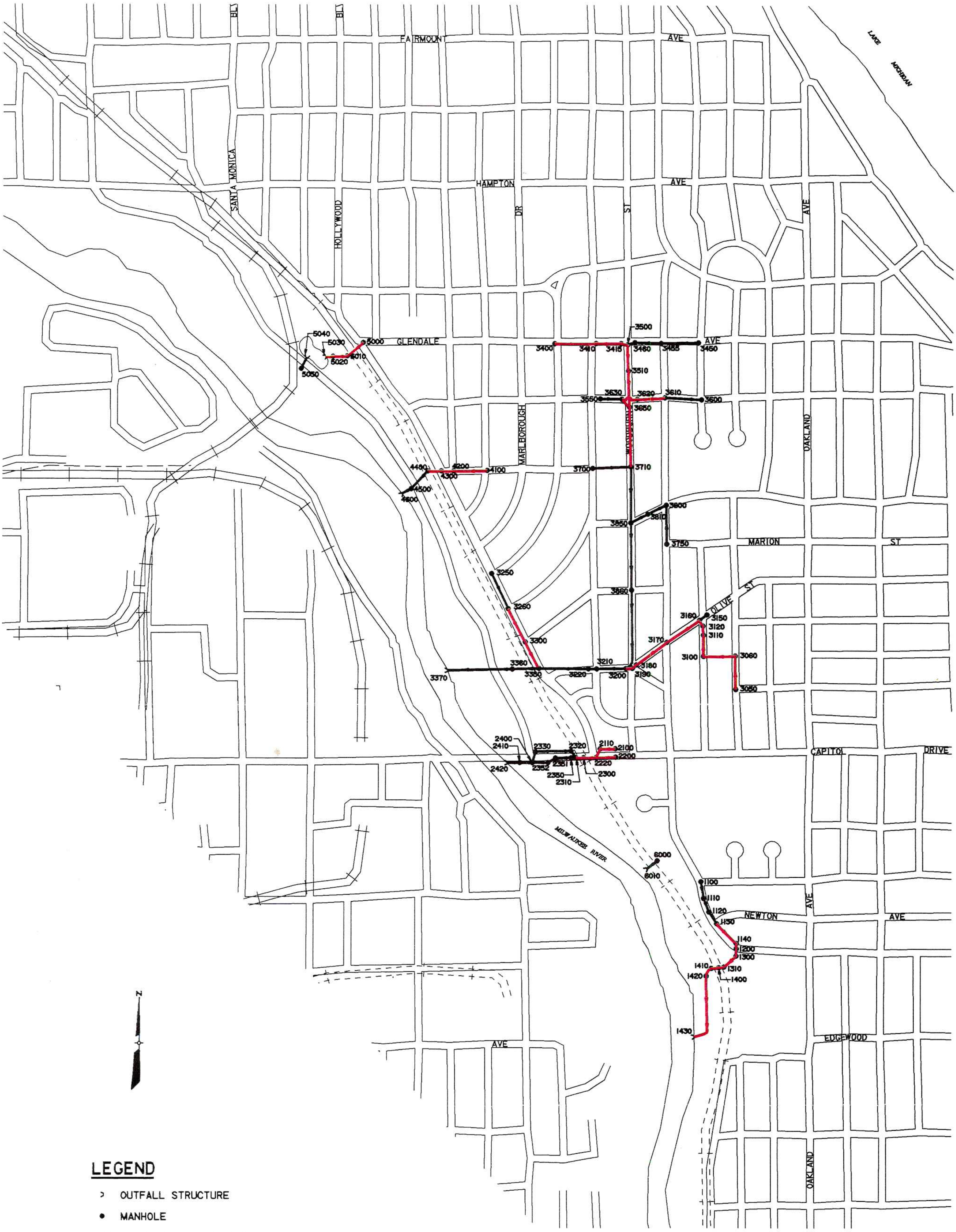
Inadequate Storm Sewers

Figure 4-2 shows the storm sewers with inadequate capacity to carry the 10-year, 1-hour storm under existing land use conditions. Table 4-2 lists the locations of inadequate storm sewers and the recommended pipe diameters needed to carry the design storm. The table shows the 39 sewer pipe locations where capacities were exceeded by the 10-year, 1-hour storm event. There were a total of 79 storm sewer pipe locations analyzed within the project area.

TABLE 4-2
UNDER CAPACITY STORM SEWERS
10-YEAR, 1-HOUR RECURRANCE INTERVAL STORM

Pipe Id.	Link No.	Pipe flow (cfs)	Pipe Capacity (cfs)	Excess Flow (cfs)	Pipe Length (ft.)	Existing Pipe Size (In.)	New Pipe Size (In.)
1130-1140	4	36.00	2.32	3.68	229	27	30
1140-200	5	36.00	29.75	6.25	114	27	30
1200-1300	6	47.95	3.55	4.40	153	36	36
1300-1310	7	56.82	40.14	16.68	199	36	42
1310-1400	8	6.61	43.55	13.06	80	36	42
1400-1410	9	59.86	3.61	0.00	80	36	42
1410-1420	10	59.78	44.09	15.69	35	36	42
1420-1430	11	59.72	43.59	16.13	70	36	42
2100-2110	12	18.00	11.70	.3	174	15	18
2110-2220	13	31.50	14.49	17.01	58	24	36
2200-2220	14	22.50	21.17	1.33	174	18	21
2220-2300	15	54.00	43.29	10.71	130	30	36
2300-2310	16	54.00	33.20	20.80	35	30	36
✓ 3400-3410	31	47.91	23.96	23.95	315	24	30
✓ 3410-3415	32	46.21	18.88	27.33	295	24	36

Pipe Id.	Link No.	Pipe flow (cfs)	Pipe Capacity (cfs)	Excess Flow (cfs)	Pipe Length (ft.)	Existing Pipe Size (In.)	New Pipe Size (In.)
3415-3500	33	44.60	12.72	31.88	51	24	36
3610-3620	39	33.00	29.34	3.66	320	24	27
3620-3630	40	39.00	30.48	8.52	102	24	27
3630-3650	41	54.00	48.87	5.13	106	36	42
3500-3510	46	106.90	47.02	59.88	245	42	54
3510-3650	47	104.85	53.54	51.31	282	42	54
3650-3710	48	155.84	95.03	60.81	627	48	54
3260-3300	53	24.00	16.81	7.19	329	24	30
3300-3350	54	33.86	22.94	10.92	271	27	30
3050-3060	56	27.00	13.35	13.65	300	24	30
3060-3100	57	36.00	33.75	2.25	122	24	30
3100-3110	58	45.00	29.90	15.10	275	30	36
3110-3120	59	45.00	34.85	10.15	40	30	36
3120-3160	60	45.00	159.10	0.00	35	30	36
3160-3170	61	55.49	46.48	9.01	332	36	42
3170-3180	62	61.44	54.72	6.72	385	36	42
3180-3190	63	61.29	56.00	5.29	25	36	42
3190-3200	64	75.62	67.83	7.79	23	36	42
4100-4200	70	15.00	11.40	3.60	323	18	21
4200-4300	71	37.50	20.74	16.76	97	24	30
4300-4400	72	36.96	21.78	15.18	218	24	30
4400-4500	73	35.72	22.94	12.78	133	24	30
5000-5010	75	33.00	17.50	15.50	198	18	24
5010-5020	76	33.00	18.83	14.17	280	18	24
5020-5030	77	33.00	3.06	29.94	10	18	30



LEGEND

- > OUTFALL STRUCTURE
- • MANHOLE
- 3380 STRUCTURE I.D. NUMBER
- SEWER FLOW DIRECTION
- SEWER FLOW > 100% CAPACITY

10-YEAR STORM UNDER CAPACITY SEWERS

VILLAGE OF SHOREWOOD, WI

FIGURE 4-2

RUST ENVIRONMENT & INFRASTRUCTURE