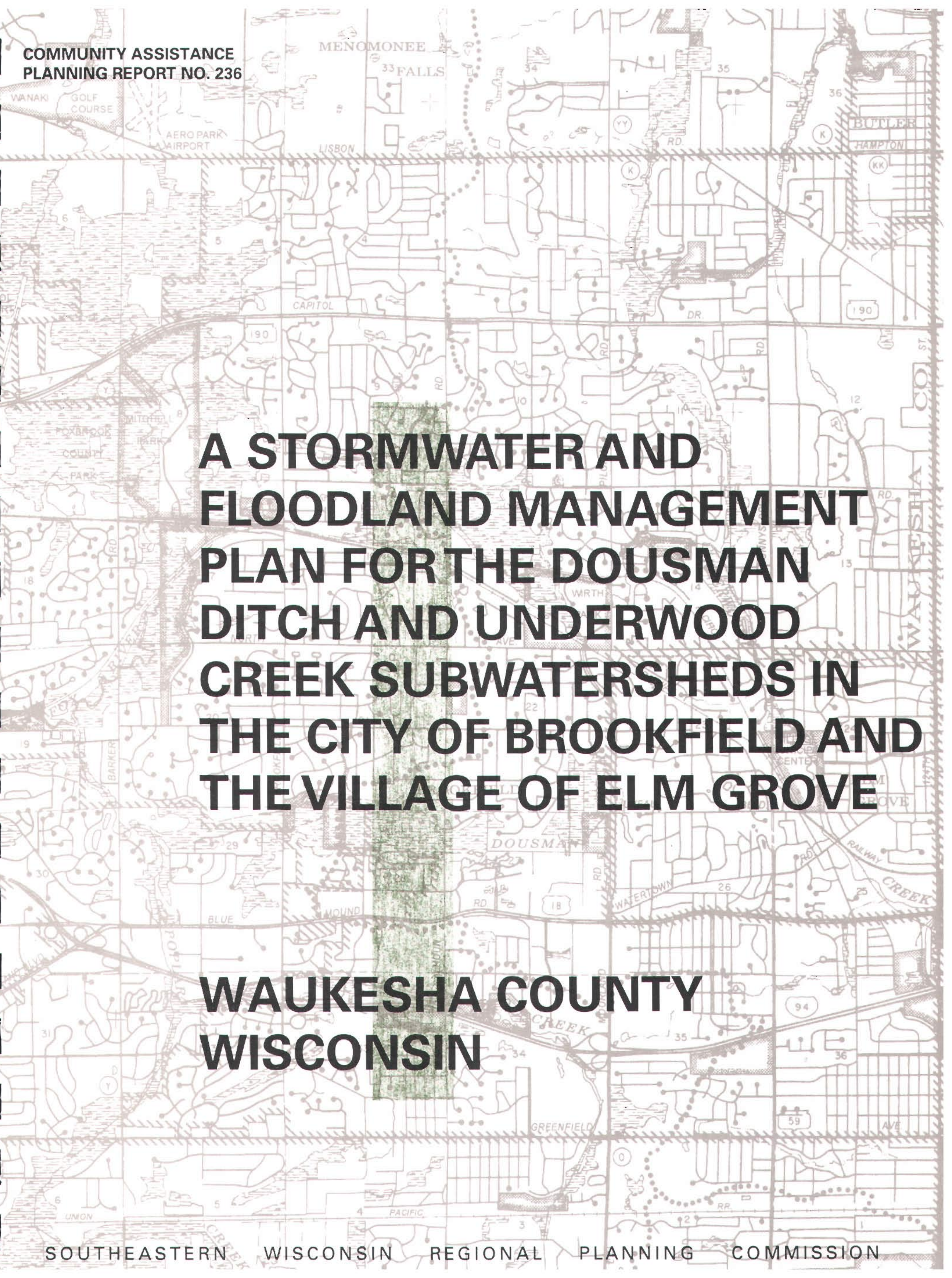

COMMUNITY ASSISTANCE
PLANNING REPORT NO. 236

A STORMWATER AND FLOODLAND MANAGEMENT PLAN FOR THE DOUSMAN DITCH AND UNDERWOOD CREEK SUBWATERSHEDS IN THE CITY OF BROOKFIELD AND THE VILLAGE OF ELM GROVE

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WISCONSIN

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Special acknowledgment is due Ms. Najoua Ksontini, PH, SEWRPC Senior Engineer; Mr. Michael G. Hahn, PE, PH, SEWRPC Principal Engineer; Mr. Michael F. Campbell, PE, Ruekert & Mielke, Inc. Principal in Charge; Mr. Todd B. Weik, RLA, Ruekert & Mielke Project Manager; Mr. Richard J. Wirtz, PE, Ruekert & Mielke Project Engineer; and Mr. Thomas H. Koepp, Ruekert & Mielke Project Engineer, for their contributions to the preparation of this report.

COMMUNITY ASSISTANCE PLANNING REPORT
NUMBER 236

A STORMWATER AND FLOODLAND MANAGEMENT PLAN FOR THE DOUSMAN DITCH AND UNDERWOOD CREEK SUBWATERSHEDS IN THE CITY OF BROOKFIELD AND THE VILLAGE OF ELM GROVE

WAUKESHA COUNTY
WISCONSIN

Prepared by the

Southeastern Wisconsin Regional Planning Commission
and Ruekert & Mielke, Inc.

In Cooperation with

City of Brookfied, Village of Elm Grove, and
Wisconsin Department of Natural Resources

February 2000

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TABLE OF CONTENTS

Chapter VI—RECOMMENDED STORMWATER AND FLOODLAND MANAGEMENT PLAN 217

Chapter VII—PLAN IMPLEMENTATION 261

Chapter VIII—SUMMARY 271

LIST OF APPENDICES

LIST OF TABLES

Chapter II

Chapter III

Chapter IV

Chapter V

Chapter VI

LIST OF FIGURES

Chapter II

Chapter III

Chapter VI

LIST OF MAPS

Chapter VI

Chapter I

INTRODUCTION

This report presents the major findings and recommendations of a stormwater and floodland management planning program for the Dousman Ditch and Underwood Creek subwatersheds of the Menomonee River watershed in the City of Brookfield and the Village of Elm Grove (see Map 1). The report describes the existing stormwater management system and the existing stormwater management and flooding problems of the study area, and identifies the causes of these problems; describes existing and planned future land use conditions and identifies related stormwater management requirements; provides a set of objectives and supporting standards to guide the development of an effective stormwater and floodland management system for the area; presents alternative stormwater and floodland management system plans for the Dousman Ditch and Underwood Creek subwatersheds; provides a comparative evaluation of the technical, economic, and environmental features of these plans; recommends a cost-effective stormwater and floodland management plan for the two subwatersheds; and sets forth a plan implementation program.

STUDY BACKGROUND

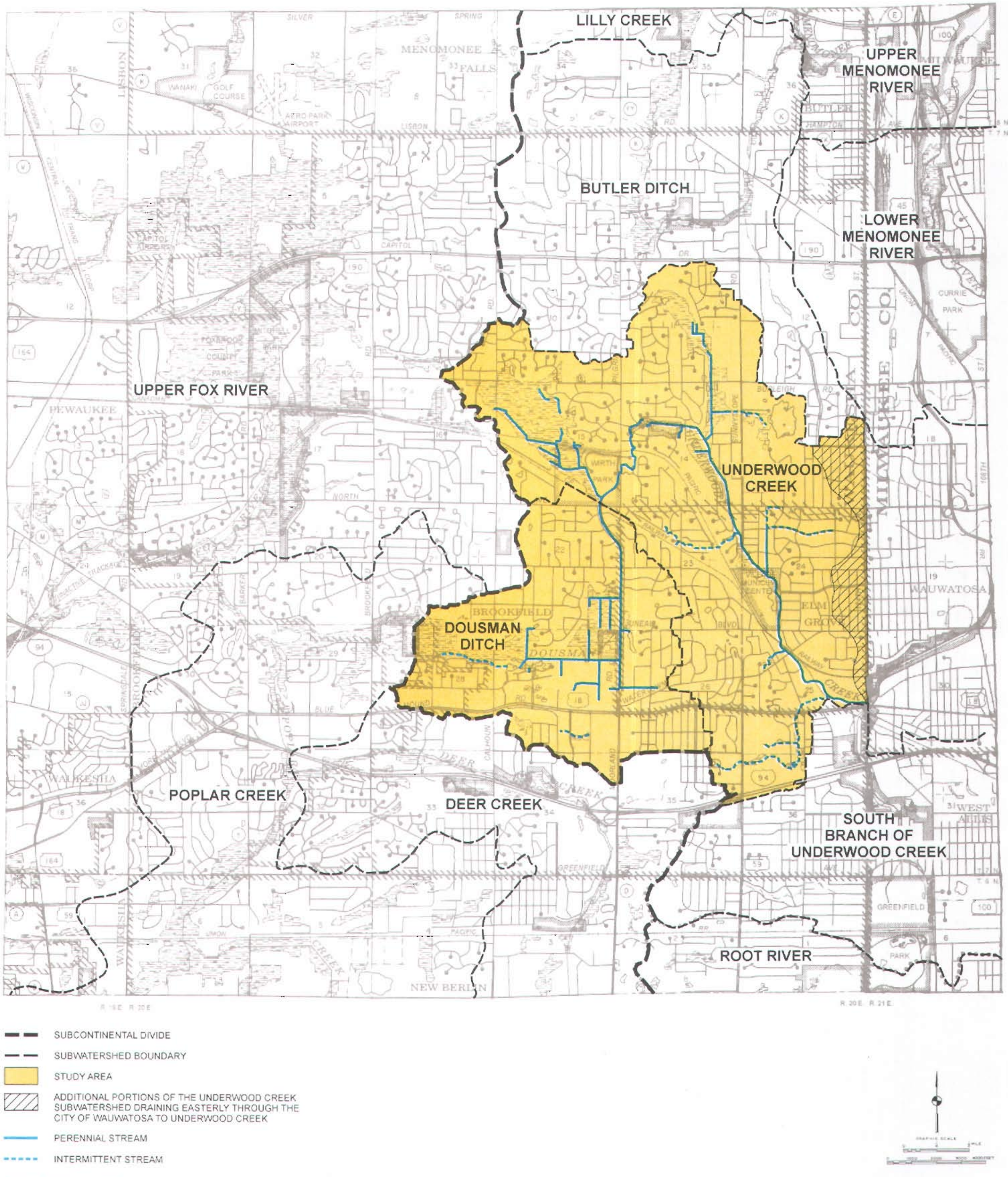
The City of Brookfield and the Village of Elm Grove are located in the northeastern quadrant of Waukesha County. The subcontinental divide between the Lake Michigan and Mississippi River basins traverses the City of Brookfield in the manner shown on Map 1. Thus, about the eastern one-half of the City lies within the Menomonee River watershed and drains to Lake Michigan, and the western one-half of the City lies within the Fox River watershed and drains to the Mississippi River system. The entire Village of Elm Grove lies within the Menomonee River watershed. As shown on Map 1, approximately 7.3 square miles of the east-central portion of the City of Brookfield and 3.5 square miles of the Village of Elm Grove are included in the study area comprised of the Dousman Ditch and Underwood Creek subwatersheds.

In 1980, the resident population of the Dousman Ditch and Underwood Creek subwatersheds within the City and the Village was approximately 17,500 persons. By 1990, the population had decreased 5 percent to approximately 16,600 persons, a decrease of about 900 persons from the 1980 level. The projected year 2010 population of this same area is expected to remain at the 1990 level. Although the 1990 and 2010 populations of the subwatersheds have decreased in comparison to 1980 due to declining average household sizes, residential land and housing units increased by about 3 percent from 1980 to 1990, and it is planned that the amount of land in residential uses will increase an additional 4 percent between 1990 and 2010. In 1980 total employment in the Dousman Ditch and Underwood Creek subwatersheds within the City and the Village was approximately 15,800 persons. By 1990 total employment had increased 35 percent to approximately 21,300 persons, an increase of about 5,500 persons over the 1980 level. The projected year 2010 employment in this same area is approximately 27,400 persons, an increase of about 6,100 persons, or about 22 percent, over the 1990 level. To accommodate the projected increase in employment and to meet the demand for residential land, urban land use within the subwatersheds may be expected to increase from a total of about 7.0 square miles in 1990, to about 7.7 square miles by 2010—an increase of about 0.7 square miles, or about 10 percent, over the 1990 level. The planned year 2010 land use condition essentially represents the full development condition for the subwatersheds.

In the absence of adequate planning, the conversion of land from rural to urban use may be expected to aggravate existing and create new stormwater management and floodland problems. In recognition of the need for a systematic plan to address existing problems and to avoid the creation of new problems, a joint resolution requesting that the Southeastern Wisconsin Regional Planning Commission assist the City of Brookfield and the Village of Elm Grove in the preparation of a stormwater and floodland management plan for the Dousman Ditch and Underwood Creek subwatersheds was adopted by the City on February 20, 1996, and by the Village on March 11, 1996. The planning work was jointly funded by the City and the Village with the aid of a Wisconsin Nonpoint Source Water Pollution Abatement Program local assistance grant from the Wisconsin Department of Natural Resources (DNR).

Map 1

STUDY AREA FOR STORMWATER AND FLOODLAND MANAGEMENT SYSTEM PLAN FOR THE DOUSMAN DITICH AND UNDERWOOD CREEK SUBWATERSHEDS: CITY OF BROOKFIELD AND VILLAGE OF ELM GROVE



Source: SEWRPC.

The purpose of this report is to present the resulting stormwater and floodland management plan. The plan seeks to promote the development of an effective stormwater and floodland management system, adequate to serve the City and the Village under full development conditions. To the extent practicable, the plan is intended to ameliorate existing stormwater management problems, to avoid the creation of new stormwater management problems as the area continues to develop, to mitigate the effects of nonpoint source pollution on surface water quality, and to help reduce flooding. More specifically, this report:

1. Describes the existing stormwater and floodland management system and the existing problems in the study area and identifies the causes of these problems;
2. Describes existing and planned land use conditions and identifies related stormwater and floodland management requirements;
3. Provides a set of objectives and supporting standards to guide the development of an effective stormwater and floodland management system;
4. Presents alternative stormwater and floodland management plans;
5. Provides a comparative evaluation of the technical, economic, and environmental features of the alternative plans;
6. Recommends a cost-effective stormwater and floodland management plan for the Dousman Ditch and Underwood Creek subwatersheds consisting of various structural and nonstructural measures; and
7. Identifies the responsibilities of, and actions required by, the various governmental units and agencies that will implement the recommended plan.

This report was prepared by the staff of the Southeastern Wisconsin Regional Planning Commission with assistance from Ruekert & Mielke, Inc., as a subcontractor to the Commission, and in cooperation with the staffs of the City of Brookfield, the Village of Elm Grove, and the Wisconsin DNR. The recommended plan, as presented herein, is properly set within the context of broad flood control and water quality management plans for the Menomonee River watershed.[1] The findings and recommendations of urban nonpoint source pollution control studies conducted by the DNR as part of the Menomonee River Priority Watersheds Program are also reflected in the alternative stormwater management plans and the recommended plan presented in this report.[2] The portions of the stormwater management plan relating to the City of Brookfield were prepared within the context of the City

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[1] *See SEWRPC Planning Report No. 26,* A Comprehensive Plan for the Menomonee River Watershed, *Volume One,* Inventory Findings and Forecasts, *October 1976, and Volume Two,* Alternative Plans and Recommended Plan, *October 1976; SEWRPC Planning Report No. 30,* A Regional Water Quality Management Plan for Southeastern Wisconsin: 2000, *Volume One,* Inventory Findings, *September 1978, Volume Two,* Alternative Plans, *February 1979, and Volume Three,* Recommended Plan, *June 1979; SEWRPC Community Assistance Planning Report No. 152 (CAPR No. 152),* A Stormwater Drainage and Flood Control System Plan for the Milwaukee Metropolitan Sewerage District, *December 1990; and SEWRPC Memorandum Report No. 93,* A Regional Water Quality Management Plan for Southeastern Wisconsin: An Update and Status Report, *March 1995. The Menomonee River watershed plan has been formally adopted by the Wisconsin Department of Natural Resources and Waukesha County, as well as by the Regional Planning Commission. The regional water quality management plan has been adopted by the Wisconsin Department of Natural Resources, Waukesha County, and the Commission. In addition to the plans listed above, a floodland management planning effort to update the delineation and mapping of floodlands in the City of Brookfield and the Village of Elm Grove was conducted by those communities and the Commission concurrently with the preparation of the stormwater management plan for the Underwood Creek and Dousman Ditch subwatersheds. In those subwatersheds, that planning effort was based primarily on the analyses conducted under SEWRPC CAPR No. 152.*

[2] *See* A Nonpoint Source Control Plan for the Menomonee River Priority Watershed Project, *Wisconsin Department of Natural Resources and Wisconsin Department of Agriculture, Trade, and Consumer Protection in cooperation with the Ozaukee, Washington, and Waukesha County Land Conservation Departments and the Menomonee River Advisory Subcommittee, March 1992.*

stormwater management guide which was adopted by the Brookfield Common Council.[3]

DISTINCTIONS BETWEEN STORMWATER DRAINAGE, STORMWATER MANAGEMENT, AND FLOOD CONTROL

The distinctions between stormwater drainage, stormwater management, and flood control are not always clear. For the purposes of this report, flood control is defined as the prevention of damage from the overflow of natural streams and watercourses. Stormwater drainage is defined as the control of excess stormwater on the land surface before such water has entered stream channels. The term "stormwater management" encompasses stormwater drainage, nonpoint source pollution control measures, and measures to mitigate the impacts of increased stormwater runoff on the receiving riparian and aquatic environment in stream channels. This report focuses on stormwater management within the context of the broader flood control plans cited above.

NEED FOR AND IMPORTANCE OF STORMWATER MANAGEMENT PLANNING

Stormwater management is one of the most important and costly requirements of sound urban development. Good stormwater management is essential to the provision of an attractive and efficient, as well as safe and healthful, environment for urban life.

Inadequate stormwater management can be costly and disruptive. Inadequate stormwater management can disrupt the safe and efficient movement of people and goods essential to the proper functioning of an urban area; undermine the structural stability of pavements, utilities, and buildings, requiring costly maintenance and reconstruction; and depreciate and destroy the market value of real property, with an attendant loss of tax base. Inadequate stormwater management can result in the excessive infiltration and flow of clear water into sanitary sewerage systems, with attendant surcharging of sanitary sewers, the backing of sanitary sewage into buildings, the bypassing of raw sewage to streams and watercourses through sanitary sewer system flow relief devices, and the attendant creation of serious hazards to public health. It can also damage the natural resource base through unacceptably high increases in the delivery of nonpoint source pollutants to streams and wetlands, increases in the frequency of erosive streamflows, modification or destruction of aquatic habitat, serious and costly soil erosion and sedimentation, and decreases in the amounts of groundwater recharge and stream baseflow.

Stormwater management planning and design requires knowledge and understanding of the complex relationships existing among the many interrelated natural and man-made features that together comprise the hydrologic-hydraulic system of the study area, and of how these relationships may change over time. Because of its important social, economic, and environmental impacts, stormwater management is a problem which requires sound resolution through careful application of the sciences of hydrology and hydraulics, as well as the arts of urban planning and engineering.[4]

BASIC CONCEPTS INVOLVED

The basic concept underlying urban stormwater management has evolved from the original concept which sought to remove excess surface water during and after a rainfall as quickly as possible through the provision of an efficient, constructed drainage system, to the current concept which emphasizes storage as well as conveyance of runoff while integrating constructed drainage facilities with the existing natural drainage system. The objectives of the current concept include

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[3] *See* Final Report - Stormwater Management Guide - City of Brookfield, *Rust Environment & Infrastructure, October 3, 1995.*

[4] *Hydrology may be defined as the study of the physical behavior of the water resource from its occurrence as precipitation to its entry into streams and watercourses or its return to the atmosphere via evapotranspiration. The application of hydrology to the planning and design of urban stormwater management systems requires the collection and analyses or definitive information on precipitation, soils, and land uses, and on the volume and timing of that portion of precipitation which ultimately reaches the surface water system as runoff. Hydraulics may be defined as the study of the physical behavior of water as it flows within pipes and natural and artificial channels; under and over bridges, culverts, and dams; and through lakes and impoundments. The application of hydraulics to the planning and design of stormwater management systems requires the collection and analysis of definitive information on the configuration of the natural and artificial stormwater management systems of the study area.*

reducing the peak rate of runoff and in some cases the total volume of runoff; reducing the transport of sediment and other water pollutants to receiving surface waters and wetlands; mitigating the adverse impacts of increased runoff and flow frequency on instream and riparian habitat; and protecting against increased downstream flooding.

The stormwater management system of an urban area may be conceived of as consisting of a major element operating infrequently and a minor element operating frequently.[5] Both of these elements can, under certain conditions, utilize constructed or natural stormwater retention or detention storage, as well as conveyance, as a potential design solution. The benefits of stormwater storage may include a reduction in the high kinetic energy of surface runoff; a reduction in both the total volume and peak rate of discharge; the provision of multiple-use opportunities for recreational and aesthetic purposes; the provision of groundwater recharge; and the entrapment of some pollutants.

For predominantly developed parts of urban communities—such as the established areas of the City of Brookfield and the Village of Elm Grove—the development of stormwater storage and nonpoint source pollution control measures may be constrained by the availability of open land on, or adjacent to, the drainage system, by relatively high costs, and by public concerns regarding safety and aesthetics. Nevertheless, successful efforts have been made to integrate such measures into the existing urban environment and they deserve careful consideration as a part of any sound stormwater management planning effort. In outlying, developing areas, the incorporation of stormwater storage facilities and nonpoint source pollution control measures may be more feasible owing to the availability of land and the opportunity to plan for such facilities as an integral part of the urban development process.

Facilities designed solely for the control of stormwater quantity, including storm sewers and dry detention basins which drain completely between storms, provide little or no reduction in nonpoint source pollutant loadings to receiving watercourses. However, when such facilities are integrated with nonpoint source pollution control measures such as source controls, wet detention basins, infiltration trenches, percolation basins, grass swales and waterways, regular street sweeping, and catch basin cleaning, a significant reduction in pollutant loadings may be achieved.

SCOPE OF THE STORMWATER AND FLOODLAND MANAGEMENT PLAN

The recommended stormwater and floodland management plan set forth in this report incorporates compatible multiple-use planning concepts and recognizes the constraints imposed by other community needs, such as park and open space, transportation, sanitary sewerage, and water supply. Stormwater and floodland management requirements under existing and planned full development land use conditions are evaluated. Flood control recommendations for Dousman Ditch and Underwood Creek have been made in the Menomonee River watershed study and refined under the drainage and flood control planning effort for the Milwaukee Metropolitan Sewerage District as noted above. Those recommendations provide a point of departure for the stormwater and floodland management plan set forth in this report. As shown on Map 1, the plan encompasses the 10.3-square-mile area in the Dousman Ditch and Underwood Creek subwatersheds within the City and Town of Brookfield and the Village of Elm Grove upstream of the confluence of Underwood Creek with the South Branch of Underwood Creek, plus an approximately 0.5-square-mile portion of the Underwood Creek subwatershed which drains easterly to Underwood Creek through the City of Wauwatosa. The two subject subwatersheds originate in the City of Brookfield. Consequently, almost all runoff in the study area is generated in the City and the Village.[6]

REVIEW OF PREVIOUS STUDIES

During preparation of the stormwater management plan, the findings and recommendations of previous studies related to stormwater management and/or flood control within the study area were reviewed. Those studies are listed below and their salient findings and recommendations are summarized.

1. *A Comprehensive Plan for the Menomonee River Watershed*, SEWRPC Planning Report No. 26, October 1976.

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[5] *The City of Brookfield stormwater guide refers to the major system as the "emergency" system and the minor system as the "convenience" system.*

[6] *A relatively small portion of the Town of Brookfield is located in the extreme southwestern portion of the study area.*

The recommended comprehensive plan for the Menomonee River watershed included a land use plan for the year 2000, a floodland management plan element, and a water quality management plan element. Floodland management recommendations for the Dousman Ditch and Underwood Creek subwatersheds in the City of Brookfield and the Village of Elm Grove included the provision of a centralized detention storage facility along Dousman Ditch in the area northwest of Blue Mound Road (USH 18) and Pilgrim Parkway, replacement of the CP Rail System bridge over Underwood Creek, and structure floodproofing and removal. The nonpoint source pollution control component of the water quality management plan called for low-cost control measures to be implemented through a combination of information and education programs and local ordinances. The recommended measures included construction erosion control, proper application of pesticides and fertilizers, proper material storage, control of pet waste, reevaluation of municipal street cleaning and de-icing operations, and consideration of the use of detention storage facilities to reduce the amounts of nonpoint source pollutants delivered to surface waters.

2. *Dousman Ditch Detention Basin Study - City of Brookfield and Village of Elm Grove, Wisconsin,* Donohue & Associates Inc., May 25, 1979.

   This study represents a refinement of the SEWRPC Menomonee River watershed study recommendations regarding the provision of a detention storage facility along the Dousman Ditch. It was recommended that two basins be provided in series, and that they be designed to retain the entire 100-year recurrence interval runoff volume from the tributary area with no significant discharge to downstream reaches during periods of flooding.

3. *Village of Elm Grove-Underwood Creek-Flood Study Summary Report*, Graef, Anhalt, Schloemer & Associates, November 1981.

   This report recommends implementation of the following flood control measures:

   - Construction of a new box culvert parallel to the existing Park and Shop enclosure.
   - Replacement of the bridges at Wall Street, Watertown Plank Road, the Villager apartments, the Sleepy Hollow Motel (two bridges), a private crossing, and at the entrance to the United Parcel Service facility.
   - Removal of the Yahr-Lange bridge, downstream from Wall Street.
   - Minor channel improvements

   The report also recommends that the Village consider construction of a box culvert along Underwood Creek, extending from Watertown Plank Road upstream to the Canadian Pacific Railway; a new culvert under the railroad tracks; modification of the Underwood Creek stream channel from the railroad tracks north to Juneau Boulevard; and replacement of the Juneau Boulevard bridge.

4. *A Stormwater Drainage and Flood Control System Plan for the Milwaukee Metropolitan Sewerage District*, SEWRPC Community Assistance Planning Report No. 52, December 1990

   The flood control recommendations for the Dousman Ditch and Underwood Creek subwatersheds as presented in this plan represent a refinement of those called for under the Menomonee River watershed study. This plan utilizes updated hydrologic and hydraulic data, takes into account the recommendations of the 1979 Dousman Ditch detention basin study, and develops refined recommendations for a two-basin detention facility and downstream structure floodproofing and elevation.

5. *A Regional Water Quality Management Plan for Southeastern Wisconsin: 2000*, Volume Three, *Recommended Plan*, SEWRPC Planning Report No. 30, June 1979.

   For the Dousman Ditch and Underwood Creek subwatersheds, this plan recommended the implementation of control measures to reduce urban nonpoint source pollutant loadings by 25 percent, along with construction erosion control, and streambank erosion control.

6. *A Nonpoint Source Control Plan for the Menomonee River Priority Watershed Project*,

Wisconsin Department of Natural Resources and Wisconsin Department of Agriculture, Trade, and Consumer Protection in cooperation with the Ozaukee, Washington, and Waukesha County Land Conservation Departments and the Menomonee River Advisory Subcommittee, March 1992.

The adopted regional water quality management plan recommends that local agencies charged with responsibility for nonpoint source pollution control prepare refined and detailed local-level nonpoint source pollution control plans. Such plans are to identify the nonpoint source pollution control practices that should be applied to specific lands. Working with the individual county land conservation committees and local units of government involved, as well as the Commission, the Wisconsin Department of Natural Resources is carrying out the recommended detailed planning for nonpoint source water pollution abatement on a watershed-by-watershed basis. The Menomonee River priority watershed study is one of the detailed plans resulting from that program.

The Menomonee River priority watershed study report includes an evaluation of surface water resources, water quality, and aquatic habitat conditions; development of water resource objectives; identification of nonpoint pollution sources and control needs; recommendations for an urban nonpoint source pollution control program; and a description of a program for implementation of the plan for the Menomonee River watershed.

The water resource-related objective established under the plan for Dousman Ditch and Underwood Creek is to enhance the existing biological and recreational uses. In the context of urban nonpoint source pollution control, the proposed means of attaining those objectives include a reduction in the quantities of sediment delivered from uplands and stream banks; control of construction erosion; a reduction in runoff pollution from the areas of existing critical urban development, which include high-density residential, commercial, industrial, and governmental and institutional land uses in the Underwood Creek subwatershed and commercial and governmental and institutional land uses in the Dousman Ditch subwatershed; and control of potential runoff pollution from areas of new urban development. Nonpoint source pollution control measures that were considered for the Dousman Ditch and Underwood Creek subwatersheds include source controls, wet detention, and street sweeping. In addition, streambank erosion controls were considered for the Underwood Creek subwatershed only.

7. *Final Report - Stormwater Management Guide - City of Brookfield*, Rust Environment & Infrastructure, October 3, 1995.

   This guide establishes the framework within which the City stormwater management program is to be conducted. The guide serves the following functions:

   a. Compares and contrasts past studies which established nonpoint source pollution reducion goals for the watersheds within the City.

   b. Provides background information on various stormwater management concepts and practices.

   c. Characterizes existing City programs related to stormwater management.

   d. Describes existing Federal, State, and local regulatory programs related to stormwater management.

   e. Summarizes the components of a possible future City stormwater management ordinance.

   f. Provides estimated costs and a time schedule for compliance with stormwater discharge application and permit process as mandated by the U.S. Environmental Protection Agency under the Federal Clean Water Act and as administered by the State of Wisconsin under Chapter NR 216 of the Wisconsin Administrative Code.

   g. Sets forth administrative approaches and funding opportunities, including the stormwater utility concept and the State of Wisconsin Local Assistance Grant and Nonpoint Source Cost-Sharing Grant programs.

   h. Identifies City stormwater management administrative and regulatory concerns.

i. Locates areas within the City where stormwater management problems have occurred.

j. Sets forth goals, objectives, and policies to direct the City stormwater management program.

k. Provides a schedule and estimated costs for implementation of the City program, including prioritization for the preparation of stormwater master plans such as that presented herein.

l. Makes recommendations regarding necessary actions in the areas of program administration, stormwater management system mapping, preparation of stormwater management plans, permitting actions under Chapter NR 216, and reducing the existing system maintenance and repair backlog.

In addition to these studies, hydrologic and hydraulic computations and reports prepared for individual recently-constructed or proposed land development projects in the City of Brookfield and the Village of Elm Grove were reviewed.

SUMMARY

The City of Brookfield and the Village of Elm Grove are located in the northeastern quadrant of Waukesha County. The subcontinental divide between the Lake Michigan and Mississippi River basins traverses the City of Brookfield in the manner shown on Map 1. Thus, about the eastern one-half of the City lies within the Menomonee River watershed and drains to Lake Michigan and the western one-half of the City lies within the Fox River watershed and drains, ultimately, to the Mississippi River. The entire Village of Elm Grove lies within the Menomonee River watershed. As shown on Map 1, the study area for this report is a 10.8-square-mile area of the Dousman Ditch and Underwood Creek subwatersheds.

The conversion of land in the Dousman Ditch and Underwood Creek subwatersheds from rural to urban use in the recent past, and the continuation of such conversion in the future may be expected to aggravate existing stormwater management and flooding problems and, in the absence of sound planning, create new problems. The need to resolve existing problems and to avoid the occurrence of new problems dictates the need to prepare a long-range stormwater and floodland management plan for the Dousman Ditch and Underwood Creek subwatersheds in the City of Brookfield and the Village of Elm Grove.

The plan presented in this report seeks to promote the development of an effective stormwater and floodland management system for the study area under full development conditions, which are anticipated to be attained by the year 2010. Such a system will minimize inconvenience and damage attendant to poor drainage and protect and enhance surface water quality and aquatic habitat.

More specifically, this report describes the existing stormwater and floodland management system and the existing problems of the study area, and identifies the causes of these problems; describes existing and planned future land use conditions and identifies related stormwater and floodland management requirements; provides a set of objectives and supporting standards to guide the development of an effective stormwater and floodland management system for the area; presents alternative stormwater and floodland management system plans for the Dousman Ditch and Underwood Creek subwatersheds; provides a comparative evaluation of the technical, economic, and environmental features of these plans; recommends a cost-effective plan for the two subwatersheds; and sets forth a plan implementation program.

The plan recognizes that good stormwater and floodland management is essential to the provision of an attractive and efficient, as well as safe and healthful, environment for urban life; and that inadequate stormwater drainage can be costly and disruptive, can create hazards to public health and safety, and can have adverse ecological and environmental impacts. Because of the technical complexity of the problem and the important social, economic, and environmental impacts involved, the plan recognizes that stormwater and floodland management planning must be based upon knowledge of the arts of urban planning and engineering and of the sciences of hydrology and hydraulics; an understanding of the social, economic, and environmental impacts involved; and information on the public attitudes toward stormwater and floodland management.

The basic concept underlying urban stormwater management has evolved from the original concept which sought to remove excess surface water during after a rainfall as quickly as possible through the provision of an efficient, constructed drainage system, to the current concept which emphasizes storage as well as conveyance of runoff while integrating constructed drainage facilities with the existing natural drainage system. The objectives of the current concept include reducing the peak rate of runoff and in some cases the total volume of runoff; reducing the transport of sediment and other water pollutants to receiving surface waters and wetlands; mitigating the adverse impacts of increased runoff and flow frequency on instream and riparian habitat; and protecting against increased downstream flooding.

The plan presented herein regards the stormwater runoff system of the area as consisting of a major element operating infrequently and a minor element operating frequently, with both of these elements incorporating, to the extent practicable, the storage as well as conveyance of excess runoff. The recommended stormwater and floodland management plan set forth herein incorporates compatible multi-use planning concepts and recognizes the opportunities provided as well as the constraints imposed by other community needs, such as park and open space, transportation, and water supply.

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Chapter II

INVENTORY AND ANALYSIS

INTRODUCTION

Information on certain pertinent natural and man-made features of the study area is essential to sound stormwater and floodland management planning. Accordingly, the collection and collation of definitive information on key hydrologic and hydraulic characteristics, on the existing stormwater management system, and on erosion and sedimentation characteristics constitute an important step in the stormwater and floodland management planning process. The resulting information is essential to the planning process, because sound alternative plans cannot be formulated and evaluated without an in-depth knowledge of the pertinent conditions in the planning area. This is particularly true for stormwater and floodland management, which must address the complex interaction of natural meteorologic events, key hydrologic and hydraulic characteristics of the planning area, and certain man-made physical systems.

This chapter presents data on 1) the hydrologic phenomena governing the magnitude and frequency of stormwater and flood flows; 2) existing stormwater drainage and flooding problems; 3) surface water quality conditions in the subwatersheds; 4) sources of pollution related to stormwater management; 5) the anticipated type, density, and spatial distribution of land uses in the study area; 6) the impact of the anticipated changes in land use on the stormwater and floodland management needs of the study area; 7) natural resource features of the study area; and 8) biological conditions.

STORMWATER MANAGEMENT STUDY AREA

Those portions of the Dousman Ditch and Underwood Creek subwatersheds within the City of Brookfield and the Village of Elm Grove constitute the study area for stormwater management planning as shown on Map 2 in Chapter I. The areal extent of the Dousman Ditch subwatershed is approximately 3.5 square miles and the Underwood Creek subwatershed is 7.3 square miles for a combined total of 10.8 square miles.

LAND USE

The Dousman Ditch and Underwood Creek stormwater and floodland management plan is intended to identify the stormwater and floodland management of the Dousman Ditch and Underwood Creek subwatersheds under existing and planned land use conditions and to propose the best means of meeting those needs. Accordingly, a buildout land use pattern was developed for these subwatersheds, based upon the Waukesha County development plan which was prepared by the Regional Planning Commission under a separate planning effort.[1]

The preliminary land use plan identifies a recommended land use pattern for buildout land use conditions, which are expected to be achieved by the year 2010, which can accommodate a resident population of about 4,513 persons in the Dousman Ditch subwatershed, and about 16,606 persons in the Underwood Creek subwatershed. This stormwater and floodland management plan is based upon buildout land use conditions.

The existing year 1990 land use pattern is shown on Map 2. The planned buildout land use pattern is shown on Map 3. The areal extent of the various existing and planned land uses within the subwatersheds are set forth in Table 1. As indicated in Table 1, in 1990 urban land uses occupied 1,569, or about 70 percent of the total area of the Dousman Ditch subwatershed, and 3,665 acres, or about 78 percent of the total area of the Brookfield and Elm Grove portion of the Underwood Creek subwatershed. About 238 acres of rural land, or about 11 percent of the Dousman Ditch subwatershed and about 370 acres of rural land, or about 8 percent of the Underwood Creek subwatershed, may be expected to be converted from rural to urban uses over the plan design period. This conversion would increase the

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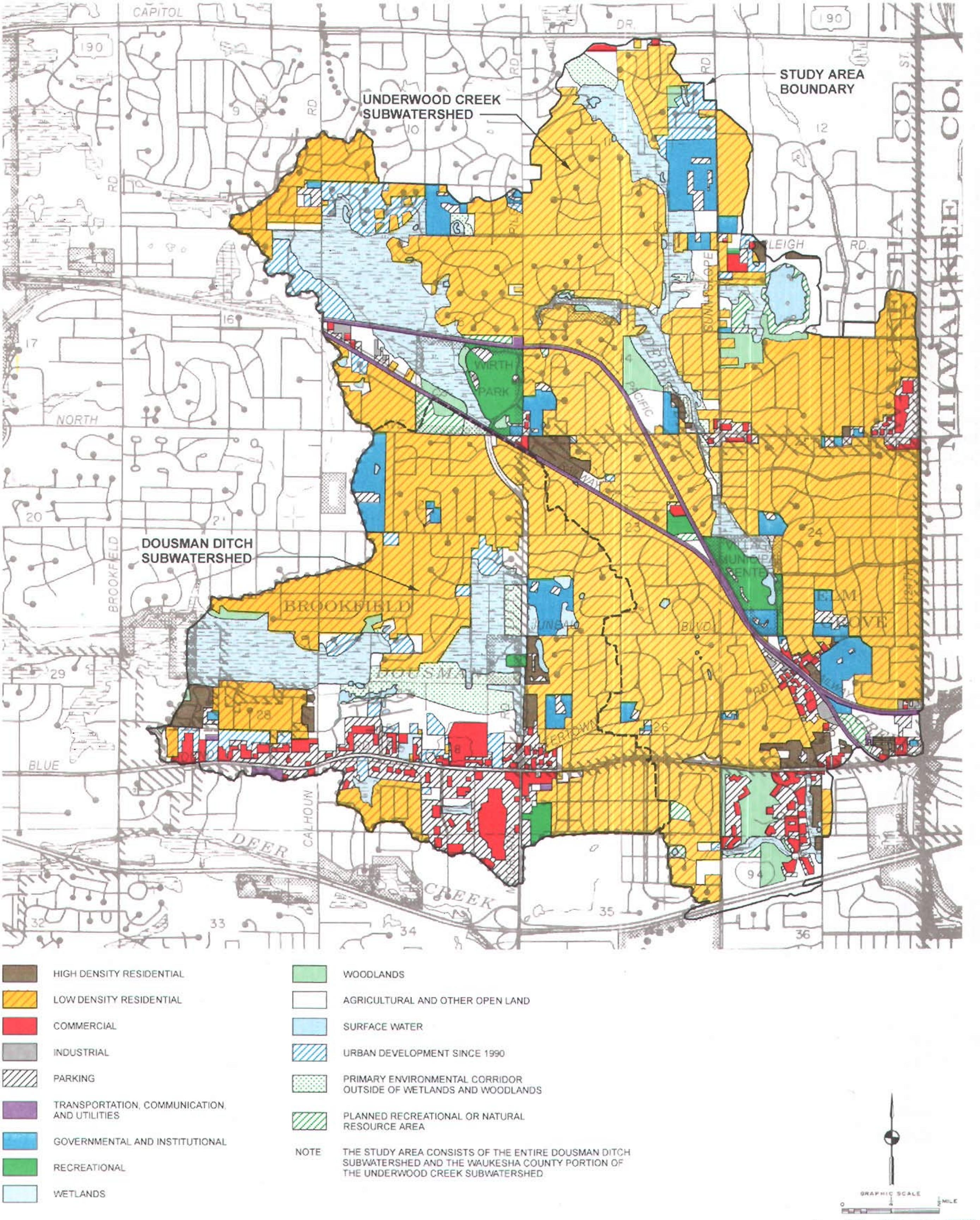
[1] *SEWRPC Community Assistance Planning Report No. 209,* A Development Plan for Waukesha County, Wisconsin, *August 1996.*

Map 2

EXISTING LAND USE IN THE DOUSMAN DITCH AND UNDERWOOD CREEK SUBWATERSHEDS IN THE CITY OF BROOKFIELD AND THE VILLAGE OF ELM GROVE

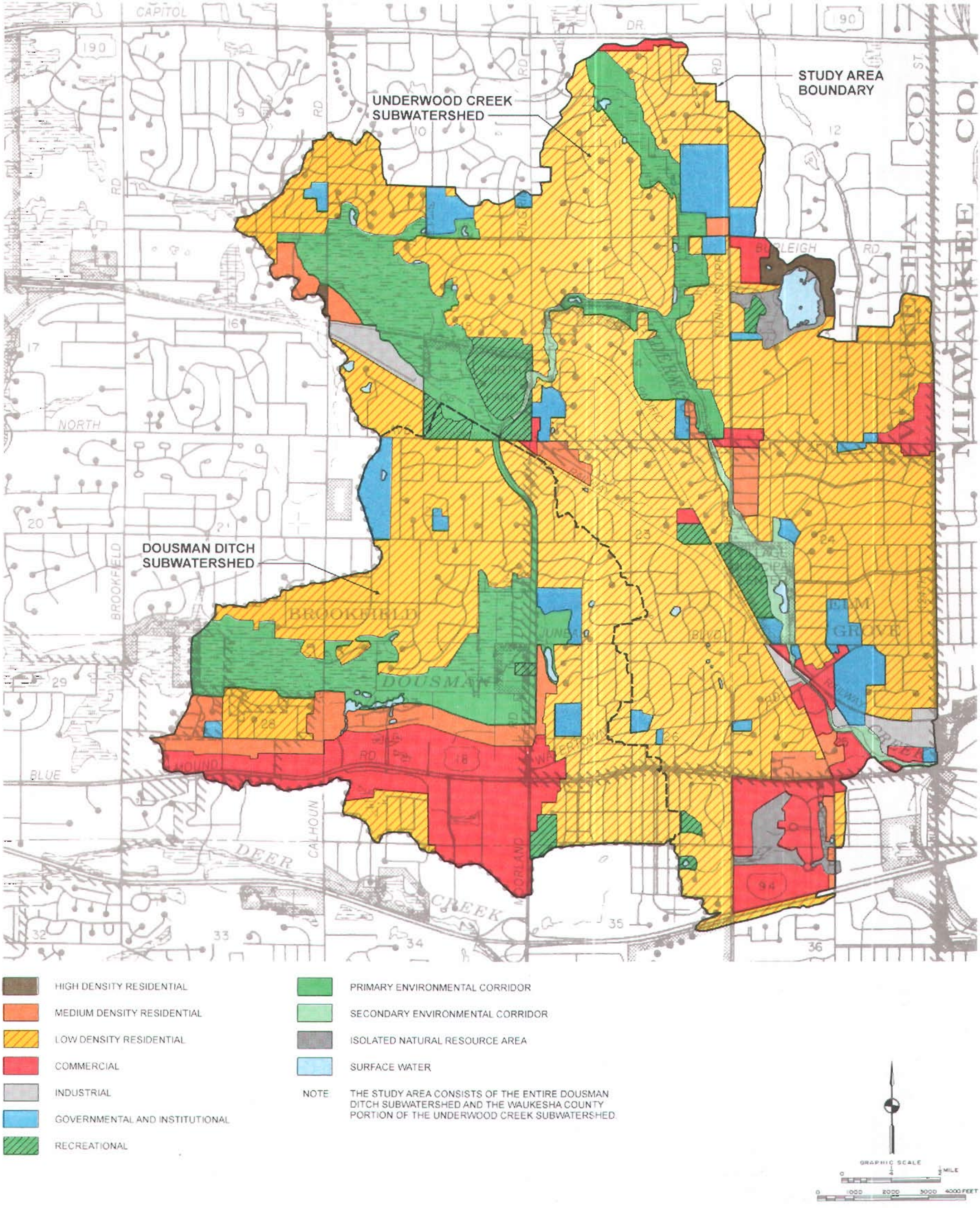


NOTE THE STUDY AREA CONSISTS OF THE ENTIRE DOUSMAN DITCH SUBWATERSHED AND THE WAUKESHA COUNTY PORTION OF THE UNDERWOOD CREEK SUBWATERSHED.

Source: SEWRPC.

Map 3

PLANNED BUILDOUT LAND USE FOR THE DOUSMAN DITCH AND UNDERWOOD CREEK SUBWATERSHEDS IN THE CITY OF BROOKFIELD AND THE VILLAGE OF ELM GROVE



NOTE: THE STUDY AREA CONSISTS OF THE ENTIRE DOUSMAN DITCH SUBWATERSHED AND THE WAUKESHA COUNTY PORTION OF THE UNDERWOOD CREEK SUBWATERSHED.

Source: SEWRPC.

Table 1

EXISTING AND PROBABLE FUTURE LAND USE IN THE DOUSMAN DITCH AND UNDERWOOD CREEK SUBWATERSHEDS: 1990 AND BUILDOUT

Land Use Category	Existing 1990		Planned Increment		Buildout Total	
	Acres	Percent of Total	Acres	Percent of Total	Acres	Percent of Total
Dousman Ditch Subwatershed						
Urban						
Residential	943	42.3	165	17.6	1,108	49.7
Commercial	288	12.9	62	21.4	350	15.7
Industrial	0	0.0	0	0.0	0	0.0
Governmental and Institutional	87	3.9	7	8.1	94	4.2
Transportation, Communication, and Utilities	232	10.4	-13	-5.8	219	9.8
Recreational	19	0.9	17	89.6	36	1.6
Subtotal	1,569	70.4	238	15.2	1,807	81.0
Rural						
Woodlands	28	1.3	0	0.0	28	1.3
Wetlands	271	12.2	0	0.0	271	12.2
Surface Water	9	0.4	0	0.0	9	0.4
Agricultural and Other Open Lands	351	15.7	-238	-67.9	113	5.1
Subtotal	659	29.6	-238	-36.1	421	19.0
Total	2,228	100.0	- -	- -	2,228	100.0
Underwood Creek Subwatershed						
Urban						
Residential	2,514	53.7	300	11.9	2,813	60.1
Commercial	176	3.8	52	29.8	228	4.9
Industrial	20	0.4	0	0.0	20	0.4
Governmental and Institutional	198	4.2	0	0.1	198	4.2
Transportation, Communication, and Utilities	637	13.6	0	0.0	637	13.6
Recreational	120	2.6	18	14.9	139	3.0
Subtotal	3,665	78.3	370	10.1	4,035	86.2
Rural						
Woodlands	119	2.6	-20	-17.2	99	2.1
Wetlands	439	9.4	0	0.0	439	9.4
Surface Water	42	0.9	0	0.0	42	0.9
Agricultural and Other Open Lands	412	8.8	-350	-84.8	63	1.4
Subtotal	1,012	21.7	-370	-36.5	643	13.8
Total	4,677	100.0	- -	- -	4,678	100.0

Source: SEWRPC.

amount of land in urban use within the Dousman Ditch subwatershed by about 15 percent, and about 10 percent within the Underwood Creek subwatershed. Of the total area to be converted within the Dousman Ditch subwatershed, about 165 acres, or 70 percent, would be converted to residential use, and about 72 acres, or 30 percent, to other urban uses. Within the Underwood Creek subwatershed, the area converted to residential use would be about 300 acres, or about 81 percent, with the remaining 70 acres or about 19 percent utilized for other urban uses.

As indicated in Table 1, under planned buildout land use conditions, urban land uses would occupy 1,807 acres, or about 81 percent of the total area of the Dousman Ditch subwatershed, and 4,035 acres, or about 86 percent of the total area of the Underwood Creek subwatershed.[2] Residential uses would occupy about 1,108 acres, or about 50 percent of the Dousman Ditch subwatershed, and about 2,813 acres, or about 60 percent within the Underwood Creek subwatershed; the remaining urban land uses, such as commercial, industrial, transportation, communication and utilities, governmental and institutional, and recreational, would occupy about 31 percent for the Dousman Ditch subwatershed and about 26 percent within the Underwood Creek subwatershed. Under planned ultimate land use conditions, rural land uses would still be expected to account for about 421 acres, or about 19 percent of the total area of the Dousman Ditch subwatershed, and about 643 acres, or about 14 percent within the Underwood Creek subwatershed. In the Dousman Ditch subwatershed, woodlands would occupy 28 acres, or about 7 percent, of the rural land; agricultural and other open lands about 113 acres, or about 27 percent; and wetlands and open water about 280 acres, or about 66 percent. Within the Underwood Creek subwatershed, woodlands would occupy about 99 acres, or about 15 percent, of the rural land; agricultural and other open lands 63 acres, or about 10 percent; and other rural land uses, including wetlands and open water, about 481 acres, or about 75 percent.

Because of the direct relationships which exist between resident population levels and land use patterns, an evaluation of the historic and probable future resident population levels in the Dousman Ditch and Underwood Creek subwatersheds was made as a part of the stormwater management and flood control planning effort. As indicated in Table 2, from 1970 to 1980 the resident population of the Dousman Ditch subwatershed decreased by about 20 percent, from about 4,900 to about 3,900 persons. From 1980 to 1990, the resident population of that subwatershed increased by about 6 percent, to about 4,200 persons. Forecasts of population growth to the year 2010 indicate that the population of this subwatershed may be expected to increase to about 4,500 persons, an increase of about 300 persons, or about 7 percent, over the 1990 population level. Also indicated in Table 2, from 1970 to 1980, the resident population of the Underwood Creek subwatershed decreased by about 14 percent, from about 20,400 to about 17,500 persons. From 1980 to 1990, the resident population of that subwatershed again decreased by about 5 percent to about 16,600 persons. The population growth to the year 2010 is projected to remain stable at about the 1990 population level. A graphic comparison of historical, existing, and forecast population levels for these subwatersheds, Waukesha County, and the Southeastern Wisconsin Region is provided in Figure 1.

Within the Dousman Ditch subwatershed, the planned year 2010 resident population level of about 4,500 persons, assuming a household size of 2.8 persons per housing unit, would result in the need for approximately 1,607 housing units. Such housing units, if uniformly distributed over the 1,108 acres of residential land anticipated to be within the subwatershed by the design year 2010, would result in a density of approximately 1.5 housing units per net residential acre. For the Underwood Creek subwatershed, if the planned year 2010 resident population was about 16,600 persons, than this would result in the need for approximately 5,929 housing units. If these housing units were distributed uniformly over the 2,813 acres of residential land, than this would result in a density of approximately 2.1 housing units per net residential acre.

LAND USE REGULATIONS

Pertinent land use regulations in the subwatershed include zoning and land subdivision control ordinances. Comprehensive zoning represents one of the most important tools available to local units of government for controlling the use of land in the public interest, and such zoning has important implications for stormwater management.

The zoning and subdivision control ordinances for the City of Brookfield and the Village of Elm Grove serve to regulate the type, location, and intensity of the various land uses, and the improvements provided for new urban development. These ordinances regulate aspects of development which influence both the amount and rate of stormwater runoff, and the quality of that runoff. For example, the size of lots and the placement and size of structures on them, as regulated by the zoning ordinances, affect the proportion of the land surface covered by impervious surfaces. Generally, as imperviousness increases, the rate and volume of stormwater runoff increase while the quality

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[2] *Much of the anticipated conversion of land from rural to urban had occurred as of 1999.*

Table 2

HISTORIC AND PROBABLE FUTURE RESIDENT POPULATION LEVELS FOR THE SOUTHEASTERN WISCONSIN REGION, WAUKESHA COUNTY, AND THE DOUSMAN DITCH AND UNDERWOOD CREEK SUBWATERSHEDS

	Southeastern Wisconsin Region		Waukesha County		City of Brookfield		Village of Elm Grove		Dousman Ditch Subwatershed		Underwood Creek Subwatershed	
Year	Population	Percent Change	Population	Percent Change	Population	Percent Change	Population	Percent Change	Population	Percent Change	Population	Percent Change
1900	501,808	- -	35,229	- -	- -	- -	- -	- -	- -	- -	- -	- -
1910	631,161	25.8	37,100	5.3	- -	- -	- -	- -	- -	- -	- -	- -
1920	783,681	24.2	42,612	14.9	- -	- -	- -	- -	- -	- -	- -	- -
1930	1,006,118	28.4	52,358	22.9	- -	- -	- -	- -	- -	- -	- -	- -
1940	1,067,699	6.1	62,744	19.8	- -	- -	- -	- -	- -	- -	- -	- -
1950	1,240,618	16.2	85,901	36.9	- -	- -	- -	- -	- -	- -	- -	- -
1960	1,573,614	26.8	158,249	84.2	19,812[a]	- -	4,994[a]	- -	- -	- -	- -	- -
1970	1,756,083	11.6	231,335	46.2	31,761	60.3	7,201	44.2	4,954	- -	20,443	- -
1980	1,764,919	0.5	280,326	21.2	34,035	7.2	6,375	-6.5	3,952	-20.2	17,509	-14.3
1990	1,742,742	-1.3	285,904	2.0	35,184	3.4	6,621	-7.0	4,213	6.2	16,606	-5.2
2010	1,872,200[b]	7.4	364,300	27.4	38,810	10.3	5,960	-9.0	4,513	7.1	16,606	0.0

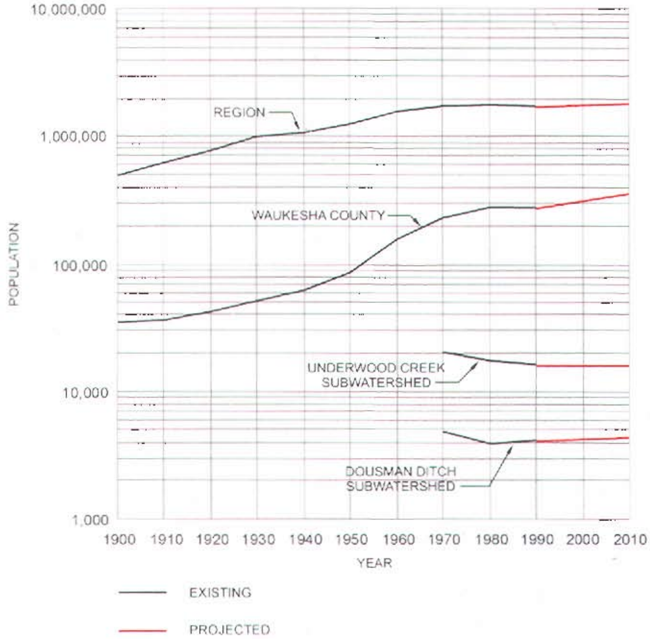
[a] *Represents 1963 population levels as determined by the 1963 SEWRPC origin-destination travel survey.*

[b] *Intermediate population growth scenario.*

Source: U.S. Bureau of the Census, Wisconsin Department of Administration, and SEWRPC.

Figure 1

COMPARISON OF HISTORICAL, EXISTING, AND FORECAST POPULATION TRENDS FOR THE SOUTHEASTERN WISCONSIN REGION, WAUKESHA COUNTY, AND THE DOUSMAN DITCH AND UNDERWOOD CREEK SUBWATERSHEDS



Source: SEWRPC.

of the runoff decreases. The type and design of the stormwater drainage system, as regulated by the subdivision control ordinances, also affect the quantity and quality of stormwater runoff. For example, stormsewered urban areas usually generate higher runoff rates and amounts, and a lower runoff quality, than do areas drained by vegetated open channels.

IMPACT OF CHANGING LAND USE ON SUBWATERSHED STORMWATER MANAGEMENT SYSTEMS

Land use and cover in the study area markedly influence the stormwater runoff process. Land cover differs from land use in that it describes a type of surface: roofed, paved, grassed, or wooded, for example; land use describes the function or activity served: residential, commercial, or recreational, for example. Table 3 lists the ranges of surface imperviousness for various land and land cover conditions.

Increases in rates and volumes of runoff due to the conversion of land from rural to urban use can increase bank erosion and bed scour in receiving streams. In addition, increased imperviousness in areas of groundwater recharge may cause a reduction in stream base flow. Stormwater runoff from urban lands also carries

Table 3

RANGE OF SURFACE IMPERVIOUSNESS FOR LAND USE AND LAND COVER CONDITIONS

Description	Range of Percent Imperviousness	Typical Corresponding Land Use/Cover Combinations
Rural	0-8	Agricultural lands, woodlands, wetlands, and unused lands
Low Imperviousness	9-20	Low-density residential with supporting urban uses and associated land cover
Low to Medium Imperviousness	21-33	Low- to medium-density residential with supporting urban uses and associated land cover
Medium Imperviousness	34-45	Medium-density residential with supporting urban uses and associated land cover
High Imperviousness	46-65	High-density residential with supporting urban uses and associated land cover
Very High Imperviousness	66-100	Commercial and industrial and associated land cover

Source: SEWRPC.

different types and increased amounts of pollutants compared to runoff from rural lands.

The stormwater management and flood control system of a watershed should serve to support the existing, and promote the planned, land use pattern of the watershed. Therefore, consideration of both the existing and probable land use pattern of the watershed is necessary for the development of effective alternative stormwater and floodland management plans and for the selection of a recommended plan.

CLIMATE

Air temperatures and the type, intensity, and duration of precipitation affect the extent of areas subject to inundation and the type and magnitude of stormwater and flooding problems within the subwatershed. Both subwatersheds have the typical continental-type climate, characterized primarily by a continuous progression of markedly different seasons and a wide range in monthly temperatures. The subwatersheds lie in the path of both low pressure storm centers moving from the west and southwest and high pressure fair weather centers moving in a generally southeasterly direction. The confluence of these air masses results in frequent weather changes, particularly during spring and winter. These temporal weather changes consist of marked variations in temperature, precipitation, relative humidity, wind speed and direction, and cloud cover. The meteorologic events influence the rate and amount of stormwater runoff, the severity of storm drainage problems, and the required capacities of stormwater conveyance and storage facilities. Definitive, long-term meteorologic data are available for the Milwaukee National Weather Service station, at Mitchell International Airport in reasonable proximity to the Dousman Ditch and Underwood Creek subwatersheds.

Temperature and Seasonal Considerations

Air temperatures, which exhibit a wide monthly range, determine whether precipitation occurs as rainfall or snowfall; whether or not the ground is frozen and therefore essentially impervious; and the rate of snowmelt and attendant runoff. Table 4 presents average monthly air temperature variations for the Milwaukee National Weather Service Station for the 35-year period from 1951 through 1985. Summer temperatures, as measured by the monthly means for June, July, and August, average from 65°F to 70°F. Winter temperatures, as measured by the monthly means for December, January, and February, average from 19°F to 25°F. For the period 1871 through 1988 at Milwaukee, the maximum recorded temperature was

Table 4

AVERAGE MONTHLY AIR TEMPERATURE AT MILWAUKEE: 1951 THROUGH 1985

Month	Average Daily Maximum (°F)	Average Daily Minimum (°F)	Mean (°F)
January	25.9	11.2	18.6
February	30.5	16.2	23.4
March	39.5	25.1	32.3
April	53.5	35.7	44.6
May	64.8	44.7	54.8
June	74.9	54.8	64.9
July	79.2	61.3	70.3
August	78.4	60.4	69.4
September	71.1	52.6	61.9
October	59.8	42.0	50.9
November	44.8	30.0	37.4
December	31.8	17.9	24.9
Annual	54.5	34.7	46.1

Source: National Weather Service and SEWRPC.

Table 5

AVERAGE MONTHLY TOTAL PRECIPITATION AND SNOW AND SLEET AT MILWAUKEE: 1951 THROUGH 1985

Month	Average Total Precipitation (inches)	Average Snow and Sleet (inches)
January	1.60	12.8
February	1.39	10.4
March	2.61	10.0
April	3.49	2.3
May	2.81	Trace
June	3.43	0.0
July	3.47	0.0
August	3.15	0.0
September	2.89	Trace
October	2.48	0.2
November	2.32	3.1
December	2.17	11.4
Annual	31.81	50.2

Source: National Weather Service and SEWRPC.

105°F in July 1934, and the lowest recorded temperature was -26°F in January 1982. The growing season, which is defined as the number of days between the last 32°F temperature reading in spring and the first in fall, averages about 180 days for the subwatershed. The last frost in spring normally occurs near the end of April, whereas the first freeze in fall usually occurs during the latter half of October. Streams, ponds, and lakes begin to freeze over in late November; ice breakup usually occurs in late March or early April. Ice jams at bridges in spring can be a cause of localized flooding, which can be severe when combined with spring rainfall.

Precipitation

Precipitation within the subwatershed takes the form of rain, sleet, hail, and snow, ranging from gentle showers of trace quantities to brief, but intense and potentially destructive, thunderstorms or major rainfall-snowmelt events. These may cause property damage, inundation of poorly drained areas, stream flooding, street and basement flooding, and severe soil erosion and sedimentation. Average monthly and annual total precipitation and snowfall data from the Milwaukee National Weather Service station at Mitchell International Airport for the period 1951 through 1985 are presented in Table 5. The average annual total precipitation in the Dousman Ditch and Underwood Creek subwatersheds based on the Milwaukee National Weather Service station data is 31.81 inches, expressed as water equivalent, while the average annual snowfall and sleetfall measured as snow and sleet is 50.2 inches. Assuming that 10 inches of measured snowfall and sleetfall are equivalent to one inch of water, the average annual snowfall of 50.2 inches is equivalent to 5.02 inches of water and, therefore, only about 16 percent of the average annual total precipitation occurs as snowfall and sleet. Average total monthly precipitation ranges from 1.39 inches in February to 3.49 inches in April. The principal snowfall months are December, January, February, and March, during which 89 percent of the average annual snowfall may be expected to occur.

An important consideration in stormwater drainage is the seasonal nature of precipitation patterns. Based on historical observations, flooding in the Dousman Ditch and Underwood Creek subwatersheds is likely to occur at any time throughout the year except during winter. This is because the drainage area is relatively small and flood peaks are influenced by the effects of poorly drained soils and urban development. The relatively large proportions of poorly to very poorly drained soils, along with impervious surfaces in urban areas, inhibit

Table 6

EXTREME PRECIPITATION EVENTS FOR SELECTED LONG-TERM STATIONS NEAR THE DOUSMAN DITCH AND UNDERWOOD CREEK SUBWATERSHEDS

Observation Station		Period of Precipitation Records	Total Precipitation (water equivalent, inches)							
			Maximum Annual		Minimum Annual		Maximum Monthly		Maximum Daily	
Name	County		Amount	Year	Amount	Year	Amount	Date	Amount	Date
Milwaukee	Milwaukee	1870-1992	50.36	1876	18.69	1901	10.03	June 1917	6.84[a]	August 6, 1986
Waukesha	Waukesha	1892-1992	43.57	1938	17.30	1901	11.41	July 1952	5.09	July 18, 1952

Observation Station		Period of Precipitation Records	Snowfall (inches)							
			Maximum Annual		Minimum Annual		Maximum Monthly		Maximum Daily	
Name	County		Amount	Year	Amount	Year	Amount	Date	Amount	Date
Milwaukee	Milwaukee	1870-1992	109.0[b]	1885-1886	11.0[b]	1884-1885	52.6	January 1918	20.3[c]	February 4-5, 1924
Waukesha	Waukesha	1892-1992	83.0[d]	1917-1918	9.1	1967-1968	56.0	January 1918	20.0[c]	January 5-6, 1918

[a] *Maximum precipitation for a 24-hour period.*

[b] *Maximum and minimum snowfalls for a winter season.*

[c] *Maximum snowfall for a 24-hour period.*

[d] *Estimated from incomplete records.*

Source: U.S. Department of Commerce, National Weather Service, Wisconsin Statistical Reporting Service, and SEWRPC.

infiltration. This increases surface runoff during even minor rainfall events. Because the dampening effects of infiltration, including leaf interception during summer months, are diminished in urban areas, the annual distribution of flood events in urbanized watersheds is similar to the annual distribution of significant rainfall events, and significant flood events may be expected to occur during spring, summer, and fall.

Extreme precipitation data for southeastern Wisconsin, based on observations for stations located throughout the Region that have relatively long periods of record, are presented in Table 6. The minimum annual precipitation within southeastern Wisconsin, as determined from the tabulated data for the indicated observation period, occurred at Waukesha in 1901, when only 17.30 inches of precipitation occurred, or 54 percent of the average annual precipitation of 31.81 inches for southeastern Wisconsin. The maximum annual precipitation within southeastern Wisconsin occurred at Milwaukee in 1876, when 50.36 inches of precipitation was recorded, equivalent to 158 percent of the average annual precipitation.

Based on a period of record from 1870 through 1992 at General Mitchell Field, the minimum annual precipitation was 18.69 inches, reported in 1901; the maximum annual precipitation was 50.36 inches, reported in 1876. The maximum monthly precipitation was 10.03 inches, recorded in June 1917; the maximum 24-hour precipitation was 6.84 inches, recorded on August 6, 1986. Based on a period of record from 1870 through 1992, the maximum and minimum annual snowfall amounts were 109.0 inches in 1885-86 and 11.0 inches in 1884-85.

Snow Cover and Frost Depth

The likelihood of snow cover and the depth of snow on the ground are important precipitation-related factors that influence the planning, design, construction, and maintenance of stormwater management and flood control facilities. Snow cover in the Dousman Ditch and Underwood Creek subwatersheds is most likely during the months of December, January, and February, when at least a 0.5 probability exists of having one inch or more of snow cover. The amount of snow cover influences the severity of spring snowmelt-rainfall flood events, which usually occur during March.

The depth and duration of ground frost, or frozen ground, influences hydrologic processes, particularly such factors as the proportion of rainfall or snowmelt that will run off the land directly into storm sewerage systems and surface watercourses. The amount of snow cover is an important determinant of frost depth. Since the thermal conductivity of snow cover is less than one-fifth that of moist soil, heat loss from the soil to the colder atmosphere is greatly inhibited by the insulating snow cover. Frozen ground is likely to exist throughout the study area for approximately four months each winter season, from late November through March, with frost penetration to a depth ranging from six inches to more than four feet occurring in January, February, and the first half of March.

SOILS

Soil properties are an important factor influencing the rate and amount of stormwater runoff from land surfaces. The type of soil is also an important consideration in the evaluation of shallow groundwater aquifer recharge and stormwater retention, detention, and infiltration facilities. The soil characteristics, the slope, and vegetative cover of the land surface also affect the degree of soil erosion which occurs during runoff events.

In order to assess the significance of the diverse soils found in southeastern Wisconsin, the Southeastern Wisconsin Regional Planning Commission negotiated a cooperative agreement with the U.S. Soil Conservation Service in 1963 under which detailed operational soil surveys were completed for the entire Region. The results of the soil surveys have been published in SEWRPC Planning Report No. 8, *Soils of Southeastern Wisconsin.* The regional soil surveys have resulted in the mapping the Region's soils in great detail. At the same time, the surveys have provided data on the physical, chemical, and biological properties of the soils, and, more importantly, have provided interpretations of the soil properties for planning, engineering, agricultural, and resource conservation purposes, and for underlying stormwater management purposes. Detailed soils maps of the study area are available for use in stormwater management planning.

With respect to watershed hydrology, the most significant soil interpretation for stormwater management is the categorization of soils into hydrologic soil groups A, B, C, and D. In terms of runoff characteristics, these four hydrologic soil groups are defined as follows:

- Hydrologic Soil Group A: Very little runoff because of high infiltration capacity, high permeability, and good drainage.
- Hydrologic Soil Group B: Moderate amounts of runoff because of moderate infiltration capacity, moderate permeability, and good drainage.
- Hydrologic Soil Group C: Large amounts of runoff because of low infiltration capacity, low permeability, and poor drainage.
- Hydrologic Soil Group D: Very large amounts of runoff because of very low infiltration capacity, low permeability, and extremely poor drainage.

The spatial distribution of the hydrologic soil groups within the Dousman Ditch and Underwood Creek subwatersheds is shown on Map 4. Only groups B, C, and D occur in the study area, with the poorly to extremely poorly drained soils in groups C and D covering about 90 percent of the area and group B soils and disturbed and unclassified soils covering the remainder.

BEDROCK

Bedrock formations underlying the study area generally lie at a depth of 50 to 200 feet below the surface of the Dousman Ditch and Underwood Creek subwatersheds, with overlying unconsolidated glacial deposits. It is not anticipated that bedrock would be encountered during construction of stormwater management facilities.

STORMWATER MANAGEMENT AND FLOOD CONTROL SYSTEM

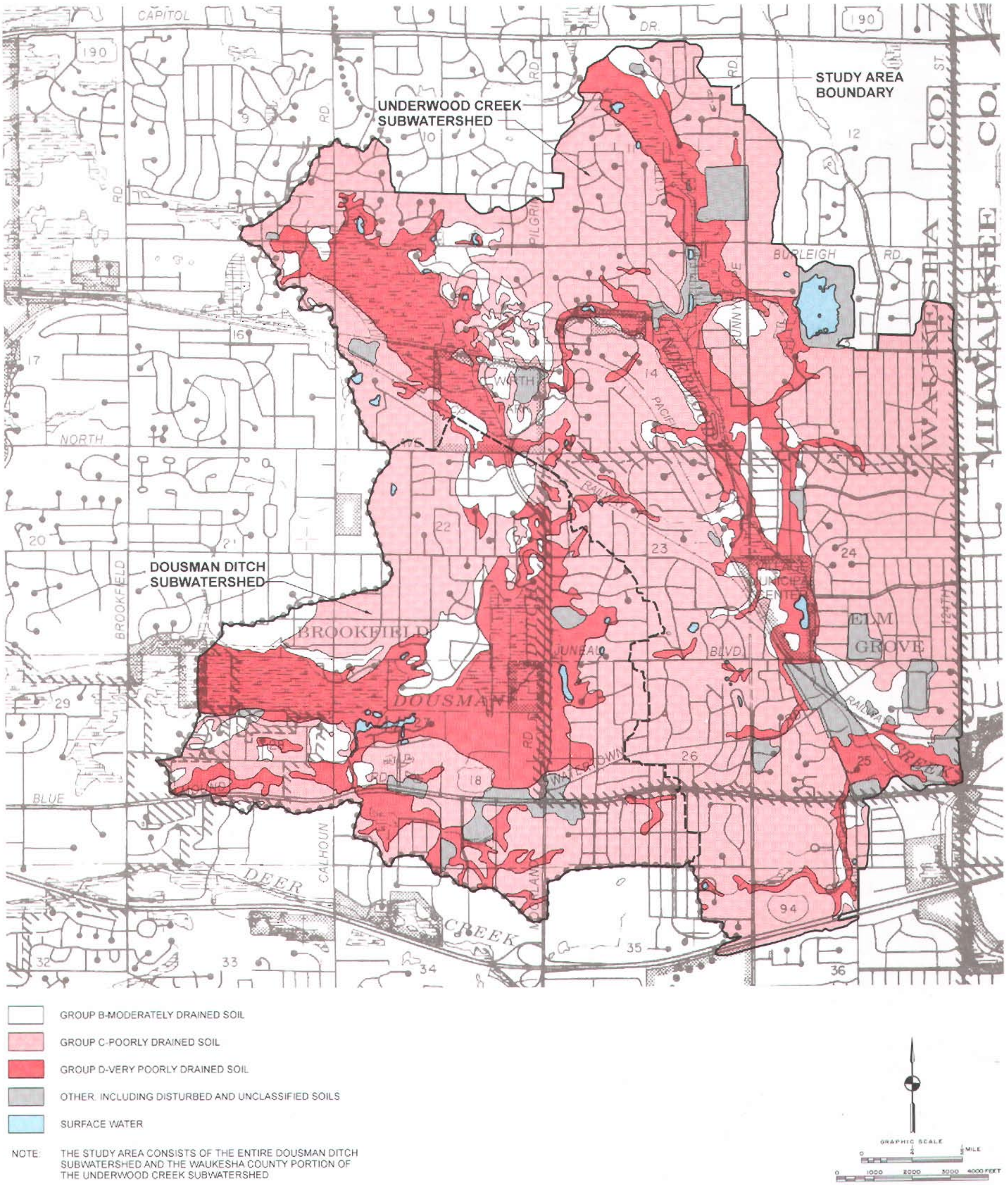
The existing stormwater management and flood control system serving the study area consists of the streams and watercourses of the area together with certain constructed drainage facilities. The performance of this system is influenced by, among other factors, study area topography and the location and extent of the tributary drainage areas, as well as by the characteristics of the streams and watercourses and related man-made drainage facilities.

Topography

Topography, or the relative elevation of the land surface in the study area, is one of the most important

Map 4

HYDROLOGIC SOIL GROUPS IN THE DOUSMAN DITCH AND UNDERWOOD CREEK STUDY AREA



NOTE: THE STUDY AREA CONSISTS OF THE ENTIRE DOUSMAN DITCH SUBWATERSHED AND THE WAUKESHA COUNTY PORTION OF THE UNDERWOOD CREEK SUBWATERSHED

Source: SEWRPC.

considerations in the planning and design of a stormwater management system. Surface topography of the land defines drainage areas, influences the rate and magnitude of surface water runoff and soil erosion, and determines both the uses to which the land can be put and related stormwater management needs.

Large-scale topographic maps of the entire City of Brookfield and Village of Elm Grove, were prepared in 1986 by Waukesha County and the Regional Planning Commission to Commission specifications at a scale of one inch equals 200 feet with contours at two-foot intervals.[3] The large-scale topographic maps and monumented control survey network which resulted from the mapping program has permanent utility for the administration of the Federal flood insurance program at the local level and for all types of municipal planning and engineering work.

The elevation of the Dousman Ditch subwatershed ranges from a low of about 820 feet above National Geodetic Vertical Datum (NGVD) in the southeast one-half of U.S. Public Land Survey Section 22, Township 7 North, Range 20 East, along Dousman Ditch itself, to a high of about 940 feet NGVD in the southeast one-quarter of U.S. Public Land Survey Section 21, Township 7 North, Range 20 East. The elevation of the Underwood Creek subwatershed ranges from a low of about 720 feet above NGVD in the southeast one-quarter of U.S. Public Land Survey Section 25, Township 7 North, Range 20 East, at the Waukesha-Milwaukee county line, to a high of about 890 feet above NGVD in the southeast one-quarter, and southwest one-quarter of U.S. Public Land Survey Sections 10 and 15, respectively, Township 7 North, Range 20 East. Land surface slopes in the Dousman Ditch subwatershed range from a low of about 1 percent along Dousman Ditch, to a high of about 30 percent near the subcontinental divide. Within the Underwood Creek subwatershed, slopes range from a low of less than 1 percent along Underwood Creek at the Waukesha-Milwaukee county line, to a high of about 12 percent in the northwestern portion of the subwatershed, along the subcontinental divide. In general, areas with slopes greater than 12 percent have severe limitations for urban residential development and, if developed, present serious potential drainage and erosion problems.

Hydrologic Units and Subbasins

For stormwater management planning purposes, each subwatershed was divided into smaller basic hydrologic units that were further divided into subbasins, as shown on Map 12 in Chapter V. The hydrologic units generally encompass the area draining to one of the streams tributary to Dousman Ditch or Underwood Creek, or the area draining to a storm sewer outfall to the Ditch or Creek. The delineation of these areas permits a more accurate representation of the watershed hydrology in the computer models used to simulate stormwater runoff.

A number of considerations entered into the delineation of the subbasins. Using the 1986 large-scale topographic maps, the subbasins were delineated so as to provide desired areas above discharge points at confluences of drainage channels, tributaries, and the main stem; at, or near, bridges and culverts; and at selected storm sewer inlets and outlets.

Within the Dousman Ditch subwatershed, there are 201 subbasins, with an average size of 11 acres, while in the Underwood Creek subwatershed, there are 404 subbasins, with an average size of 12 acres.

Streams, Drainage Channels, Storm Sewers, and Ponds

Perennial streams are watercourses which maintain a continuous flow throughout the year. Intermittent streams are those watercourses which do not sustain continuous flow during dry periods.

Perennial streams in the subwatersheds include Dousman Ditch, Underwood Creek, the North Branch of Underwood Creek, and several unnamed tributaries to Dousman Ditch. The perennial and intermittent streams in the subwatershed receive runoff from storm sewers, culverts, roadside swales, drainageways, and drainage ditches. All known perennial and intermittent streams and ponds in the study area are shown on Map 5.

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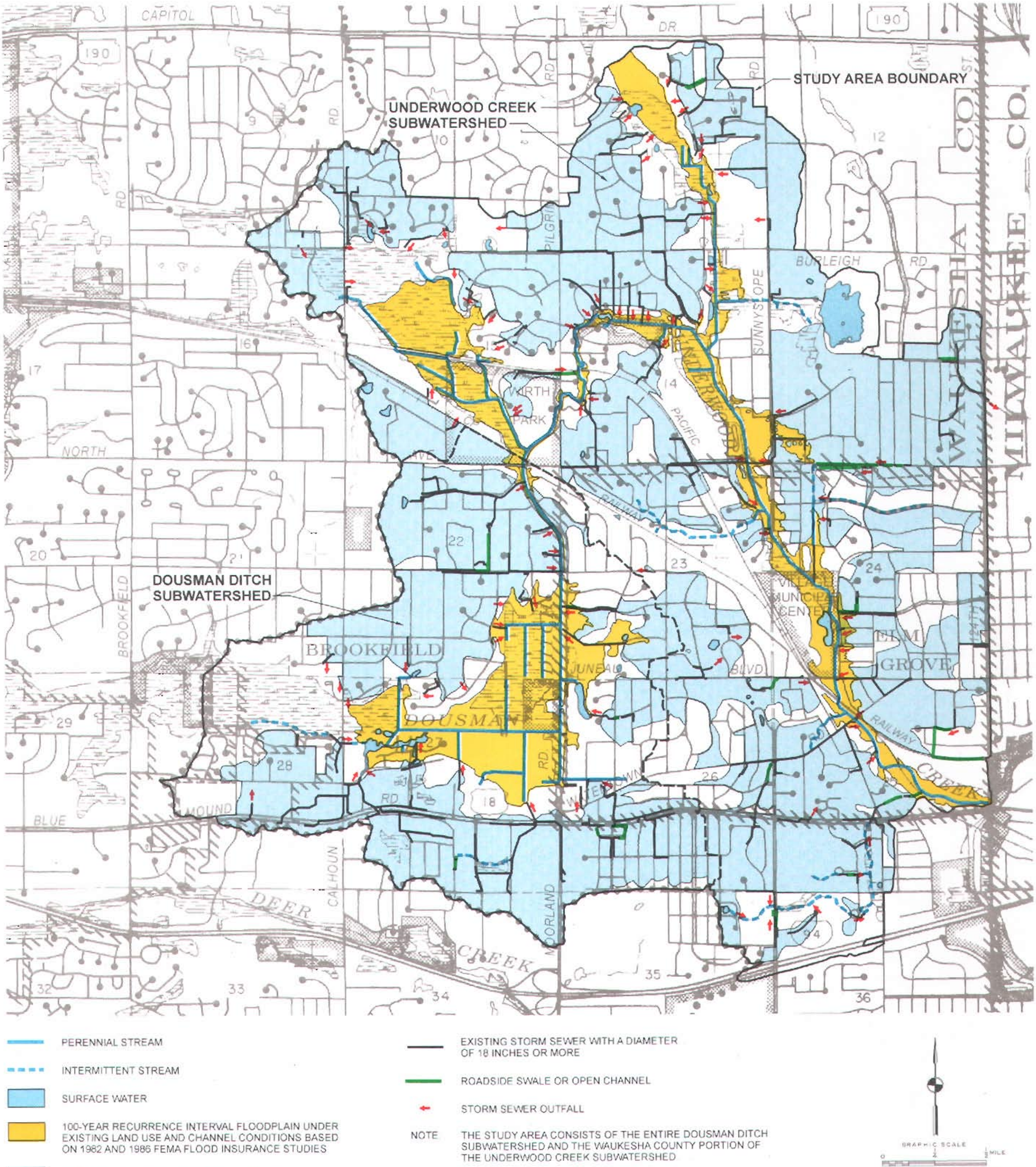
[3] *In 1998, new large-scale topographic maps were prepared by the County and the Commission at a scale of one inch equals 100 feet with contours at two-foot intervals. Preliminary draft copies of those maps were available in 1999. Although the hydrologic and hydraulic analyses for the stormwater management plan primarily used data from the 1986 maps, the 1998 maps were consulted during the final stages of the analyses.*

Map 5

SELECTED CHARACTERISTICS OF THE SURFACE WATER DRAINAGE SYSTEM IN THE DOUSMAN DITCH AND UNDERWOOD CREEK SUBWATERSHEDS IN THE CITY OF BROOKFIELD AND THE VILLAGE OF ELM GROVE: 1996



Source: City of Brookfield, Village of Elm Grove, and SEWRPC.

Constructed stormwater drainage facilities within the Dousman Ditch and Underwood Creek subwatersheds, defined as constructed channels or roadside swales, storm sewers and appurtenances, and ditch enclosures, as opposed to natural watercourses, have a combined service area of about half of the total study area.

The constructed stormwater drainage systems are maintained by the Public Works Departments of the City of Brookfield and the Village of Elm Grove. Maintenance activities include sewer inspection; sewer, culvert, catch basin, and channel cleaning; and minor repair work on sewers, manholes, catch basins, and inlets.

Both the City of Brookfield and the Village of Elm Grove are in the process of adopting stormwater management ordinances that regulate stormwater runoff from new urban development and redevelopment. Prior to adoption of the ordinances, stormwater management requirements for new development or redevelopment were applied on a case-by-case basis. The ordinances are being adopted pursuant to the communities' State stormwater discharge permit applications that were submitted in February of 2000.

Wetlands

Wetlands are natural areas in which the groundwater table lies near, at, or above the surface of the ground, and which support certain types of vegetation. Wetlands are usually covered by organic soils, silts, and marl deposits. Wetlands provide valuable ecological habitats and stabilize streamflows by storing peak discharges and releasing water during low-flow conditions. Wetlands also have important recreational, educational, and aesthetic values.

A sound stormwater and floodland management plan should, to the extent practicable, utilize the stormwater storage capacity of any existing natural wetlands, while preserving the quality of the wetlands. Thus, wetland preservation is an integral part of this plan. Wetlands in the study area were identified in a special inventory conducted by the Commission using aerial photographic interpretation and field inspection supplemented by analysis of mapped soil data. The location and extent of wetlands in the subwatershed are shown on Map 2 and quantified in Table 1. In 1990, there were approximately 271 acres of wetlands in the Dousman Ditch subwatershed, and 439 acres in the Underwood Creek subwatershed comprising about 12 percent and 9 percent of the areas, respectively. Those areas should remain the same under build-out conditions.

Navigability Assessment for Streams in the Dousman Ditch and Underwood Creek Subwatersheds

Reasons for the Determination of Navigability

The Wisconsin Department of Natural Resources (WDNR) and the U.S. Army Corps of Engineers (USCOE) have authority to regulate wetlands and waterways. Regulatory actions of the WDNR relative to waters of the State are carried out pursuant to authority granted in Chapters 30 and 31 of the *Wisconsin Statutes*. The USCOE has similar authority relative to waters of the United States.

As set forth in Chapters 30 and 31, the following activities of possible interest relative to stormwater and floodland management planning require a determination of navigability in order to ascertain whether the activity requires a permit from the State of Wisconsin:

- Construction, dredging, or enlargement of any artificial waterway, canal, channel, ditch lagoon, pond, lake, or similar waterway where the purpose is ultimate connection with existing navigable waters.
- Connecting any artificial waterway, canal, channel, ditch lagoon, pond, lake, or similar waterway with an existing body of navigable water.
- Grading or removing topsoil from the bank of any navigable waterbody where the area exposed by such grading or soil removal will exceed 10,000 square feet.
- Straightening or changing the course of any navigable stream.
- Enclosure of navigable waters in a drain, conduit, storm sewer, or similar structure.
- Construction of private bridges.
- Placement of any structure on the bed of a navigable waterway.
- Placement of riprap to prevent erosion of the bed or bank of a navigable waterway.

- Construction of a dam in a navigable waterway.

In addition, as described below, navigability determinations affect the delineation of the boundaries of the shoreland zone and, therefore, the designation of shoreland wetlands.

Two activities in waterways that are regulated under Chapter 30, regardless of the whether the waterbody in question is navigable, are:

- Removal of material from the bed of any lake or stream.

- Diversion of water from a stream.

Regulations Governing Shoreland Wetlands in Southeastern Wisconsin

The shoreland wetland areas of the Southeastern Wisconsin Region are regulated by Counties pursuant to Chapter NR 115 of the *Wisconsin Administrative Code*, and by Cities and Villages pursuant to Chapter NR 117 of the *Wisconsin Administrative Code.* Wetlands regulated pursuant to Chapters NR 115 and NR 117 of the *Wisconsin Administrative Code* are those wetlands of five or more acres in areal extent, located within the shoreland zone. The shoreland zone is the area located within 300 feet of the ordinary high water mark of a navigable stream, or within 1,000 feet of the ordinary high water mark of a lake, pond, or flowage, or within the 100-year recurrence interval floodplain of the navigable stream, lake, pond, or flowage, whichever is greater. These shoreland-wetland rules are administered through local zoning ordinances and overseen by the WDNR. In addition, the U.S. Army Corps of Engineers has authority over wetland filling activities. Pursuant to the provisions of Chapter NR 103 of the *Wisconsin Administrative Code*, which establishes water quality standards for wetlands, the WDNR must grant Water Quality Certification before a USCOE wetland permit is considered to be valid.

Determination of Navigability

Provisions set forth in the Northwest Ordinance of 1787, and reflected in the Wisconsin Constitution of 1848, declare the navigable waters of the State to be public waters that the public has a right to use and enjoy. The criteria for determining navigability having been refined over the years by decisions rendered by the Wisconsin Supreme Court. Natural streams are considered to be navigable if they contain a defined bed and bank, present evidence of an ordinary high water mark, and demonstrate an ability to float a small watercraft on a recurring basis, even if this is only once a year or during periods of high water.

Nonnatural or artificial waters may also be considered navigable under specific circumstances. Thus, impoundments or flowages on navigable streams may be considered navigable. Artificial channels used to drain water from agricultural lands—so-called farm drainage ditches—such as some channels tributary to the upper reaches of Dousman Ditch, are not considered navigable, unless and until there is a change in adjacent land use from agricultural to an urban use, or it can be shown that the ditches were navigable streams prior to ditching. Likewise, artificial ponds constructed prior to 1988 may be considered navigable dependent upon whether the pond is directly or ultimately connected to an existing navigable waterway, whether the physical connection is above or below the ordinary high water mark of an existing navigable waterway, and whether the pond is within 500 feet of an existing navigable waterway. Artificial ponds constructed during or after 1988 are public only if they are expressly made public through the permitting process administered by the WDNR and set forth in Chapter 30 of the *Wisconsin Statutes.*

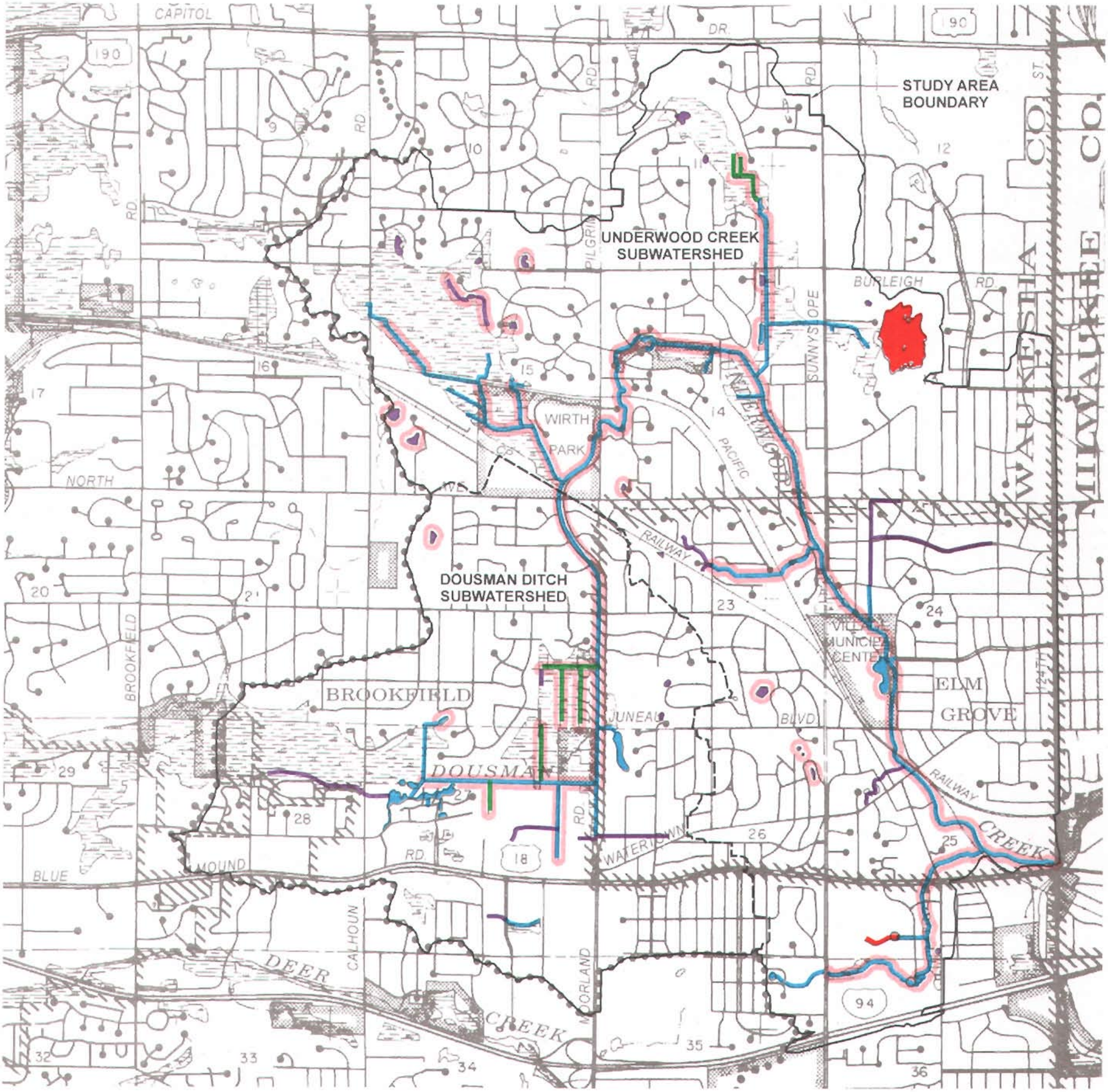
The ordinary high water mark separates the area wherein public rights of navigation may be exercised from the area wherein private rights apply. The ordinary high water mark is defined as that point on a bank or shoreline where the water, by its presence, wave action or flow, leaves a distinct mark on the bank or shoreline. This mark may be indicated by erosion, changes in vegetation, or other, easily recognizable characteristic. With few exceptions, public rights prevail over private rights below the ordinary high water mark. The WDNR has responsibility for determining the location of the ordinary high water mark.

Navigability Determination within the Dousman Ditch and Underwood Creek Watershed

Map 6 sets forth a summary of navigability determinations recently conducted within the Dousman Ditch and Underwood Creek drainage area by the staffs of the WDNR, Regional Planning Commission, and City of Brookfield. These determinations were based upon the identification and verification of the channel configurations of the perennial and intermittent streams within the study area, using the U.S. Geological Survey base maps compiled in 1959 with revisions in 1971 at a scale of one inch equals 2,000 feet and the Commission's 1995 one inch equals 400 feet scale

Map 6

STATUS OF STREAM NAVIGABILITY DETERMINATIONS IN THE STUDY AREA: 1999



🟦 NAVIGABLE AS IDENTIFIED BY WDNR STAFF OR AS DESIGNATED BY A CHAPTER 30 PERMIT

🟥 NONNAVIGABLE PRIVATE WATER BODIES

🟩 NONNAVIGABLE AGRICULTURAL DITCHES (COULD BECOME NAVIGABLE AT THE TIME OF CONVERSION TO NONAGRICULTURAL USE)

🟪 NAVIGABILITY STATUS UNDETERMINED, WOULD BE DETERMINED BY WDNR STAFF ON A CASE-BY-CASE BASIS

▨ WATER BODIES AND PERENNIAL AND INTERMITTENT STREAMS IDENTIFIED ON THE U.S. GEOLOGICAL SURVEY 7.5-MINUTE QUADRANGLE MAPS COMPILED IN 1959 AND REVISED IN 1971

NOTE: THE STUDY AREA CONSISTS OF THE ENTIRE DOUSMAN DITCH SUBWATERSHED AND THE WAUKESHA COUNTY PORTION OF THE UNDERWOOD CREEK SUBWATERSHED.

Source: Wisconsin Department of Natural Resources and SEWRPC.

digital orthophotographs. Those waterways previously determined to be navigable were identified by the Commission staff based upon information from the WDNR files maintained by the Division of Water Regulation and Zoning in the Southeast Region. Historical aerial photographs were used to establish the approximate years of construction of several ponds identified within the study area. These inventories were confirmed during a joint field reconnaissance conducted on April 29, 1999, by WDNR, Commission, and City of Brookfield staffs. As shown on Map 6, four principal categories of waterway were identified, including 1) navigable waters, 2) nonnavigable waters, 3) agricultural ditches, and 4) those waters for which navigability could not be determined. This latter category included several ponds, located throughout the watershed, which could not be accessed during the field survey.

Map 6 provides a basis from which a preliminary determination of jurisdiction pursuant to shoreland wetland and floodland permitting requirements may be made by the City of Brookfield, Village of Elm Grove, WDNR, and U.S. Army Corps of Engineers. The ultimate determination of jurisdiction remains a site-specific action to be undertaken by the WDNR pursuant to the procedures set forth in Chapter 30 of the *Wisconsin Statutes.* The navigability classifications set forth on the map are not all-inclusive and the navigability status of waterways may change over time based on changing site conditions.

Bridges, Culverts, and Other Structures

Bridges and culverts significantly influence the hydraulic behavior of a stream system. Constrictions caused by bridges and culverts can, during storm events, result in backwater effects, thereby creating a floodland storage area upstream of the structure that is larger than that which would exist in the absence of the bridge or culvert. Depending on the character of the upstream lands, the floodland area may be a valuable flood storage zone if open lands are inundated or it may be a flooding problem area if structures and roads are flooded. Thus, if restrictive bridges or culverts do not contribute to the creation of an upstream flood and hazard and if the associated roadway meets established standards relative to the frequency of overtopping during floods, replacement with a larger structure may not be desirable. Such replacement could create new downstream flooding problems, or exacerbate existing problems, by reducing the available flood storage volume and increasing downstream flood flows and stages.

Table 7 provides information on the size and types of bridges and culverts along Dousman Ditch, Underwood Creek, the North Branch of Underwood Creek, and their tributaries.

Flood Discharges and Natural Floodlands

Floodlands in Wisconsin are regulated pursuant to Chapter NR 116 of the *Wisconsin Administrative Code.* The provisions of Chapter NR 116 require counties, cities, and villages to regulate activities within the area along a stream that is estimated to be inundated by runoff arising from a one in 100-year recurrence interval flood. Floodland regulations are set forth in local zoning ordinances. The WDNR has oversight authority relative to the administration of the local floodland zoning ordinances.

As stated in Chapter I of this report, flood insurance studies were prepared for the City of Brookfield and the Village of Elm Grove, including Dousman Ditch and Underwood Creek, by the Federal Emergency Management Agency as documented in the August 1986 *Flood Insurance Study for the City of Brookfield, Waukesha County, Wisconsin,* and the January 1982 *Flood Insurance Study for the Village of Elm Grove, Waukesha County, Wisconsin.*

The flood flows developed for those studies were reviewed and updated for the floodland management element of this study. Chapter VI of this report presents refined estimates of the flood flows under planned land use and existing and planned channel conditions.

The Federal flood insurance study reports include flood insurance rate maps which show the expected elevations of the base 100-year flood and the attendant flood hazard areas. Map 5 shows the flood hazard areas as delineated in the Federal flood studies.

STORMWATER DRAINAGE AND FLOODING PROBLEMS

Stormwater Drainage Problems

Generalized areas with known existing drainage problems as identified by the staffs of the City of Brookfield and the Village of Elm Grove are shown on Map 7. Existing stormwater drainage problems are described in detail in Chapter V of this report.

The identified existing and potential drainage problems were considered in the evaluation of the existing stormwater drainage system and in the design of alternative stormwater and floodland management system

Table 7

STRUCTURE INFORMATION FOR UNDERWOOD CREEK, DOUSMAN DITCH, AND TRIBUTARIES

Structure Number	Structure Identification	U. S. Public Land Survey Section	Structure Type and Size	Structure Length (feet)	Upstream Invert Elevation (feet NGVD)	Downstream Invert Elevation (feet NGVD)
			Underwood Creek			
1230	United Parcel Service bridge	NE 1/4, SE 1/4, Section 25	Double 12.0-foot-wide by 7.9-foot-high structural plate pipe arch	50.6	715.6	715.6
1232	Pedestrian bridge	NE 1/4, SE 1/4, Section 25	64.4-foot-wide wood bridge	10.0	715.4	715.4
1240	Private bridge	NE 1/4, SE 1/4, Section 25	22.0-foot-wide concrete bridge	23.8	716.5	716.5
1245	Private bridge	NE 1/4, SE 1/4, Section 25	22.0-foot-wide concrete bridge	23.8	717.4	717.4
1250	Private bridge	NE 1/4, SE 1/4, Section 25	35.5-foot-wide concrete bridge	21.4	718.3	718.3
1255	Private bridge	NW 1/4, SE 1/4, Section 25	28.0-foot-wide concrete bridge	15.0	720.6	720.6
1260	Canadian Pacific Railway	SW 1/4, NE 1/4, Section 25	40.7-foot-wide, three-span concrete bridge	13.3	725.1	725.1
1265	Private bridge	SW 1/4, NE 1/4, Section 25	23.0-foot-wide concrete bridge	15.4	727.8	727.8
1270	Wall Street	SE 1/4, NW 1/4, Section 25	28.0-foot-wide concrete bridge	28.3	729.5	729.5
1271	Elm Grove shopping Center Enclosure	NE 1/4, NW 1/4, Section 25	22.0-foot-wide by 6.2-foot-high box culvert	570.0	732.4	730.0
1275	W. Watertown Plank Road	NE 1/4, NW 1/4, Section 25	24.0-foot-wide by 8.8-foot-high box culvert	66.6	731.7	731.7
1276	Private bridge	NE 1/4, NW 1/4, Section 25	22.0-foot-wide by 8.0-foot-high box culvert	100.0	733.9	733.4
1280	Private bridge	NE 1/4, NW 1/4, Section 25	20.0-foot-wide concrete bridge	30.0	733.2	732.1
1290	Canadian Pacific Railway	NE 1/4, NW 1/4, Section 25	26.0-foot-wide, two-span concrete bridge	28.4	734.2	734.2
1295	Juneau Boulevard	SE 1/4, SW 1/4, Section 24	20.0-foot-wide concrete bridge	33.0	735.3	735.2
1300	Village Hall bridge	SE 1/4, SW 1/4, Section 24	29.0-foot-wide concrete bridge	28.0	736.7	736.7
1305	Marcella Avenue	SE 1/4, NE 1/4, Section 23	Four 9.6-foot-wide by 4.8-foot-high corrugated metal arch	30.5	741.7	741.6
1310	North Avenue	SE 1/4, SE 1/4, Section 25	29.0-foot-wide concrete bridge	63.4	744.7	744.7
1313	Private Drive	SW 1/4, NE 1/4, Section 14	Four 5.0-foot-diameter and double 4.0-foot-diameter corrugated metal pipe	28.0	749.3[a]	749.3[a]
1315	Clearwater Road	SW 1/4, NE 1/4, Section 14	Four 4.5-foot-diameter corrugated metal pipe	40.0	750.0	750.3
1320	Santa Maria Court	SW 1/4, NW 1/4, Section 14	32.5-foot-wide, two-span concrete bridge	38.0	762.9	762.9
1325	Woodbridge Road	SW 1/4, NW 1/4, Section 14	12.0-foot-wide concrete bridge	31.0	777.3	777.3

Table 7 (continued)

Structure Number	Structure Identification	U. S. Public Land Survey Section	Structure Type and Size	Structure Length (feet)	Upstream Invert Elevation (feet NGVD)	Downstream Invert Elevation (feet NGVD)
1330	Indian Creek Parkway	SW 1/4, NW 1/4, Section 14	11.6-foot-wide by 7.4-foot-high structural plate pipe-arch	34.8	786.7	786.7
1335	Canadian Pacific Railway	NW 1/4, SW 1/4, Section 14	10.0-foot-wide arch stone bridge	54.0	794.4	794.4
1339	Private bridge	NW 1/4, SW 1/4, Section 14	9.0-foot-wide concrete bridge	12.0	801.3	801.3
1345	Private bridge	NW 1/4, SW 1/4, Section 14	8.0-foot-wide concrete bridge	17.0	811.6	811.6
1350	Pilgrim Parkway	NE 1/4, SE 1/4, Section 15	16.0-foot-wide concrete bridge	28.0	814.8	814.8
1353	Wirth Park bridge	NW 1/4, SE 1/4, Section 15	3.5-foot-diameter corrugated metal pipe	22.0	819.1	818.6
1355	Canadian Pacific Railway	SE 1/4, NW 1/4, Section 15	18-inch-diameter reinforced concrete pipe	30.0	823.3	823.3
1355A	Canadian Pacific Railway[b]	NW 1/4, SE 1/4, Section 15	36-inch-diameter reinforced concrete pipe	40.0	821.0	820.8
Dousman Ditch						
1355B	Canadian Pacific Railway	SE 1/4, SE 1/4, Section 15	35.0-foot-wide, two-span concrete bridge	13.0	815.6	815.6
1360	North Avenue	SE 1/4, SE 1/4, Section 15	Triple 8.0-foot-diameter reinforced concrete pipe	130.0	816.4	814.7
1370	Gebhardt Road	SE 1/4, NE 1/4, Section 22	44.0-foot-wide concrete bridge	46.4	818.3	818.3
1372	Private Drive	NE 1/4, NE 1/4, Section 27	13.8-foot-wide concrete bridge	20.0	820.0	820.0
1376	Field Crossing	NE 1/4, NE 1/4, Section 27	5.0-foot-diameter corrugated metal pipe and 4.2-foot-wide by 2.6-foot-high corrugated metal pipe arch	18.0	821.8	821.8
1377	Field Crossing	SW 1/4, NE 1/4, Section 27	3.0-foot-diameter corrugated metal pipe and 4.5-foot-wide by 3.4-foot-high corrugated metal pipe arch	21.0	823.4	823.4
1380	Private Drive	SW 1/4, NW 1/4, Section 27	Triple 5.5-foot-diameter corrugated metal pipe	32.0	824.4	824.2
North Branch of Underwood Creek						
NBUC1	Burleigh Road	NW 1/4, NE 1/4, Section 14	4.8-foot-wide by 3.0-foot-high corrugated metal pipe arch	60.0	751.8	751.6
Bishops Woods Tributary						
BWTRIB1	Canadian Pacific Railway	NW 1/4, SE 1/4, Section 25	8.2-foot-wide by 5.8-foot-high structural plate pipe arch	62.0	726.1	725.3
BWTRIB2	Apartments Parking Lot Enclosure	NW 1/4, SE 1/4, Section 25	8.2-foot-wide by 5.2-foot-high horizontal elliptical reinforced concrete pipe	253.0	729.7	727.4
BWTRIB3	Private Drive	NW 1/4, SE 1/4, Section 25	8.2-foot-wide by 5.2-foot-high horizontal elliptical reinforced concrete pipe	39.0	731.0	730.2
BWTRIB4	Elm Grove Storm Sewer-East pipe	NE 1/4, SW 1/4, Section 25	8.2-foot-wide by 5.2-foot-high horizontal elliptical reinforced concrete pipe	300.0	742.3	736.4

Table 7 (continued)

Structure Number	Structure Identification	U. S. Public Land Survey Section	Structure Type and Size	Structure Length (feet)	Upstream Invert Elevation (feet NGVD)	Downstream Invert Elevation (feet NGVD)
BWTRIB5	Elm Grove Storm Sewer-West pipe	NE 1/4, SW 1/4, Section 25	6.0-foot-diameter reinforced concrete pipe	200.0	746.2	742.3
BWTRIB6	Blue Mound Road	NE 1/4, SW 1/4, Section 25	Double 4.5-foot-diameter reinforced concrete pipe	170.0	748.0	746.2
BWTRIB7	Bishops Lane	SE 1/4, SW 1/4, Section 25	Double 6.0-foot-wide by 3.7-foot-high corrugated metal pipe	36.0	760.5	760.0
BWTRIB8	Bishops Way	NE 1/4, NW 1/4, Section 36	Double 6.0-foot-wide by 3.7-foot-high corrugated metal pipe	220.0	800.0	795.0
BWTRIB9	Sunny slope Road	NW 1/4, NW 1/4, Section 36	3.5-foot-wide by 2.4-foot-high corrugated metal pipe	70.0	853.6	850.3
BWTRIB1 0	Indian Ridge Drive	NE 1/4, NE 1/4, Section 35	3.6-foot-wide by 2.3-foot-high corrugated metal pipe	80.0	872.6	871.9
Lilly Road Tributary						
LRTRIB1	Lilly Road	NE 1/4, NE 1/4, Section 14	5.3-foot-wide by 3.6-foot-high corrugated metal pipe arch	60.0	756.0	755.5
Woodlawn Circle Tributary						
WCTRIB1	Park Drive	SW 1/4, SW 1/4, Section 24	18-inch-diameter corrugated metal pipe	83.0	747.5	745.6
WCTRIB2	Canadian Pacific Railway-East track	NW 1/4, SW 1/4, Section 24	Double 4.0-foot-diameter reinforced concrete pipe	37.0	760.0	759.5
WCTRIB3	Canadian Pacific Railway-West track	NE 1/4, SE 1/4, Section 23	8.0-foot-wide by 3.5-foot-high box culvert	34.0	766.6	766.2
WCTRIB4	Woodlawn Circle	SE 1/4, SE 1/4, Section 23	30-inch-diameter corrugated metal pipe	94.0	775.0	772.7
WCTRIB5	Hillside Road	SE 1/4, SE 1/4, Section 23	30-inch-diameter corrugated metal pipe	40.0	781.0	779.5
WCTRIB6	Rock Court	SE 1/4, SE 1/4, Section 23	30-inch-diameter corrugated metal pipe	42.0	794.9	793.7
Wrayburn Tributary						
WRTRIB1	Wrayburn Road	NW 1/4, NW 1/4, Section 24	Double 4.0-foot-wide by 2.8-foot-high corrugated metal pipe arch	46.0	745.3	745.1
WRTRIB2	Hollyhock Lane	NW 1/4, NW 1/4, Section 24	Double 4.0-foot-wide by 2.8-foot-high corrugated metal pipe arch	180.0	747.4	746.5
WRTRIB3	Arrowhead Court	NE 1/4, NW 1/4, Section 24	Double 4.0-foot-wide by 2.8-foot-high corrugated metal pipe arch	50.0	757.4	756.8
WRTRIB4	Crossing between Arrowhead Court and Fairhaven Boulevard	NW 1/4, NE 1/4, Section 24	4.0-foot-wide by 2.8-foot-high corrugated metal pipe arch	46.0	762.7	762.5

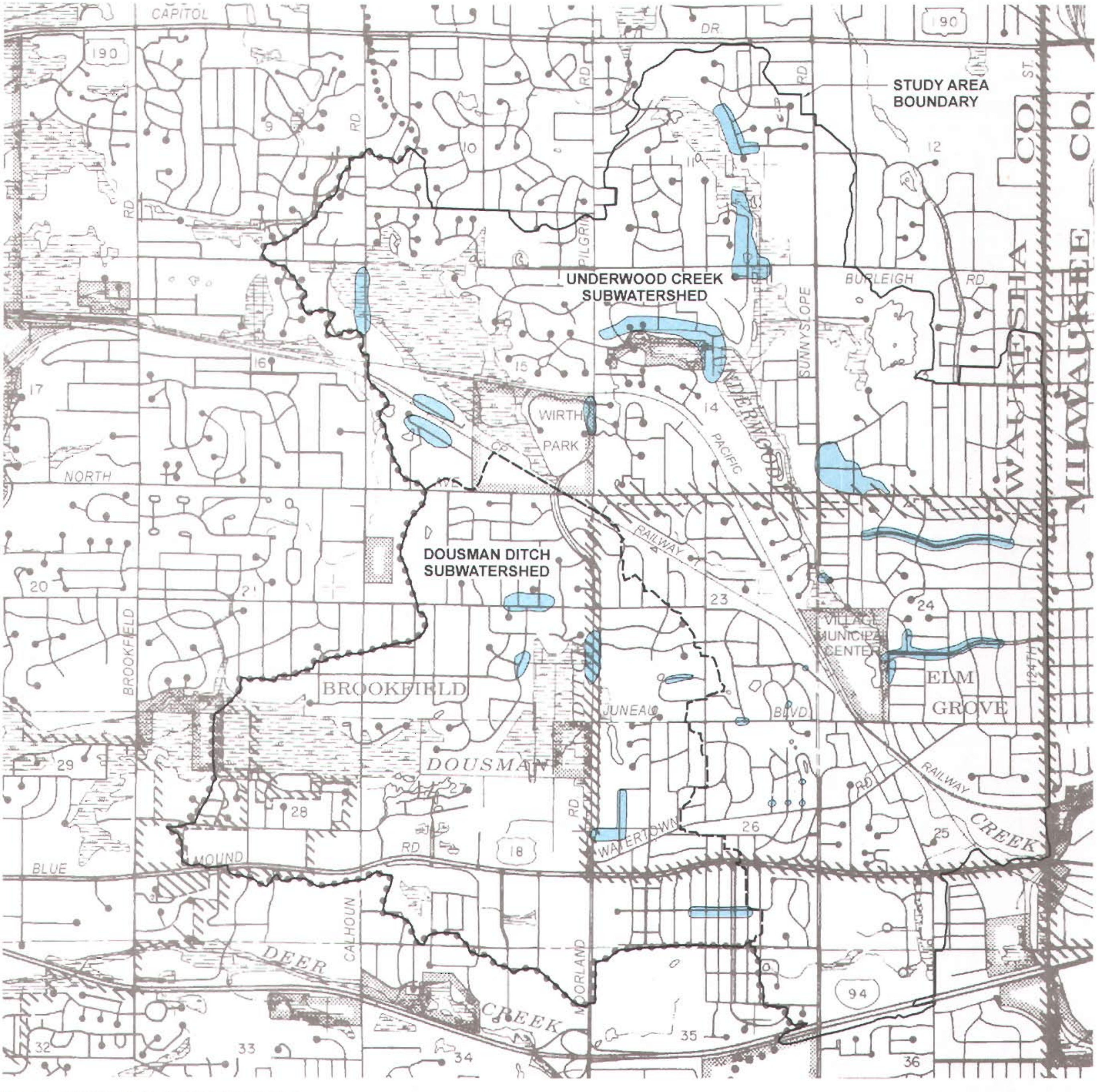
[a] *These are the invert elevations of the two 4.0-foot diameter corrugated metal pipes, which are set lower than the four 5.0-foot diameter corrugated metal pipes.*

[b] *Structure is located east of the Canadian Pacific Railway crossing of Underwood Creek.*

Source: SEWRPC.

Map 7

EXISTING GENERALIZED STORMWATER DRAINAGE AND FLOODING PROBLEM AREAS THE UNDERWOOD CREEK AND DOUSMAN DITCH SUBWATERSHEDS IN THE CITY OF BROOKFIELD AND THE VILLAGE OF ELM GROVE



▭ STORMWATER DRAINAGE AND/OR FLOODING PROBLEM AREA AS REPORTED BY CITY OR VILLAGE

NOTE: THE STUDY AREA CONSISTS OF THE ENTIRE DOUSMAN DITCH SUBWATERSHED AND THE WAUKESHA COUNTY PORTION OF THE UNDERWOOD CREEK SUBWATERSHED.

IN ADDITION TO THE AREAS INDICATED ON THIS MAP, EXTENSIVE FLOODING HAS OCCURRED ALONG UNDERWOOD CREEK IN THE VILLAGE OF ELM GROVE AND IN THE CITY OF BROOKFIELD UPSTREAM OF W. NORTH AVENUE. SEE CHAPTER V AND MAPS 14 THROUGH 18 OF THIS REPORT FOR ADDITIONAL INFORMATION ON STORMWATER DRAINAGE AND FLOODING PROBLEMS.

GRAPHIC SCALE
0 ½ 1 MILE
0 1000 2000 3000 4000 FEET

Source: City of Brookfield, Village of Elm Grove, and SEWRPC.

plans. Those plans are thus intended to abate stormwater drainage and flooding problems during storms with recurrence intervals up to, and including, 100 years. Because the June 1997 and August 1998 storms described in Chapter V had recurrence intervals in excess of 100 years and because localized drainage system inadequacies, electrical power outages, and sanitary sewer infiltration contributed to flooding problems during those storms, the recommended measures would not completely eliminate all problems experienced during such storms. However, the measures would reduce the severity of the problems experienced even during storms with recurrence intervals greater than 100 years.

Infiltration of groundwater and inflow of stormwater into sanitary sewers is a problem related to stormwater drainage. Infiltration may be defined as water that leaks into a sanitary sewerage system through defective pipes, pipe joints, connections, or manhole walls. Inflow may be defined as water discharged into a sanitary sewerage system from such sources as roof leaders, cellar, yard, and area drains, foundation drains, cooling water discharges, drains from springs and swampy areas, manhole covers, cross connections from storm sewers and combined sewers, catch basins, storm waters, surface runoff, street wash waters, or drainage.

The Underwood trunk sewer (Underwood interceptor) is connected to the metropolitan trunk sewer system of the Milwaukee Metropolitan Sewerage District (MMSD). Infiltration/inflow studies of the City and Village sanitary sewer systems in the Lake Michigan drainage basin, including the Dousman Ditch and Underwood Creek subwatersheds, were prepared by the MMSD in 1978. Those studies found excessive infiltration and inflow and were, therefore, followed by a sewer system evaluation survey by the MMSD in 1981. That survey recommended a sanitary sewer rehabilitation program to reduce infiltration and inflow. Subsequent to the sewer system evaluation survey, the City and the Village undertook sewer system improvements to reduce infiltration and inflow. In addition, the downstream conveyance facilities were modified as recommended in the MMSD 1980 facility plan, including upgrades to the metropolitan trunk sewer system. As described in Chapter V, the City and Village have taken additional action to investigate and reduce sources of infiltration and inflow to the sanitary sewer system.

The City and Village ordinances prohibiting the connection of clearwater drains to the sanitary sewer system and efforts directed toward reduction of infiltration and inflow, along with the provision of an effective stormwater drainage and floodland management system as recommended in this report, should help limit infiltration and inflow to the sanitary sewerage system.

Flooding Problems

The severity of flooding problems along Dousman Ditch and Underwood Creek has increased over time as urban development has proceeded in the subwatershed. Historic flooding problems through 1973 are documented in SEWRPC Planning Report No. 26, *A Comprehensive Plan for the Menomonee River Watershed*, Volume One, October 1976. The flood of June 23, 1940, resulted in localized street closings of W. Bluemound Road due to flooding, while the flood of March 30, 1960, resulted in serious flooding along the 1.70-mile reach of Underwood Creek from the Milwaukee-Waukesha county line upstream to the north end of the Village Park. Damage included flooding to the business district, flooding of basements and lower floors, and flooding of roadways. The flood of July 17-18, 1964 resulted in localized street flooding of W. Bluemound Road at the Waukesha-Milwaukee county line. The flood of September 18, 1972, resulted in localized street closings on W. Bluemound Road, and W. North Avenue, as well as some basement flooding. The flood of April 21, 1973, resulted in serious flooding. This included damage to residential, business, industrial, and commercial sections of Elm Grove. Flooding was both primary and secondary and occurred along the entire 2.25-mile reach through Elm Grove. While the storm of August 6, 1986, produced very heavy rain in parts of Milwaukee County, rainfall in the study areas was less severe and flooding was generally localized. The effects of the floods of June 21, 1997 and August 6, 1998, are described in detail in Chapter V of this report.

DESCRIPTION OF SOURCES OF WATER POLLUTION

The quality of the surface waters in the Dousman Ditch and Underwood Creek subwatersheds is an important concern of this study. Improper stormwater management may result in pollutant contributions from these watersheds to the streams and also in high flow velocities and volumes, which can cause erosion of streambanks and scour of the streambed. Under these conditions, high pollutant loadings are contributed, some of which are deposited in downstream beds, thereby potentially influencing water quality conditions over a relatively long period of time. Erosion and the resulting sediment contributed to the stream systems can destroy important stream and riparian habitat and aquatic life and can result in the discharge of pollutants, such as nutrients, pesticides, and metals, which are transported in the stream system attached to sediment particles. Stormwater runoff from urban lands, including lawns and pavements, can contain high concentrations of water pollutants such as organic substances, nutrients, fecal coliform organisms, metals, and sediment. High pollutant concentrations and excessive erosion and sedimentation in the streams of the subwatersheds reduce their suitability, and the suitability of downstream waters, for recreational uses such as swimming, fishing, and boating; limit the ability of the waterbody to support desirable forms of fish and other aquatic life; adversely affect the aesthetics of the water resource; reduce the hydraulic capacity of drainage channels and streams; and result in the loss of, or damage to, public and private property.

There are no Wisconsin Pollutant Discharge Elimination Systems (WPDES) stormwater discharge permits for discharges to any streams in the study area. There is one WPDES general wastewater permitted point sources of pollution which discharges to Dousman Ditch. There are two WPDES general wastewater permitted point sources of pollution which discharge to Underwood Creek or its tributaries. Thus, both point and nonpoint sources of pollution account for the pollutant loadings to Underwood Creek and its tributaries. The nonpoint sources include urban and rural land stormwater runoff, construction site erosion, streambank erosion, atmospheric contributions, and industrial material leaks and spills. Pollutant loading estimates to Dousman Ditch and Underwood Creek are presented in Chapter IV of this report.

Rural Land Runoff

As noted previously, as of 1999, much of the land in the study area that was identified as rural in 1990 has been developed in urban uses. Thus, the importance of rural land runoff as a source of pollution to these subwatersheds has decreased.

Much of the remaining rural land is natural, undisturbed woodlands and wetlands that contribute few pollutants to surface waters. Within the Dousman Ditch subwatershed, no conversion is expected to take place of existing woodlands and wetlands, while in the Underwood Creek subwatershed, only about 17 percent of the present woodland and none of the wetland area is expected to be converted to urban use under buildout conditions. These natural areas will, thus, remain as important natural buffers to help reduce pollutant loadings to the streams.

Urban Land Runoff

Under buildout land use conditions, urban land uses are expected to cover about 81 percent and 86 percent of the Dousman Ditch and Underwood Creek subwatersheds, respectively. Stormwater runoff from lawns, rooftops, streets and driveways, parking lots, and storage areas contributes sediment, nutrients, organic matter, oil and grease, bacteria, metals, and toxic organic substances to streams. Urban development generally increases stormwater flow rates and runoff volumes and the loadings of some pollutants. Stormwater runoff impacts are most severe in areas having large amounts of impervious areas directly connected to storm sewers or receiving waters. Stormwater pollutant concentrations and loadings vary considerably depending on the land use and land management activities.

Of particular concern is the potential for loadings of some priority pollutants. The priority pollutants are 126 substances identified by the U.S. Environmental Protection Agency as potentially being found in surface waters and which, in excessive concentrations, are toxic to humans or to fish and other aquatic life. Some of these priority pollutants may be deposited in the bottom sediments, potentially contaminating fish food supplies and having toxic effects on benthic organisms. Certain pollutants accumulate in the tissue of aquatic organisms. The Wisconsin Department of Natural Resources has issued fish consumption advisories for some urban streams because of accumulations of polychlorinated biphenyls (PCBs) in the tissue of fish. The U.S. Environmental Protection Agency, as part of the Nationwide Urban Runoff Program completed in 1983,[4] measured the concentration of priority pollutants in 121 urban runoff samples collected at 61 sites located throughout the United States. The Agency reported that 77 of the 126 priority pollutants were each detected in at least one of the urban runoff samples. Each of 17 of the priority pollutants listed in Table 8 were detected in more than 10 percent of the runoff samples. Five of the substances, all metals, were detected in more than 50 percent of the samples tested,

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[4] *U.S. Environmental Protection Agency,* Results of the Nationwide Urban Runoff Program, *Volume I,* Final Report, *December 1983.*

Table 8

PRIORITY POLLUTANTS DETECTED IN MORE THAN 10 PERCENT OF URBAN STORMWATER RUNOFF SAMPLES TESTED THROUGHOUT THE UNITED STATES: 1983

Priority Pollutant	Detection Level (percent)
1. Lead	94
2. Zinc	94
3. Copper	91
4. Chromium	58
5. Arsenic	52
6. Cadmium	48
7. Cyanide	23
8. α - Hexachlorocyclohexane	20
9. α - Endosulfan	19
10. Pentachlorophenol	19
11. Chlordane	17
12. Fluoranthene	16
13. γ - Hexachlorocyclohexane (Lindane)	15
14. Pyrene	15
15. Phenol	14
16. Phenanthrene	12
17. Dichloromethane (methylene chloride)	11

Source: U.S. Environmental Protection Agency.

with three of those metals, lead, zinc, and copper, detected in more than 90 percent of the samples. The metals lead, zinc, copper, and cadmium were also frequently detected at all of the sites monitored under a Nationwide Urban Runoff Program project conducted in Milwaukee County.[5]

Toxic organic substances were less prevalent than were metals in the runoff samples. All of the organic substances tested were identified in 20 percent or less of the samples tested.

The U.S. Environmental Protection Agency reported that acute and/or chronic water quality criteria recommended by the Agency for lead, zinc, copper and cadmium levels were exceeded in some of the urban runoff samples.[6] Exceeding the criteria does not necessarily indicate that an actual violation of the criteria would occur in receiving waters. However, urban runoff constitutes the majority of the flow in Dousman Ditch and Underwood Creek during storm events. Thus, criteria violations could indeed occur in these streams during storm events if nonpoint source controls are not provided.

Table 9 presents a general list of selected toxic substances frequently detected in stormwater runoff from residential and industrial land. Pesticides were most frequently found in residential areas, while industrial land runoff more often contained other toxic organic substances. Metals were frequently found in both residential and industrial land runoff.

Potential sources of selected toxic substances in urban runoff are listed in Table 10. Studies have found that some substances, such as Lindane, dieldrin, polychlorinated biphenyls, and some metals, are contributed to urban waters during both wet weather and dry weather.[7] Automobile use contributes to loadings of several priority pollutants. Substances contributed by coal and wood combustion, plastics, and preserved wood may be difficult to control at their source.

Construction Site Erosion

Construction site erosion is a significant potential source of sediments to Dousman Ditch and Underwood Creek. In the period from 1990 to achievement of buildout land use conditions, it is expected that 238 acres, or about 11 percent of the Dousman Ditch subwatershed, and 369 acres, or about 8 percent of the Underwood Creek subwatershed, will be converted from rural to urban use. As of 1999, much of that conversion of land had occurred and stringent construction control ordinances were being enforced in both the City of Brookfield and the Village of Elm

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[5] *R. Bannerman, K. Baun, M. Bohn, P.E. Hughes, and D.A. Graczyk,* Evaluation of Urban Nonpoint Source Pollution Management in Milwaukee County, Wisconsin, *Volume I,* Urban Stormwater Characteristics, Sources, and Pollutant Management by Street Sweeping, *U.S. Environmental Protection Agency, PB 84-113164, 1983.*

[6] *U.S. Environmental Protection Agency,* Results of the Nationwide Urban Runoff Program, *Volume I,* Final Report, *December 1983.*

[7] *R. Pitt and J. McLean,* Toronto Area Watershed Management Strategy Study: Humber River Pilot Watershed Project, *Ontario Ministry of the Environment, Toronto, Ontario, 1986.*

Table 9

SELECTED TOXIC SUBSTANCES FREQUENTLY DETECTED IN RESIDENTIAL AND INDUSTRIAL LAND STORMWATER RUNOFF

Toxic Substance	Residential Land Runoff	Industrial Land Runoff
Haloginated Aliphatics		
1,2,-dichlorethane	- -	X
Methylene chloride	- -	X
Tetrachlorethylene	- -	X
Phthalate Esters		
Bis (2-Ethylene) phthalate	X	- -
Butylbenzyl phthalate	X	X
Diethyl phthalate	- -	X
Di-N-Butyl phthalate	X	X
Polycyclic Aromatic Hydrocarbons		
Phenanthrene	- -	X
Pyrene	- -	X
Chrysene	X	X
Fluoranthene	- -	X
Other Volatile Compounds		
Benzene	X	X
Chloroform	- -	X
Ethylbenzene	- -	X
N-Nitro-sodimethylamine	- -	X
Toluene	- -	X
Metals		
Chromium	- -	X
Copper	X	X
Lead	X	X
Zinc	X	X
Pesticides and Phenols		
Y – Hexachlorocyclohexane (Lindane)	X	- -
Chlordane	X	- -
Dieldrin	X	- -
Endosulfan sulfate	X	- -
Endrin	X	- -
Isophorone	X	- -
Methoxychlor	- -	X
Polychlorinated biphenyls	X	X
Pentachlorophenol	X	X
Phenol	X	- -
α - Hexachlorocyohexane	X	- -

Source: Wisconsin Department of Natural Resources.

Grove. Thus, the relative contribution of sediment from construction sites would be expected to diminish in the future.

Construction activities typically involve soil disturbance, the destruction of the vegetative cover, and changes in surface topography and drainage. In particular, the clearing and grading of construction sites subjects the soils to high erosion rates. Erosion rates from construction sites are typically 10 to 20 times higher than rates from agricultural land.[8] This exces

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[8] *S.J. Goldman, K. Jackson, and T.A. Bursztynsky,* Erosion and Sediment Control Handbook, *McGraw-Hill Book Company, 1986.*

Table 10

POTENTIAL SOURCES OF SELECTED TOXIC SUBSTANCES FOUND IN URBAN RUNOFF

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

Source: Wisconsin Department of Natural Resources.

sive soil erosion frequently causes onsite construction problems, and the eroded sediment often causes sedimentation problems in downstream areas. The sediments are frequently deposited in storm sewers, culverts, drains, and waterways, decreasing their capacities and clogging them, sometimes causing flooding problems. Furthermore, erosion of the soil from the site is, in many cases, a loss of a valuable natural resource.

These high sediment contributions also contain nutrients which may increase algal growths, reduce water clarity, deplete oxygen supplies, lead to fish kills, and create odors. Ecological damages to nearby streams often include erosion of streambanks and destruction of streambank vegetation, covering of benthic fauna and fish spawning sites with sediment, filling of stream pools, and increased turbidity, which reduces instream photosynthesis and overall stream productivity.

Streambank Erosion

The energy of flowing water in a stream channel is dissipated along the stream length by turbulence, streambank and bed erosion, and sediment resuspension. In general, increased urbanization may be expected to result in increased stream flow rates and volumes, with potential increases in streambank erosion and bottom scour. Streambank erosion destroys aquatic habitat, spawning, and feeding areas; contributes to downstream water quality degradation by releasing sediments to the water; and provides material for subsequent sedimentation downstream, which, in turn, covers valuable benthic habitats, impedes navigation, and fills downstream stormwater storage basins, wetlands, ponds, and lakes. These effects may be mitigated by utilization of proper stormwater management practices.

In the early 1990s, the WDNR conducted surveys of streambank erosion in the Dousman Ditch and Underwood Creek subwatersheds under the Menomonee River priority watershed study. The stream surveys identified streambank erosion areas along Underwood Creek and estimated the following: the stream length affected; the height of the eroding streambank; the lateral recess, or erosion rate, of the bank; and the weight of sediment lost. Only about 150 linear feet of streambank were estimated to be eroding along Underwood Creek, as characterized in Chapter IV of this report. Commission staff observation of stream conditions during the 1999 field reconnaissance to assess navigability verified that streambank erosion is not a widespread problem for the streams in the study area.

Atmospheric Contributions

Pollutants may also be contributed directly to surface waters through airborne emissions and subsequent dry fallout and washout. Atmospheric sources may be important contributions of sediment, nutrients, metals, and toxic organic substances. The total suspended particulate loading from the atmosphere in urban areas is up to 50 percent higher than in rural areas.[9] These particles also act as carriers for other pollutants.

Important nutrients contributed by the atmosphere are phosphorus and nitrogen. Windblown soil is the major source of phosphorus in dry fallout.[10] Particles containing phosphorus are also washed out by precipitation. Total phosphorus concentrations in rainwater are typically two to three times higher than the levels which can cause eutrophic conditions in lakes. Oxides of nitrogen may react with sodium, potassium, and other metals to form soluble nitrates which, when washed from the atmosphere, may contribute to the fertility of surface waters. Nutrient loadings from the atmosphere are usually highest in spring and summer, when nutrient contributions may have the most significant impact on aquatic plant growth.

Atmospheric loadings are also important sources of metals, primarily lead, zinc, and cadmium.[11] A major source of lead is from the exhaust of automobiles burning leaded gasoline. However, the increasing use of unleaded gasoline has resulted in a corresponding decrease in dissolved lead concentrations in surface waters.[12] Lead, like most metals, has an affinity for very small particles.

Atmospheric sources also contribute to loadings of toxic organic substances such as polychlorinated biphenyls and polycyclic aromatic hydrocarbons (PAHs). PCBs, which are insoluble, are usually associated with extremely small particles, from 0.002 to 0.1 micron in diameter.[13] PCB loadings from the atmosphere are highest near industrial areas. Although production of PCBs is now banned, much of the

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[9] *International Joint Commission,* The IJC Menomonee River Watershed Study, *Volume 8,* Atmospheric Chemistry of Lead and Phosphorus, *December 1979.*

[10] *U.S. Environmental Protection Agency,* Determination of Atmospheric Phosphorus Addition to Lake Michigan, *EPA-600/3-80-063, July 1980.*

[11] *International Joint Commission,* The IJC Menomonee River Watershed Study, *Volume 6,* Dispersibility of Soils and Elemental Composition of Soils, Sediments, and Dust and Dirt from the Menomonee River Watershed, *December 1979.*

[12] *R.B. Alexander and R.A. Smith, "Trends in Lead Concentrations in Major U.S. Rivers and Their Relation to Historical Changes in Gasoline-Lead Consumption,"* Water Resources Bulletin, *Vol. 24, No. 3, pp. 557-568, June 1988.*

[13] *International Joint Commission,* The IJC Menomonee River Watershed Study, *Volume 9,* Atmospheric Chemistry of PCBs and PAHs, *March 1980.*

present input of PCBs results from the low-temperature incineration of solid wastes that contain PCBs.[14] PAHs are released to the atmosphere as a by-product of man-made combustion processes.

Leaks and Spills of Industrial Materials

Leaks and spills of industrial materials may be directly discharged to waterways or the materials may be transported to the waterways via stormwater surface runoff and groundwater flow. These materials often contain toxic metals and organic substances which destroy streambank vegetation, contaminate bottom sediments, and harm fish and aquatic life. Contaminated bottom sediments may act as a residual source of the toxic substances, causing long-term effects which persist for years after the occurrence of the spill or leak. Industrial land uses only constitute about 0.3 percent of the total study area. Thus, while leaks or spills could occur, the small amount of industrial activity in the study area indicates that such leaks or spills would not be prevalent.

EXISTING NONPOINT SOURCE POLLUTION CONTROL FACILITIES AND PROGRAMS WITHIN THE SUBWATERSHED

Under existing conditions, control of nonpoint source pollutants within the Dousman Ditch and Underwood Creek subwatersheds is accomplished through the filtering and infiltration effects of roadside drainage swales; through sweeping of streets twice a year; through catch basin cleaning; through case-by-case stormwater management requirements for new development or redevelopment; and through enforcement of construction erosion control ordinances. The City and the Village are reevaluating their ice and snow removal policies and considering reducing the use of sand on streets. Fifteen ponds in the study area serve to reduce loadings of nonpoint source pollutants to streams.

DESCRIPTION AND ASSESSMENT OF EXISTING WATER QUALITY AND BIOLOGICAL CONDITIONS

Stormwater management planning efforts require the evaluation of existing water quality conditions and of the relationship of those conditions to existing biological communities. This section discusses the existing water quality conditions in Dousman Ditch and Underwood Creek based on the available data, which are limited. However, relatively extensive biological surveys have been conducted since 1984 by the Wisconsin Department of Natural Resources. Survey results summarized herein address fishery resources, bottom-dwelling organisms, and aquatic habitat conditions.

Water Quality Conditions

Limited water quality samples have been taken from Underwood Creek, and none have been taken from Dousman Ditch. Water quality samples were taken from 1968 to 1975, downstream from the study area, near 106th Street and Bluemound Road in the City of Wauwatosa. The samples indicated an average dissolved oxygen concentration of 8.8 milligrams per liter (mg/l), with a minimum recorded concentration of 5.3 mg/l. Average temperature during this time period was 74.7°F (23.7°C), with a maximum recorded temperature of 88.0°F (31.1 °C).[15] Both values are suitable for fish and aquatic life.

Fecal coliform counts during this time frame averaged 2,595 membrane filter fecal coliform counts per 100 milliliters (MFFCC/100 ml), with a maximum count of 14,000 MFFCC/100 ml. The bacteria levels measured were, in general, higher than the levels which can be considered safe for full or partial body contact in recreational uses.[16]

Known areas of concern have been documented which impact water quality in Underwood Creek. An unknown discharge which negatively impacts water

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[14] *U.S. Environmental Protection Agency,* Toxic Substances in the Great Lakes, *EPA 905/9-80-005, June 1980.*

[15] *SEWRPC Technical Report No. 17,* Water Quality of Lakes and Streams in Southeastern Wisconsin: 1964-1975, *June 1978..*

[16] *Wisconsin Department of Natural Resources,* Bacteria Report for the North Branch, East-West Branch, and Menomonee River Watershed, *The Milwaukee River Priority Watershed Project, 1985.*

quality has been observed coming from the Brookfield Square shopping center, which is tributary to Dousman Ditch. South of the Elm Grove Village Park, and upstream from the confluence of Underwood Creek with the South Branch of Underwood Creek in Wauwatosa, an abandoned municipal/industrial landfill has been discharging leachate into the Creek, limiting water quality.

Intermittent sanitary sewer relief discharges to Underwood Creek have occurred during floods. The potential impacts of such discharges and the possibility of installing permanent bypass pumps for infrequent use is being evaluated by the City, Village, and WDNR.

Fishery Resources

The fish community in Dousman Ditch and Underwood Creek is somewhat limited. Fish diversity and population are limited primarily due to low-flow conditions, especially in summer months, which is partly attributable to lowering of the water table. Some of the representative species include blacknose dace, creek chub, various species of sunfish, white sucker, and northern pike.

Table 11 summarizes the fish species surveyed in Underwood Creek from 1984 to 1994. Of the 14 species identified, six species were classified as sport fish; one species as intolerant of pollution; four species as tolerant of pollution; and three species as very tolerant of pollution. The fish community in 1984 was dominated by very tolerant brook stickleback, the tolerant creek chub and johnny darter, the tolerant white sucker, and the intolerant blacknose dace. In 1994, the dominant species were the creek chub, white sucker, and blacknose dace. Three warmwater sport fish species, including green sunfish, bluegill, and northern pike, were identified in 1994.

Benthic Organisms

Benthic macroinvertebrates are bottom-dwelling organisms that are important sources of food for fish and also serve as an indicator of overall water quality conditions.

A procedure known as the Hilsenhoff Biotic Index, based on the benthic invertebrates present, was used by the WDNR to classify overall water quality conditions. The Index calculations indicated that Underwood Creek had fair to poor water quality. Factors that are limiting macroinvertebrate populations include stream modification, nonpoint source pollution from commercial land uses, streambank erosion, unpermitted discharges, and low flow characteristics.

Aquatic Habitat

The aquatic habitat consists of those physical and biological characteristics of a surface water which determine its potential for supporting different communities of organisms. In 1984, the WDNR surveyed the habitat of the main stem of Underwood Creek and the Dousman Ditch.

Upstream of Pilgrim Road, the fish and aquatic life habitat of Underwood Creek was somewhat suitable for various species. Substrates were primarily sand and gravel, with finer silts along the banks. Bank vegetative cover was dominated by grasses. Stream channel widths ranged from eight to 10 feet, and water depths in this segment ranged from one to 1.5 feet in runs. Bank erosion was not significant, due to the abundant grasses. Overall habitat for fish and aquatic life in this segment was rated by the WDNR as fair to poor.

Downstream of Pilgrim Road to the Pomona Park Pond, the fish and aquatic life habitat improved. The substrate consisted of course sand to course gravel with small amounts of boulder material. Within the pond itself, bottom substrates were dominated by silts.[17] Outside of the pond, the Creek was approximately eight feet wide, and water depths ranged from 0.3 to 0.5 foot in the riffles and runs and from 0.5 to one foot in the pools. This segment was primarily a series of riffles and shallow runs. Additional fish and aquatic life habitat was provided by pools which provide important habitat during low-flow periods. The banks were well covered with mixed grasses, shrubs, and trees, as well as a boulders and smaller rocks, resulting in limited erosion. Habitat in this segment was rated by the WDNR as fair.

Downstream of the Pomona Park Pond to North Avenue, the substrate was diverse, ranging from compact clay to course gravel. The channel banks had little ground cover, due to extensive shading from tree growth, making them more susceptible to bank erosion than previous segments. The channel width was approximately 12 to 15 feet and the water depths ranged from 0.1 to 0.3 foot in riffles, 0.5 to 0.75 foot in runs. Shallow pools had formed behind riffle areas and

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[17] *The structure controlling outflow from that pond has been removed since the time of the survey.*

Table 11

FISHERY RESOURCES IN UNDERWOOD CREEK: 1984 THROUGH 1994

Species	Tolerance Classification[a]	Upstream of South Branch of Underwood Creek	Upstream of Juneau Boulevard	Upstream of North Avenue							Upstream of Clearwater Road
		River Mile 3.10	River Mile 4.00	River Mile 4.9				River Mile 5.0	River Mile 5.1		River Mile 6.5
		10/04/84	05/23/84	06/01/91	06/01/92	06/01/93	06/09/94	06/19/94	05/23/84	05/24/84	10/04/84
Black Bullhead (Ictaluras melas)	WS	--	1	--	--	--	--	--	--	--	--
Blacknose Dace (Rhinichthys atratulus)	IT	46	18	--	--	18	--	31	2	7	28
Bluegill (Lepomis macrochirus)	WS	1	6	--	--	2	1	--	--	--	1
Brook Stickleback (Culaea inconstans)	VT	--	--	--	2	1	--	--	--	99	--
Central Mudminnow (Umbra limi)	VT	22	--	1	--	1	20	13	--	--	8
Creek Chub (Semotilus atromaculatus)	T	99	35	2	6	22	14	48	19	1	53
Fathead Minnow (Pimephales promelas)	VT	--	5	1	--	--	--	--	2	--	--
Golden Shiner (Notemigonus crysoleucas)	T	1	--	--	--	--	--	--	--	--	--
Green Sunfish (Lepomis cyanellus)	WS	--	--	20	7	3	6	2	--	--	12
Johnny Darter (Etheostoma nigrum)	T	--	1	1	1	--	4	11	--	--	39
Northern Pike (Esox lucius)	WS	--	--	4	--	--	1	--	--	--	--
Pumpkinseed Sunfish (Lepomis gibbosus)	WS	--	6	7	2	2	--	--	--	--	--
Sunfish (Lepomis sp.)	WS	1	1	--	--	--	--	--	--	--	1
White Sucker (Catostomus commersoni)	T	52	27	16	20	10	2	20	14	1	18
Tolerance Class Summary											
WS Species/Number Fish	--	2/2	4/14	3/31	2/9	3/7	3/8	1/2	0/0	0/0	3/14
IT Species/Number Fish	--	1/46	2/19	1/1	1/1	1/18	1/4	2/42	1/2	1/7	2/67
T Species/Number Fish	--	3/152	2/62	2/18	2/26	2/32	2/16	2/68	2/33	2/2	2/71
VT Species/Number Fish	--	1/22	1/5	1/1	1/2	2/2	1/20	1/13	1/2	1/99	1/8
Total Species/Number Fish	--	7/222	9/100	7/51	6/38	8/59	7/48	6/125	4/37	4/108	8/160

[a] *WS – Warmwater sport*
IT – Intolerant forage
T – Tolerant forage
VT – Very tolerant

Source: Wisconsin Department of Natural Resources.

beneath debris, where holes had been scoured, with depths ranging from one to 2.5 feet. Overall, fish and aquatic life habitat in this segment was rated by the WDNR as poor in 1984.

Downstream of North Avenue to the Elm Grove Village Park, the fish and aquatic life habitat improved. The substrate consisted of silt to course gravel. The Creek was approximately 12 to 15 feet wide, except in the area of one pool at the downstream portion of this segment, which ranged form 12 to 20 feet wide. Water depths ranged from 0.3 to 0.5 foot in the riffles and runs and from one to three feet in the pool. Additional fish and aquatic life habitat was provided by pools, which reduce the impact of low-flow periods. The banks were well covered with dense grasses, thus reducing the effects of erosion. Habitat in this segment was rated by the WDNR as fair.

Downstream of the Village Park, to its confluence with the South Branch of Underwood Creek, the fish and aquatic life habitat degraded somewhat. The substrate consisted of silt to concrete, and natural boulders. The Creek was approximately eight to 12 feet wide, with water depths of 0.3, one, and three feet for riffles, runs, and pools, respectively. Additional habitat is provided by tree obstructions, frequent riffles and runs are also present. Within the natural portions of this segment, the banks are dominated a dense growth of trees, reducing the amount of ground cover, resulting in significant erosion. Habitat in this segment was rated by the WDNR from fair to poor.

The Dousman Ditch habitat on average was rated fair to poor by the WDNR in 1984. Substrate material ranged from well sorted silts to gravel. The banks are dominated by a dense growth of grasses, except where stormwater discharge occurs. Erosion occurs in isolated pockets.

SUMMARY

The stormwater management and flood control plan presented in this report focuses on the 3.5-square-mile Dousman Ditch subwatershed, and the 7.3-square-mile Underwood Creek subwatershed. An inventory of pertinent hydrologic and hydraulic characteristics of the subwatershed and related natural and man-made features is an essential step in the stormwater management and flood control planning process. Accordingly, this chapter presents data on 1) the hydrologic phenomena governing the magnitude and frequency of stormwater and flood flows; 2) exist ing stormwater drainage and flooding problems; 3) surface water quality conditions in the subwatersheds; 4) sources of pollution related to stormwater management; 5) the anticipated type, density, and spatial distribution of land uses in the study area; 6) the impact of the anticipated changes in land use on the stormwater and floodland management needs of the study area; 7) natural resource features of the study area; and 8) biological conditions.

Land use characteristics, including impervious area, the type of storm drainage system, the level and characteristics of human activity, and the type and amount of pollutants deposited on the land surface, greatly influence the quantity and quality of stormwater runoff. Urban land uses within the Dousman Ditch subwatershed are expected to increase about 15 percent, from a total of 1,569 acres, or 70 percent of the subwatershed area in 1990, to about 1,807 acres, or 81 percent of the subwatershed area, under planned buildout land use conditions. Urban land uses within the Underwood Creek subwatershed are expected to increase about 10 percent, from a total of 3,665 acres, or 78 percent of the subwatershed area in 1990, to about 4,035 acres, or 86 percent of the subwatershed area, under planned buildout land use conditions. The residential land use category is expected to experience the largest absolute increase, about 943 acres, to a total in the plan design year of about 1,108 acres in the Dousman Ditch subwatershed, while in the Underwood Creek subwatershed, it is expected to increase from about 2,514 acres, to a total of about 2,813. As of 1999, much of the developable rural land existing in 1990 had been converted to urban areas.

The resident population of the Dousman Ditch subwatershed area is expected to increase from about 4,200 persons in 1990 to about 4,500 persons under planned ultimate conditions, while in the Underwood Creek subwatershed, the resident population is expected to remain fairly stable at about 16,600 persons between 1990 and planned ultimate conditions.

Changes from rural to urban land use affect the amount and quality of stormwater runoff. Increased rates and volumes of runoff result from the higher proportion of impervious areas, such as streets, parking lots, and rooftops. Thus, urban development can increase flood flows, stages, streambank erosion, and streambed scour in downstream watercourses. Such development can also increase the downstream surface-water pollutant loadings and may reduce stream base flows. Therefore, careful planning of urban stormwater management systems to meet sound water resource and related management objectives is essential.

Existing pertinent land use regulations include zoning and land division ordinances. These land use regulations represent important tools for the City of Brookfield and the Village of Elm Grove in directing the use of land in the public interest. Such zoning has important implications for stormwater management.

Climatological factors affecting stormwater management include air temperature and the type and amount of precipitation. Air temperature affects whether precipitation occurs as rainfall or snowfall, whether the ground is frozen and, therefore, essentially impervious, and the rate of snowmelt and attendant runoff. The seasonal nature of precipitation patterns is an important consideration in stormwater drainage. Flooding along the streams in the study area is likely to occur at any time throughout the year except during winter because of the relatively small drainage areas and the impacts of urban development. The maximum monthly precipitation recorded at the National Weather Service station at Mitchell International Airport in Milwaukee was 10.03 inches in June 1917 and the maximum 24-hour precipitation was 6.84 inches, recorded on August 6, 1986. The amount of snow cover influences the severity of snowmelt flood events and the extent and depth of frozen soils.

Soil properties influence the rate and amount of stormwater runoff from land surfaces. About 90 percent of the study area is covered by soils which generate moderate relatively large amounts of runoff.

For planning purposes, the study area was divided into 605 subbasins. These subbasins have an average size of 12 acres.

Constructed stormwater drainage facilities serve about half of the study area subwatershed. A system of open drainage channels and associated culverts serves the remainder.

Existing stormwater drainage problems include street, yard, and basement flooding. Direct overland flooding of structures has occurred along Underwood Creek.

If it is determined that a stream is navigable, a permit from the State of Wisconsin is required prior to undertaking certain activities related to the stream. Because such a permit may be required to perform stream maintenance related to stormwater and floodland management, the navigability of certain streams in the study area was investigated and inventoried on Map 6.

Possible sources of water pollutants to Dousman Ditch and Underwood Creek include stormwater runoff from urban and rural land, construction site erosion, streambank erosion, atmospheric contributions, and industrial material leaks and spills. There are three known point sources of pollution which discharge to Underwood Creek or its tributaries.

Few water quality samples have been taken from Dousman Ditch and Underwood Creek. The limited data available indicate that portions of the stream are contaminated with bacteria from both human and animal waste sources. There is no evidence of inadequate dissolved oxygen levels, or of excessive temperature or nutrient levels. However, fecal coliform levels measured in the past were quite high.

The fishery resources in Underwood Creek were surveyed between 1984 and 1994. Fourteen species ranging from very tolerant fish to warmwater sport fish were identified. The benthic, or bottom-dwelling, organisms present in the Creek were dominated by pollution-tolerant species and were representative of poor water quality conditions. In general, the aquatic habitat was rated as fair to poor for most of the reaches Dousman Ditch and Underwood Creek.

Chapter III

STORMWATER AND FLOODLAND MANAGEMENT OBJECTIVES, STANDARDS, AND DESIGN CRITERIA

INTRODUCTION

Planning may be defined as a rational process for formulating and meeting objectives. Consequently, the formulation of objectives is an essential task which must be undertaken before plans can be prepared. This chapter sets forth a set of stormwater and floodland management objectives and supportingstandards for use in the design and evaluation of alternative system plans for the Dousman Ditch and Underwood Creek subwatersheds in the City of Brookfield and the Village of Elm Grove, and in the selection of a recommended plan from among those alternatives.

In addition, this chapter sets forth engineering design criteria and describes analytical procedures which were used in the preparation and evaluation of the alternative system plans. These criteria and procedures include the engineering techniques used to design the alternative plan elements; to test the physical feasibility of those elements; and to make necessary economic comparisons between the plan elements. This chapter thus documents the degree of detail and level of sophistication employed in the preparation of the recommended plan, and thereby is intended to provide a better understanding by all concerned of the plan and of the need for refinement of some aspects of the plan prior to and during implementation.

STORMWATER AND FLOODLAND MANAGEMENT OBJECTIVES AND STANDARDS

The following seven stormwater and floodland management objectives were formulated to guide the design, test, and evaluation of alternative plans and the selection of a recommended plan from among the alternatives considered:

1. The development of a stormwater and floodland management system which reduces the exposure of people to drainage-related inconvenience and to health and safety hazards and which reduces the exposure of real and personal property to damage through inundation resulting from flooding and inadequate stormwater drainage.
2. The development of a system which will effectively serve existing and planned future land uses and will promote implementation of the adopted land use plan set forth in the Waukesha County development plan.[1]
3. The development of a stormwater management system which will abate nonpoint source water pollution and help achieve the recommended water use objectives and supporting water quality standards for surface waterbodies.
4. The development of a system which will maintain or enhance existing terrestrial and aquatic biological communities, including fish and wildlife.
5. The development of a stormwater and floodland management system which will be flexible and readily adaptable to changing needs.
6. The development of a stormwater and flood-management system which will not pollute the groundwater aquifers serving the City and the Village.
7. The development of a stormwater and floodland management system which will efficiently and effectively meet all of the other stated objectives at the lowest practicable cost.

Complementing each of these objectives is a set of quantifiable standards which can be used to evaluate the relative or absolute ability of alternative plan

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[1] *SEWRPC Community Assistance Planning Report No. 209,* A Development Plan for Waukesha County, Wisconsin, *August 1996.*

Table 12

OBJECTIVES AND STANDARDS FOR STORMWATER AND FLOODLAND MANAGEMENT IN THE DOUSMAN DITCH AND UNDERWOOD CREEK SUBWATERSHEDS IN THE CITY OF BROOKFIELD AND THE VILLAGE OF ELM GROVE

OBJECTIVE NO. 1

The development of a stormwater and floodland management system which reduces the exposure of people to drainage-related inconvenience and to health and safety hazards and which reduces the exposure of real and personal property to damage through inundation resulting from inadequate stormwater drainage.

STANDARDS

1. In order to prevent significant property damage and safety hazards, the major components of the stormwater management system and the floodland management system should be designed to accommodate runoff from a 100-year recurrence interval storm event.

2. In order to provide for an acceptable level of access to property and of traffic service, the minor components of the stormwater management system should be designed to accommodate runoff from a 10-year recurrence interval storm event.

3. In order to provide an acceptable level of access to property and of traffic service, the stormwater management system should be designed to provide two clear 10-foot lanes for moving traffic on existing arterial streets, and one clear 10-foot lane for moving traffic on existing collector and land access streets during storm events up to and including the 10-year recurrence interval event.

4. Flow of stormwater along and across the full pavement width of collector and land access streets shall be acceptable during storm events exceeding a 10-year recurrence interval when the streets are intended to constitute integral parts of the major stormwater drainage system.

5. Plan components shall be designed to comply with the requirements of Chapter NR 116 of the *Wisconsin Administrative Code.*

6. All new and replacement bridges and culverts over waterways shall be designed so as to accommodate, according to the categories listed below, the designated flood events without overtopping of 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 through traffic: a 50-year recurrence interval flood discharge.

   c. Freeways and expressways: a 100-year recurrence interval flood discharge.

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

7. All new and replacement bridges and culverts along waterways shall be designed so as not to inhibit fish passage in areas which are supporting, or which are capable of supporting, valuable recreational sport and forage fish species.

OBJECTIVE NO. 2

The development of a stormwater and floodland management system which will effectively serve existing and planned future land uses and will promote implementation of the adopted land use plan set forth in the Waukesha County development plan.

Table 12 (continued)

STANDARDS

1. Stormwater drainage systems should be designed assuming that the layout of collector and land access streets for proposed urban development and redevelopment will be carefully adjusted to the topography in order to minimize grading and drainage problems, to utilize to the fullest extent practicable the natural infiltration, drainage, and storage capabilities of the site, and to provide the most economical installation of a gravity flow drainage system. Generally, drainage systems should be designed to complement a street layout wherein collector streets follow valley lines and land access streets cross contour lines at right angles.

2. Stormwater drainage systems should be designed assuming that the layouts and grades of collector and land access streets can, during major storm events, serve as open runoff channels supplementary to the minor stormwater drainage system without flooding adjoining building sites. The stormwater drainage system design should avoid midblock sags in street grades, and street grades should generally parallel swale, channel, and storm sewer gradients.

3. Street elevations and grades, and appurtenant site elevations and grades, shall be set to provide overland gravity drainage to natural watercourses so that positive drainage may be effected during major storm events and in the event of failure of piped stormwater drainage facilities.

4. Stormwater management systems shall utilize rural street cross-sections with roadside swales and culverts in all areas of the Village of Elm Grove except along major collector streets, arterial highways, and areas of high-density development which are designated for the use of urban street cross-sections with curbs and gutters, inlets, and storm sewers. Stormwater management systems in all areas of planned new development in the City of Brookfield shall utilize urban street cross-sections with curbs and gutters, inlets, and storm sewers. The existing cross-section shall be retained in areas of existing development in the City where either rural or urban cross-sections are in place, including hybrid urban/rural sections where ditch enclosures have been constructed.[a]

5. The stormwater and floodland management system shall be designed to minimize the creation of new drainage or flooding problems, or the intensification of existing problems, at both upstream and downstream locations.

6. Stormwater and floodland management systems should utilize the existing storage capacity of wetlands and open spaces to the extent practicable.

OBJECTIVE NO. 3

The development of a stormwater management system which will abate nonpoint source water pollution and help achieve the recommended water use objectives and supporting water quality standards for surface waterbodies.

STANDARD

1. Stormwater management facilities should promote the achievement of recommended water use objectives and supporting water quality standards for lakes, streams, and wetlands, and should not degrade existing habitat conditions for fish and aquatic life. The applicable water use objectives for the streams concerned are shown on Map 8, and the water quality standards supporting these use objectives are presented in Tables 13 and 14.[b]

2. Stormwater management practices should promote the attainment of sediment quality criteria for toxic substances as set forth in Table 15.

OBJECTIVE NO. 4

The development of a stormwater and floodland management system which will maintain or enhance existing terrestrial and aquatic biological communities, including fish and wildlife.

STANDARDS

1. Stormwater and floodland management systems shall be designed to minimize disruption to primary and secondary environmental corridors, including the incorporated woodlands, wetlands, and wildlife habitat areas.

2. Stormwater and floodland management facilities should be designed to protect valuable and sensitive wetlands from the adverse impacts of stormwater runoff.

Table 12 (continued)

3. Stormwater and floodland management facilities shall be designed to control sedimentation in receiving streams and to prevent the loss of fish and aquatic life habitat through streambank erosion and streambed scour.

4. To the extent practicable, stormwater drainage and flood control facilities should be designed to avoid enclosure of tributary streams identified as having significant and valuable biological and recreational uses.

OBJECTIVE NO. 5

The development of a stormwater and floodland management system which will be flexible and readily adaptable to changing needs.

STANDARDS

1. Stormwater and floodland 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 urban development, in economic activity growth, in the objectives or standards, or in the technology of stormwater and floodland management.

2. Where practicable and advantageous to the achievement of the objectives of this plan, multipurpose stormwater storage facilities should be provided. Such facilities should serve two or more of the following functions: water quantity control, water quality control, active or passive recreation, and aesthetic enhancement.

OBJECTIVE NO. 6

The development of a stormwater and floodland management system which will not pollute the groundwater aquifers serving the City and the Village.[c]

STANDARD

1. Where practicable, wet detention basins and infiltration devices shall not be located within the boundary of a recharge area to a wellhead identified in a wellhead area protection plan; within 100 feet of a private well; 100 feet of a transient, noncommunity public water system;[d] or within 1,200 feet of a well serving a public water system other than a transient noncommunity system.

2. Where, of necessity, wet detention basins are located in areas where contamination of the groundwater is possible, the basins should be provided with an impermeable liner.

3. Stormwater discharges to infiltration devices should be pretreated to avoid groundwater contamination and to assure proper long-term functioning of the infiltration device.

OBJECTIVE NO. 7

The development of a stormwater and floodland management system which will efficiently and effectively meet all of the other stated objectives at the lowest practicable cost.

STANDARDS

1. The sum of stormwater and floodland management system capital investment and operation and maintenance costs should be minimized.

2. Maximum feasible use should be made of all existing stormwater and floodland management components, as well as the natural storm drainage system. The latter should be supplemented with engineered facilities only as necessary to serve the anticipated stormwater and floodland management needs generated by existing and proposed land use development and redevelopment.

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

Table 12 (continued)

4. Stormwater storage facilities—consisting of retention facilities and of both centralized and onsite detention facilities—should, where hydraulically feasible and economically sound, be considered as a means of reducing the size and resultant costs of the required stormwater conveyance facilities downstream of the storage sites.

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[a] *Hyrid urban/rural sections with ditch enclosures consist of rural street cross-sections where the ditch bed has been raised and a storm sewer has been constructed along the side of the road, following the ditch alignment.*

[b] *The recommended objectives and standards are a revision of those set forth in the areawide water quality management plan as documented in SEWRPC Memorandum Report No. 93,* A Regional Water Quality Management Plan for Southeastern Wisconsin: An Update and Status Report, *March 1995. Those objectives are also set forth in* A Nonpoint Source Control Plan for the Menomonee River Priority Watershed Project, *Wisconsin Department of Natural Resources and Agriculture, Trade and Consumer Protection, March 1992.*

The State-adopted water use objectives as set forth in Chapter NR 104.06 of the Wisconsin Administrative Code *differ from the recommended objectives in that they classify Underwood Creek downstream of Juneau Boulevard as a variance stream which meets the fishable waters standard except in terms of dissolved oxygen concentrations, fecal coliform concentrations, and temperature conditions, which generally tend to be less than optimal. The WDNR has proposed reclassifying those portions of Underwood Creek that are concrete-lined to limited aquatic life waters and reclassifying those reaches that are not concrete-lined to warmwater forage fish waters. However, the* Wisconsin Administrative Code *has not been changed to reflect that reclassification. Because no specific objective is listed in Chapter NR 104 for Dousman Ditch, it is classified as a warmwater sport fish stream under the* Wisconsin Administrative Code. *The WDNR proposes no change in the* Wisconsin Administrative Code *objectives for Dousman Ditch.*

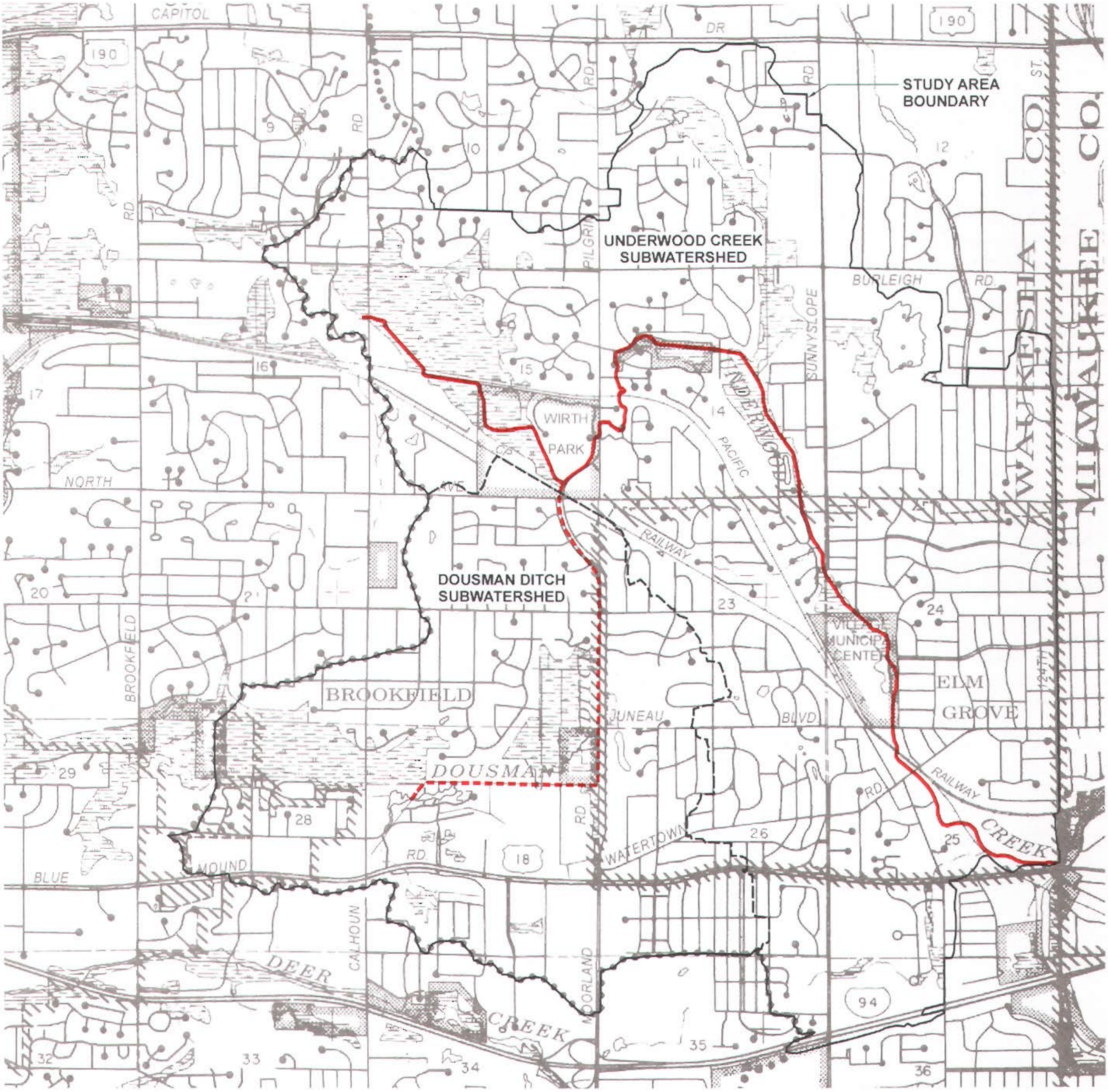
[c] *The water supply for the City of Brookfield is provided by municipal wells developed in either the dolomite aquifer or the deep sandstone aquifer. The water supply for the Village of Elm Grove is provided by nonmunicipal wells, primarily developed in the shallow sand and gravel aquifer.*

[d] *Chapter NR 809 of the* Wisconsin Administrative Code, *which sets forth rules regarding safe drinking water, defines a transient, noncommunity public water system as a system for the provision to the public of piped water for human consumption, if such system serves at least 25 people at least 60 days of the year. Examples of such systems include those serving taverns, motels, restaurants, churches, campgrounds, and parks.*

Source: SEWRPC.

Map 8

RECOMMENDED WATER USE OBJECTIVES FOR DOUSMAN DITCH AND UNDERWOOD CREEK IN THE CITY OF BROOKFIELD AND THE VILLAGE OF ELM GROVE



WARMWATER FORAGE FISH COMMUNITY AND LIMITED RECREATIONAL USE

LIMITED FORAGE FISH COMMUNITY AND LIMITED RECREATIONAL USE

NOTE THE STUDY AREA CONSISTS OF THE ENTIRE DOUSMAN DITCH SUBWATERSHED AND THE WAUKESHA COUNTY PORTION OF THE UNDERWOOD CREEK SUBWATERSHED

GRAPHIC SCALE

0 ¼ ½ MILE

0 1000 2000 3000 4000 FEET

Source: SEWRPC.

Table 13

RECOMMENDED WATER USE OBJECTIVES AND WATER QUALITY STANDARDS FOR STREAMS WITHIN THE DOUSMAN DITCH AND UNDERWOOD CREEK SUBWATERSHEDS[a]

Water Quality Parameters	Combinations of Water Use Objectives Adopted for Southeastern Wisconsin Inland Lakes and Streams[b,c]			
	Warmwater Sport Fish Community and Full Recreational Use	Warmwater Forage Fish Community and Limited Recreational Use	Limited Forage Fish Community and Limited Recreational Use[d]	Limited Aquatic Life and Limited Recreational Use
Temperature[e,f,g] (°F)	89.0 maximum	89.0 maximum	- -	- -
Dissolved Oxygen[g] (mg/l)	5.0 minimum[h]	5.0 minimum[h]	3.0 minimum[i]	3.0 minimum[i]
pH Range[j] (S.U.)	6.0 - 9.0	6.0 - 9.0	6.0 - 9.0	6.0 - 9.0
Total Phosphorus[k] (mg/l)	0.1, 0.02 maximum	- -	- -	- -
Un-ionized Ammonia Nitrogen[l] (mg/l)	0.04 maximum	0.04 maximum	3.0, 6.0 maximum[m]	- -
Chloride[n] (mg/l)	1,000 maximum	1,000 maximum	1,000 maximum	- -
Fecal Coliform (MFFCC)	200, 400 maximum[o]	1,000; 2,000 maximum[p]	1,000; 2,000 maximum[p]	1,000; 2,000 maximum[p]

[a] *Wisconsin Department of Natural Resources and additional categories established under the areawide water quality management planning program, plus those combinations of water use categories applicable to the Southeastern Wisconsin Region. It is recognized that under both extremely high and extremely low flow conditions, instream water quality levels can be expected to violate the established water quality standards for short periods of time without damaging the overall health of the stream. It is important to note the critical differences between the official State and federally adopted water quality standards—composed of "use designations" and "water quality criteria"—and the water use objectives and supporting standards of the Regional Planning Commission described here. The U.S. Environmental Protection Agency and the Wisconsin Department of Natural Resources, being regulatory agencies, utilize water quality standards as a basis for enforcement actions and compliance monitoring. This requires that the standards have a rigid basis in research findings and in field experience. The Commission, by contrast, must forecast regulations and technology far into the future, documenting the assumptions used to analyze conditions and problems which may not currently exist anywhere, much less in or near Southeastern Wisconsin. As a result, more recent—and sometimes more controversial—study findings must sometimes be applied. This results from the Commission's use of the water quality standards as criteria to measure the relative merits of alternative plans.*

[b] *All waters shall meet the following minimum standards at all times and under all flow conditions: substances that will cause objectionable deposits on the shore or in the bed of a body of water, floating or submerged debris, oil, scum, or other material, and material producing color, odor, taste or unsightliness shall not be present in such amounts as to interfere with public rights in waters of the State. Substances in concentrations or combinations which are toxic or harmful to humans shall not be present in amounts found to be of public health significance, nor shall substances be present in amounts which are acutely harmful to animal, plant or aquatic life.*

[c] *Standards presented in the table have been applied for planning purposes to lakes over 50 acres in surface area and to major streams of the Region.*

[d] *No un-ionized ammonia nitrogen standard has been established for streams or lakes classified as supporting limited forage fish communities. The maximum standard for total ammonia, as set forth in Chapter NR 104 of the* Wisconsin Administrative Code, *is included in the table.*

[e] *There shall be no temperature changes that may adversely affect aquatic life. Natural daily and seasonal temperature fluctuations shall be maintained. The maximum temperature rise at the edge of the mixing zone above the natural temperature shall not exceed 5 °F for streams.*

[f] *There shall be no significant artificial increases in temperature where natural trout reproduction is to be maintained.*

[g] *Dissolved oxygen and temperature standards apply to continuous streams and the epilimnion of stratified lakes and to the unstratified lakes; the dissolved oxygen standard does not apply to the hypolimnion of stratified inland lakes. However, trends in the period of anaerobic conditions in the hypolimnion of deep inland lakes should be considered important to the maintenance of their natural water quality.*

[h] *Standard noted is applied using a probabilistic analyses approach as defined in SEWRPC Memorandum Report No. 93,* A Regional Water Quality Management Plan for Southeastern Wisconsin: An Update and Status Report*; absolute minimum standard of 3.0 mg/l of dissolved oxygen also applies.*

Footnotes to Table 13 (continued)

[i] *Standard noted is applied using a probabilistic analyses approach as defined in SEWRPC Memorandum Report No. 93; absolute minimum standard of 1.5 mg/l of dissolved oxygen also applies.*

[j] *The pH shall be within the stated range with no change greater than 0.5 units outside the estimated natural seasonal maximum and minimum.*

[k] *In streams classified for full recreational use, the total phosphorus concentration shall not exceed 0.1 mg/l. In lakes classified for full recreational use, the total phosphorus concentration shall not exceed 0.02 mg/l during spring when maximum mixing is underway. A phosphorus standard does not apply to streams and lakes classified for limited recreational use. Total phosphorus standards were developed by the Commission for use in the initial water quality management plan from U.S. Environmental Protection Agency recommendations set forth in* Quality Criteria for Water, *1976.*

[l] *A committee established by the Wisconsin Department of Natural Resources is currently evaluating whether the ammonia standard should be modified, and, if so, how the standard should be modified.*

[m] *Standard is for total ammonia. Ammonia Nitrogen, expressed as N, at all points in the receiving water of Limited Forage Fish Communities should not be greater than 3 mg/l during warm temperature conditions (May-October), and 6 mg/l during cold temperatures (November - April), to minimize the zone of toxicity and to reduce dissolved oxygen depletion caused by oxidation of the ammonia.*

[n] *Threshold concentration for the propagation of freshwater fish above which the effects on aquatic life may become significant as determined by the California State Water Pollution Control Board, 1952.*

[o] *The fecal coliform count (MFFCC) should not exceed 200 per 100 ml as a geometric mean based on no less than five samples per month, nor exceed 400 per 100 ml in more than 10 percent of all samples during any month.*

[p] *The fecal coliform count (MFFCC) should not exceed 1,000 per 100 ml as a geometric mean based on no less than five samples per month, nor exceed 2,000 per 100 ml in more than 10 percent of all samples during any month.*

Source: Wisconsin Department of Natural Resources and SEWRPC

Table 14

ACUTE AND CHRONIC TOXICITY CRITERIA[a]

Water Quality Parameters	Water Use Objectives					
	Warmwater Forage Fish, Limited Forage Fish, and Limited Aquatic Life with Limited Recreational Use			Warmwater Sport and Forage Fish, Limited Forage Fish, and Limited Aquatic Life with Full or Limited Recreational Use		
	Hardness (mgCaCO$_3$/l)			Hardness (mgCaCO$_3$/l)		
	50	100	200	50	100	200
	Acute Toxicity (μg/l)			Chronic Toxicity (μg/l)		
Cadmium	12.3	27.2	60.1	1.2	2.0	3.1
Chromium	1,061	1,871	3,301	30.6	54.6	95.4
Copper	8.6	16.6	31.8	6.0	11.5	22.1
Lead	70.0	169.1	408.6	4.2	10.1	24.4
Nickel	599.5	1,078	1,937	36.8	66.1	118.9
Silver	0.88	2.0	4.5	0.88	2.0	4.5
Zinc	62.7	112.8	202.9	27.6	49.6	89.2
	pH (s.u.)			pH (s.u.)		
	6.5	7.8	8.8	6.5	7.8	8.8
	Acute Toxicity (μg/l)			Chronic Toxicity (μg/l)		
Pentachlorophenol	6.2	23.0	62.8	4.7	17.5	47.8

[a] *Values set forth in Chapter NR 105 of the* Wisconsin Administrative Code.

Source: Wisconsin Department of Natural Resources.

Table 15

LOWEST AND SEVERE EFFECT LEVELS OF CONTAMINANTS PRESENT IN SEDIMENTS IN WISCONSIN

Chemicals	Lowest Effect Level[a]	Severe Effect Level[a]
As (Arsenic)	6	85
Cd (Cadmium)	1.1	9
Cr (Chromium)	31	145
Cu (Copper)	25	390
Hg (Mercury)	0.15	1.3
Ni (Nickel)	31	75
Pb (Lead)	31	250
Zn (Zinc)	120	820
Total PAHs (Polycyclic Aromatic Hydrocarbons)	4	500
Total PCBs (Polychlorinated Bi-phenyls)	0.07	26.4
Aldrin	0.002	0.4
Chlordane	0.007	0.3
Total DDT	0.007	0.6
op + pp DDT	0.008	3.6
pp DDD	0.008	0.3
pp DDE	0.005	1
Mirex	0.007	- -
TCDD (dioxin) •g/kg	0.0003	- -
NH_3-N	75	- -
Oils and Grease	1,000	- -
CN (Cyanide)	0.1	- -

[a] *Concentrations are in mg/kg dry sediment, with the exception of TCDD, which is in •g/kg.*

Source: Ontario Ministry of Environment and Energy, NOAA, Wisconsin Department of Natural Resources, and SEWRPC.

designs to meet each objective. The objectives and standards, which are set forth in Table 12, incorporate the goals, objectives, and policies of the 1995 City stormwater management guide, where appropriate.

The planning standards fall into two groups—comparative and absolute. The comparative standards, by their very nature, can be applied only through a comparison of alternative plan proposals. The absolute standards can be applied individually to each alternative plan proposal since they are expressed in terms of maximum, minimum, or desirable values.

OVERRIDING CONSIDERATIONS

In the application of the stormwater and floodland management development objectives and standards to the preparation, test, and evaluation of system plans, several overriding considerations must be recognized. First, it must be recognized that any proposed stormwater and floodland management facilities must constitute integral parts of a total system. It is not possible from an application of the standards alone, however, to assure such system integration, since the standards cannot be used to determine the effect of individual facilities on the system as a whole, nor on the environment within which the system must operate. This requires the application of planning and engineering techniques developed for this purpose which can be used to quantitatively test the potential performance of proposed facilities as part of a total system. The use of mathematical simulation models facilities such quantitative tests. Furthermore, by using these models, the configuration and capacity of the system can be adjusted to the existing and future runoff loadings. Second, it must be recognized that it is unlikely that any one plan proposal will fully meet all of the standards; and the extent to which each standard is met, exceeded, or violated must serve as the measure of the ability of each alternative plan proposal to achieve the objective which the given standard complements. Third, it must be recognized that certain objectives and standards may be in conflict and require resolution through compromise,

Table 16

POINT RAINFALL INTENSITY-DURATION-FREQUENCY DATA FOR MILWAUKEE, WISCONSIN[a]

Recurrence Interval (years)	Duration and Intensity[b]						
	5 Minutes	10 Minutes	15 Minutes	30 Minutes	1 Hour	2 Hours	24 Hours
2	4.30	3.43	2.85	1.90	1.14	0.67	0.099
5	5.49	4.46	3.76	2.55	1.55	0.91	0.134
10	6.26	5.14	4.35	2.99	1.84	1.07	0.156
25	7.26	5.99	5.10	3.53	2.19	1.27	0.186
50	7.98	6.62	5.65	3.93	2.44	1.41	0.208
100	8.77	7.28	6.23	4.34	2.70	1.56	0.229

[a] *These data are based on a statistical analysis of Milwaukee rainfall data for the 84-year period 1903 through 1986.*

[b] *Intensity expressed in inches per hour.*

Source: SEWRPC.

such compromise being an essential part of any design effort.

ANALYTICAL PROCEDURES AND ENGINEERING DESIGN CRITERIA

Certain engineering criteria and procedures were used in designing alternative stormwater and floodland management plan elements, and in making the economic evaluations of those alternatives. While these criteria and procedures are widely accepted and firmly based in current engineering practice, it is, nevertheless, useful to briefly document them here. The criteria and procedures provide the means for quantitatively sizing and analyzing the performance of both the minor and major components of the total stormwater management system components considered in this plan. In addition, these criteria and procedures can serve as a basis for the more detailed design of system components. These criteria and procedures thus constitute a reference for use in facility design, and as such are intended to be applied uniformly and consistently in all phases of the implementation of the recommended stormwater and floodland management plan.

Analytical Procedures

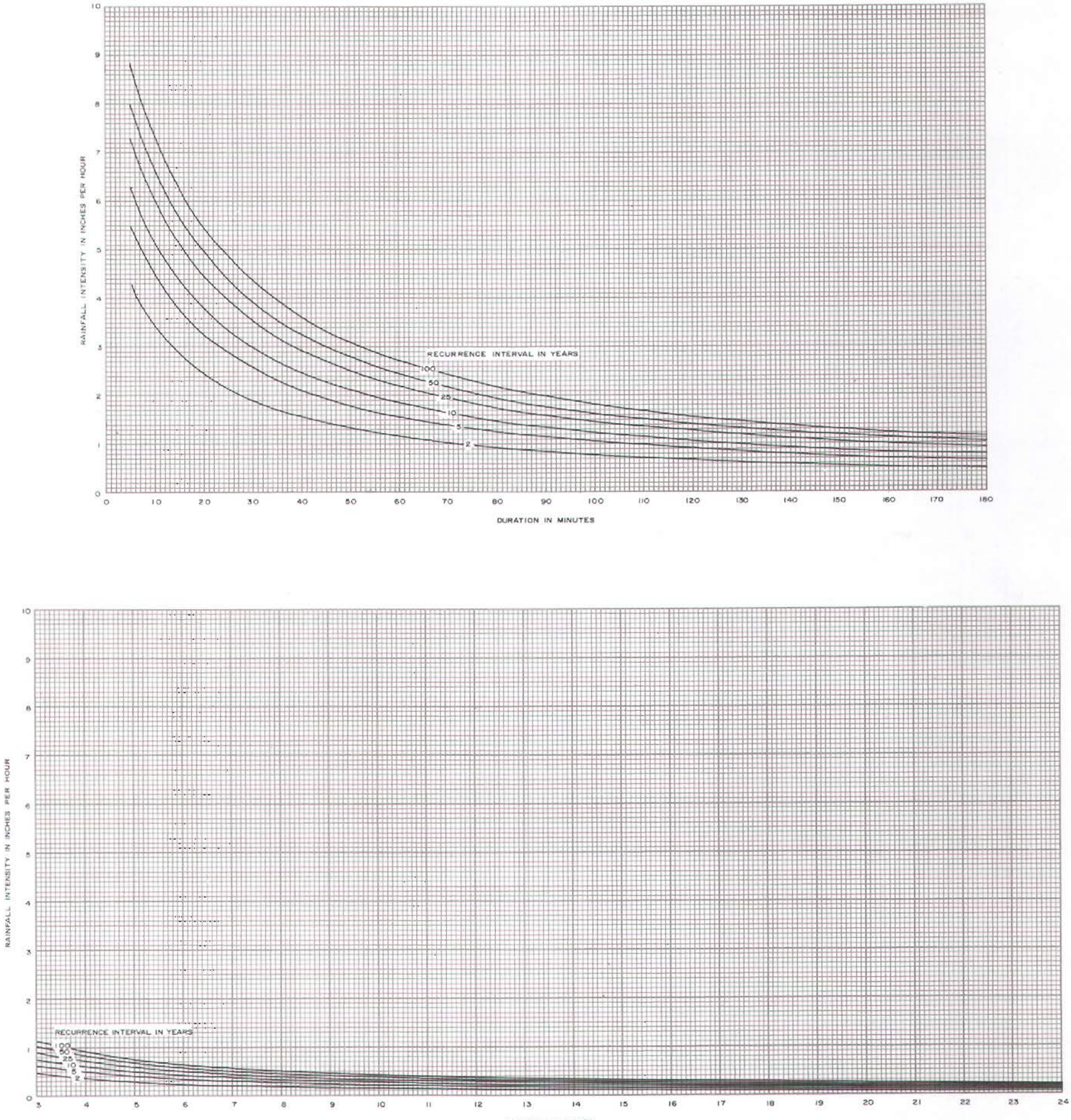
Rainfall Intensity-Duration-Frequency Data

Fundamental data for stormwater management planning and design are the rainfall intensity-duration-frequency relationships representative of the area. Such relationships facilitate determination of the total rainfall amount which may be expected to be reached or exceeded for a particular duration at a given recurrence interval. Under its comprehensive water resources planning program, the Southeastern Wisconsin Regional Planning Commission has devel oped a set of rainfall intensity-duration-frequency relationships using both a graphic procedure and a mathematical curve fitting method. The data for the 84-year rainfall record from 1903 through 1986 collected by the National Weather Service at the General Mitchell Field National Weather Service station in Milwaukee are summarized in tabular form in Table 16 and in graphic form in Figure 2. The intensity-duration-frequency equations resulting from the analysis of the Milwaukee data are presented in Table 17. Analyses conducted by the Commission staff indicate that these data are valid for use not only within the Milwaukee area, but anywhere in Southeastern Wisconsin. The curves in Figure 3,

Figure 2

POINT RAINFALL INTENSITY-DURATION-FREQUENCY CURVES FOR MILWAUKEE, WISCONSIN[a]

DURATIONS OF 5 MINUTES TO 180 MINUTES



[a] *The curves are based on Milwaukee rainfall data for the 84-year period of 1903 to 1986. These curves are applicable within an accuracy of ± 10 percent to the entire Southeastern Wisconsin Planning Region.*

Source: SEWRPC.

Table 17

POINT RAINFALL INTENSITY-DURATION-FREQUENCY EQUATIONS FOR THE DOUSMAN DITCH AND UNDERWOOD CREEK SUBWATERSHEDS STUDY AREA AND THE REGION[a]

Recurrence Interval (years)	Duration of Five Minutes or More But Less than 60 Minutes[b]	Duration of 60 Minutes or More through 24 Hours[b]
2	$i = \frac{85.1}{14.8 + t}$	$i = 26.9\,t^{-0.771}$
5	$i = \frac{118.9}{16.7 + t}$	$i = 36.4\,t^{-0.771}$
10	$i = \frac{143.0}{17.8 + t}$	$i = 43.3\,t^{-0.773}$
25	$i = \frac{172.0}{18.7 + t}$	$i = 51.0\,t^{-0.772}$
50	$i = \frac{193.4}{19.2 + t}$	$i = 56.8\,t^{-0.771}$
100	$i = \frac{214.4}{19.4 + t}$	$i = 63.0\,t^{-0.773}$

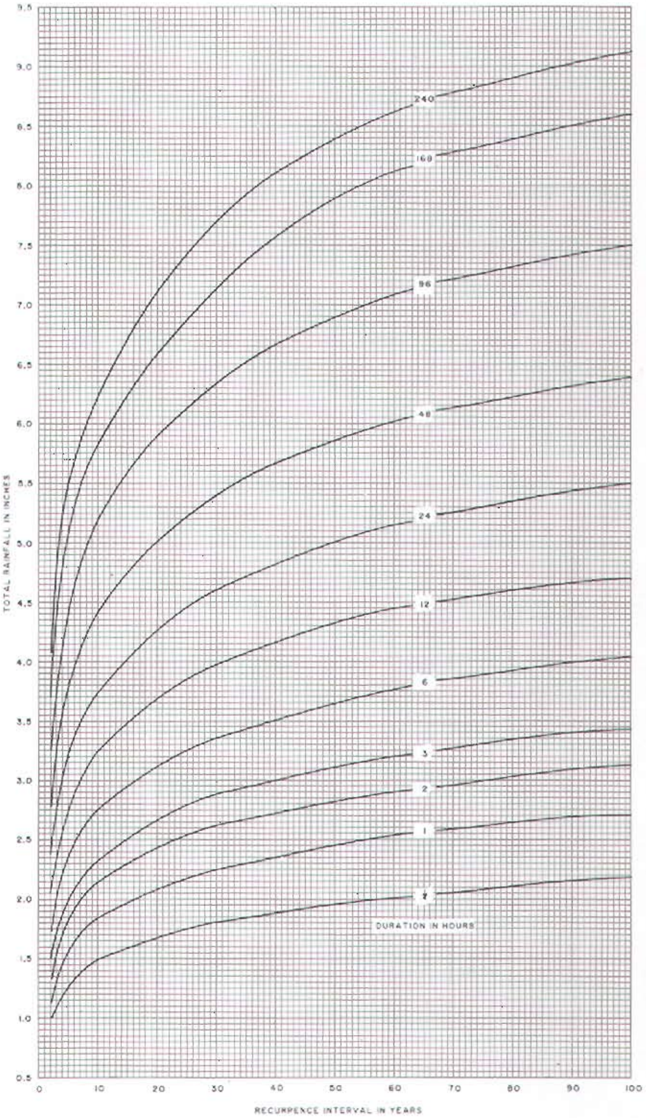
[a] *The equations are based on Milwaukee rainfall data for the 84-year period 1903 to 1986. These equations are applicable, within an accuracy of ± 10 percent, to the entire Southeastern Wisconsin Planning Region.*

[b] *i = Rainfall intensity in inches per hour*
t = Duration in minutes

Source: SEWRPC.

Figure 3

POINT RAINFALL DEPTH-DURATION-FREQUENCY RELATIONSHIPS IN THE DOUSMAN DITCH AND UNDERWOOD CREEK SUBWATERSHEDS



Source: SEWRPC.

which relate total rainfall to duration and frequency, were developed using the curves of Figure 2. It should be noted that the Commission is currently undertaking a study to update and refine the rainfall intensity-duration-frequency data for Southeastern Wisconsin, incorporating current statistical procedures and an expanded period of record through the year 1998. While this study may result in changes to the data, it is not expected to impact the alternative plans selected or significantly impact the costs involved.

Design Rainfall Frequency

To ensure that the stormwater system is able to effectively control the stormwater runoff in a cost-effective manner, storm events of specified recurrence intervals must be selected as a basis for the design and evaluation of both the minor and major drainage systems. The selection of these design storm events should be dictated by careful consideration of the frequency of inundation which can be accepted versus the cost of protection. This involves value judgments which should be made by the responsible local officials involved and applied consistently in both the public and private sectors.

The average frequency of rainfall used for design purposes determines the degree of protection afforded by the stormwater management system. This protection should be consistent with the damage to be prevented. In practice, however, the calculation of benefit-cost ratios is not deemed warranted for ordinary urban drainage facilities, and a design rainfall recurrence interval is selected on the basis of experienced engineering judgment and experience with the performance of stormwater management facilities in similar areas.

In this respect, it should be noted that the cost of storm sewers and other drainage facilities is not directly proportional to either the design storm frequency or the flow rates. A 10-year recurrence interval storm produces approximately 16.5 percent greater rainfall intensities and 26 percent greater runoff intensities than a five-year recurrence interval storm. This higher runoff rate requires sewer pipe diameters to be on the order of 10 percent larger. However, drainage systems are limited to commercially available pipe sizes which, in the most frequently used range of 15- to 66-inch diameter, have incremental diameter increases of 10 to 20 percent, corresponding incremental capacity increases of 27 to 58 percent, and corresponding average in-place cost increases of 15 to 23 percent. The incremental cost increases on a systemwide basis may be expected to be on the order of 15 percent, because only portions of any given system will require modified sizes due to the adoption of a 10-year design storm standard rather than a five-year standard.

Another consideration in evaluating alternative design recurrence intervals for drainage facilities is the risk of exceeding capacity. A five-year recurrence interval event, which may be expected to occur on the average of 20 times in 100 years, has a 50 percent chance of being exceeded in about 3.5 years, a period which may be unacceptable from a public relations point of view. In contrast, a 10-year recurrence interval event, which is expected to occur on the average of 10 times in 100 years, has a 50 percent chance of being exceeded in about seven years, and a 100-year recurrence interval event, which is expected to occur on the average of one time in 100 years, has a 50 percent chance of being exceeded in about 69 years.

Based upon consideration of the costs and risks entailed, and consistent with the current policies of the City of Brookfield and the Village of Elm Grove, a 10-year recurrence interval storm was selected for use in the design of the elements of the minor stormwater management system for the study area.

When designing the minor urban stormwater management system, the designer should be aware that exceeding capacity does not cause incipient catastrophe. On the contrary, it means only that the minor drainage system capacity has been completely utilized and the unaccommodated portion of the stormwater flow will begin to cause inconvenience and/or disruption of activities as it courses through the major system. In this respect, the minor system differs substantially from the major system.

A 100-year recurrence interval storm was selected for use in delineating areas of potential inundation along the major stormwater drainage system, and to size some elements of the system. This recurrence interval is used by the Regional Planning Commission in its flood control planning efforts, and by federal and state agencies for floodland regulation. The 100-year recurrence interval event generally—with only certain unusual exceptions—approximates, in terms of the amount of land area inundated, the largest known flood levels that have actually occurred in the Region since its settlement by Europeans. Therefore, use of a 100-year recurrence interval event provides a conservatively safe level of protection against property damage and hazard to human health and safety from surcharge of the major, as opposed to the minor, stormwater management system.

Time Distribution of Design Rainfall

The hydrologic analyses conducted for this planning effort used design storms developed by distributing the total precipitation amounts determined from the Commission rainfall intensity-duration-frequency data according to a set of four temporal rainfall distributions developed by F.A. Huff.[2] These rainfall distributions represent the "best available information on the time-distribution characteristics of heavy rainstorms at a point on small basins ... in Illinois and the Midwest."[3] Each of the distributions is characteristic of storms of different durations. The median first

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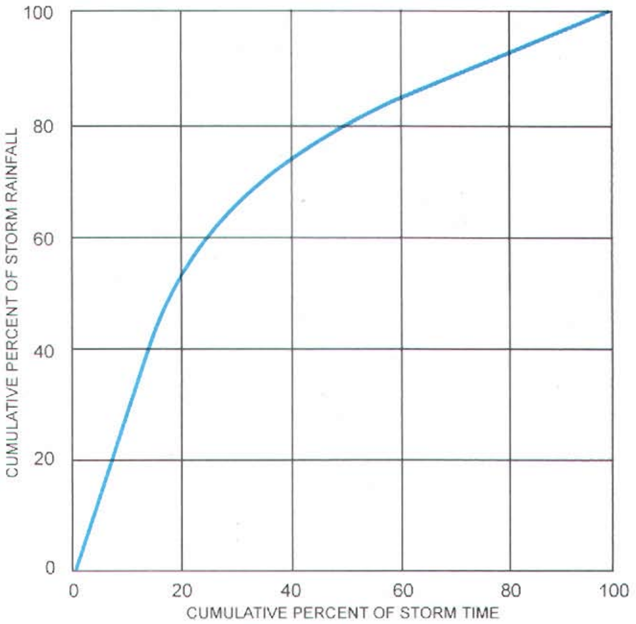
[2] *Floyd A. Huff, "Time Distribution of Rainfall in Heavy Storms,"* Water Resources Research, *Vol. 3, No. 4, 1967, pp. 1007-1019, and Floyd A. Huff,* Time Distribution of Heavy Rainstorms in Illinois, *Illinois State Water Survey Circular 173, 1990.*

[3] *Floyd A. Huff,* Time Distribution of Heavy Rainstorms in Illinois, *Illinois State Water Survey Circular 173, 1990.*

Figure 4

FIRST QUARTILE STORM MEDIAN TIME DISTRIBUTION

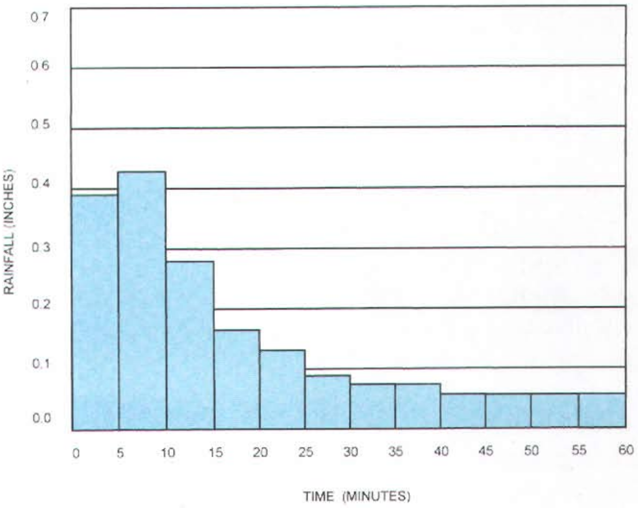


Source: F.A. Huff, "Time *Distribution of Rainfall in Heavy Storms," Water Resources Research, Vol. 3, No. 4, 1967, pp 1,007-1,019.*

quartile distribution, as shown in Figure 4, is characteristic of storms with durations from zero to six hours. The median second, third, and fourth quartile distributions are characteristic of storms with durations from 6.1 to 12 hours, 12.1 to 24 hours, and greater than 24 hours, respectively. The quartile designation refers to the portion of the storm in which the rainfall is most intense. Thus, for a second quartile storm of 12-hour duration, the most intense rainfall period would occur in the second quarter of the storm, or from the third to sixth hours. The design storm patterns, or hyetographs, for 10- and 100-year recurrence interval storms of one-hour duration are given in Figures 5 and 6. Those Figures were developed by distributing the 10- and 100-year recurrence interval, one-hour rainfall amounts given in Figure 3 according to the curve of Figure 4.

Figure 5

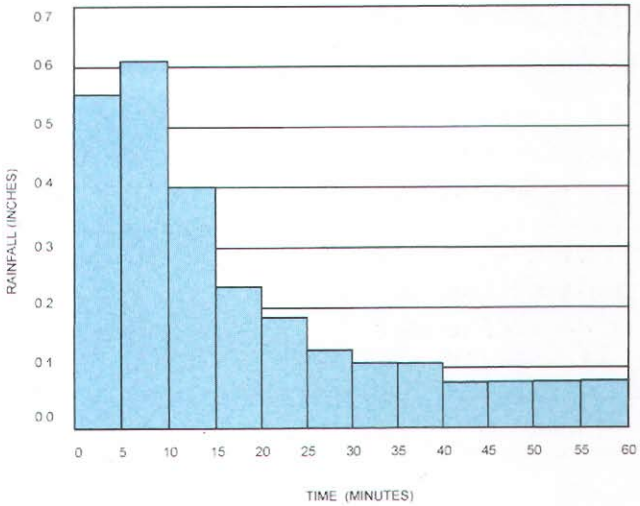
DESIGN STORM PATTERN FOR 10-YEAR RECURRENCE INTERVAL, ONE-HOUR STORM



Source: SEWRPC.

Figure 6

DESIGN STORM PATTERN FOR 100-YEAR RECURRENCE INTERVAL, ONE-HOUR STORM



Source: SEWRPC.

Design storms of varying durations were analyzed to determine the critical durations for the production of peak flow rates and critical runoff volumes at key locations within the subwatersheds. Generally, the critical storm duration for a given location along the drainage network increases with the amount of land area tributary to that point in the network. The presence of significant amounts of stormwater storage volume within the system also results in a longer critical storm duration. A third factor affecting the critical storm duration is the nature of the conveyance network in a given subbasin. If two subbasins have the same drainage areas, soil, and land cover characteristics, and similar drainage patterns, but one has a storm sewer conveyance system and the other has an open channel conveyance system, it is likely that the critical storm duration would be longer for the subbasin with the open channel system, since flow travel times in that system would be longer.

Additional Hydrologic and Hydraulic Data

Data on the hydrologic and hydraulic characteristics of the study area were also available from the files of the Commission, including data on soils; topography; the drainage patterns of the natural streams and watercourses; the waterway openings of related bridges and culverts, and related flood hazard areas; wetlands; and areas with existing flood problems. Used in the analyses were topographic maps prepared by Waukesha County and the Commission to Commission specifications at a scale of 1 inch equals 200 feet, with contours at two-foot intervals,[4] and Commission digital aerial orthophotographs prepared at a scale of 1 inch equals 400 feet. In 1996, the City and the Village each conducted extensive programs to prepare digital stormwater infrastructure system maps for the Dousman Ditch and Underwood Creek subwatersheds. Those maps were used extensively in the analyses of the existing systems and in developing the alternative and recommended plans.

Simulation of Hydrologic, Hydraulic, and Nonpoint Source Pollutant Delivery Processes

Quantification of the stormwater flow rates and volumes and of nonpoint source pollutant loading rates under both existing and probable future land use conditions allows sound, rational decisions to be made concerning stormwater management. Such quantification aids in determining the type, location, and configuration of stormwater management facilities, and is essential to sizing facilities such as storm sewers, open channels, culverts and bridges, storage and pumping facilities, and nonpoint source pollution abatement measures. Rainfall-runoff modeling techniques were used under the study to quantify stormwater flow rate and volume in both the minor and major drainage systems and to quantify flood flows in the stream system.

1. The XP-SWMM Stormwater Management Model computer program, developed by XP Software, Inc., was used for hydrologic and hydraulic analysis of the stormwater management systems of the Dousman Ditch and Underwood Creek subwatersheds.[5] The model was used to develop, combine, and route flood hydrographs generated for each subbasin of a given subwatershed. That process of combining and routing hydrographs yielded total runoff hydrographs at critical locations within each subwatershed. The model enables the evaluation of a complex hydrologic/hydraulic network, accounting for the effects on flow hydrographs of routing through storm sewers, open channels, and natural and man-made storage reservoirs.

   Subbasin runoff hydrographs under existing and probable future conditions were developed using the U.S. Soil Conservation Service (SCS) dimensionless unit hydrograph option of XP-SWMM. Under this procedure, rainfall runoff is determined by subtracting interception, infiltration, and surface storage losses from the design storm amounts. Such losses are determined using a runoff curve number calculated from the land cover and hydrologic soil group distributions in a given subbasin.

   A unit hydrograph, representing one inch of runoff from a given subbasin for a given duration of rainfall excess, was developed for each subbasin by applying timing parameters characteristic of the subbasin to the SCS standard dimensionless unit hydrograph. The subbasin flood hydrograph was generated by applying each time increment of rainfall excess to the unit hydrograph and then summing the individual hydrographs for each storm time increment, according to the principle of superposition.

   Hydrograph routing through the network was accomplished using the full Saint Venant equations for one-dimensional, gradually varied unsteady flow. The hydraulics of the major and minor systems were explicitly modeled in cases where storm sewers were found to surcharge, dividing the total flow between an overland

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[4] *The City and Village obtained data for new large-scale topographic mapping at a scale of one inch equals 100 feet and a two-foot contour interval in 1998. Those maps became available in 1999 as this plan was being completed. The new maps were consulted during the final stages of plan preparation.*

[5] *The XP-SWMM program is an enhanced version of the U.S. Environmental Protection Agency (USEPA) Stormwater Management Model (SWMM) Version 4.*

component flowing in a street and the piped component in the storm sewer. Because the XP-SWMM program models the hydraulics of the drainage network, it was applied to directly evaluate the hydraulic adequacy of the exiting stormwater management system and to perform the systems-level design of modifications or additions to the system.

2. The Hydrological Simulation Program-Fortran (HSPF)[6] was used for the development of flood discharges in Dousman Ditch, Underwood Creek, and the North Branch of Underwood Creek. The HSPF model simulates streamflow on a continuous basis using recorded climatological data as input. Flood discharges were developed by conducting discharge-frequency analyses of the simulated annual peak discharges generated by the hydrologic model according to the log Pearson Type III method of analyses, as recommended by the U.S. Water Resources Council[7] and as specified by the Wisconsin Department of Natural Resources. That approach for development of flood flows for the floodland management element of the plan is consistent with the methods used for the 1976 Menomonee River watershed study, the 1990 stormwater drainage and flood control system plan for the Milwaukee Metropolitan Sewerage District (MMSD), and the ongoing MMSD Menomonee River watercourse system plan.

3. The U.S. Army Corps of Engineers HEC-RAS "River Analysis System" model for gradually varied steady flow was used to determine flood stages along Dousman Ditch, Underwood Creek, and the North Branch of Underwood Creek and along selected streams which are part of the major drainage system. Flood profiles were developed using two- through 100-year recurrence interval flood flows for full development land use conditions, and both existing and planned stormwater drainage and channel conditions. Where those profiles indicated the existence of flooding problem areas during the 100-year recurrence interval flood conditions, HEC-RAS was used to evaluate alternatives for alleviating flooding problems.

4. The Source Loading and Management Model (SLAMM) was used to determine nonpoint source pollutant loadings.[8] SLAMM was used to estimate pollutant contributions from various land use areas under both existing and planned land use conditions and to evaluate the effects of various pollution abatement measures. Average annual nonpoint source pollutant loadings of total suspended solids, total phosphorus, lead, copper, and zinc were calculated by the SLAMM model using 1981 precipitation data from the National Weather Service station at Milwaukee Mitchell International Airport. Those data are reasonably representative of a typical annual set of storms.

Criteria and Assumptions

The criteria and assumptions set forth below were generally applied in the development of the stormwater management system plan. Many of the criteria may also apply at the project design level. The criteria and assumptions incorporate the goals, objectives, and policies of the 1995 City stormwater management guide, where appropriate.

Street Cross-Sections, Site Grading, Inlets, and Parallel Roadside Culverts

An important secondary function of all streets and highways is the collection and conveyance of stormwater runoff. The planning of stormwater drainage systems should therefore be done simultaneously with the planning of the location, configuration, and gradients of the street system. At the systems planning level, recommendations concerning the approximate gradients of existing and proposed streets are provided. Pertinent details of the curbs and gutters, roadside swales, and street crowns are assumed based upon typical cross-sections and must be further addressed in subsequent project development engineering.

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[6] *U.S. Environmental Protection Agency, Environmental Research Laboratory,* Hydrological Simulation Program-Fortran, User's Manual for Release 10, *Athens, Georgia, September 1993.*

[7] *United States Water Resources Council, "Guidelines for Determining Flood Flow Frequency,"* Bulletin No. 17 of the Hydrology Committee, *Washington, D.C., March 1976.*

[8] *Robert Pitt and John Voorhees,* Source Loading and Management Model, *Version 6.2, 1994.*

The location and size of inlets and culverts, as a part of the minor stormwater drainage system, are dictated by the allowable stormwater spread and depth of flow in streets, and attendant interference with the safe movement of pedestrian and vehicular traffic. The details of inlet locations and sizes are not determined at the systems level, but would be investigated during the detailed design of storm sewer systems.

Given the standards formulated under the study, only two assumptions concerning site grading, and one assumption concerning culverts and inlets, were required for the systems planning. It was assumed that all new urban development and redevelopment would be designed to facilitate good drainage, with slopes away from all sides of buildings to provide positive gravity drainage to streets or to drainage swales. It was also assumed that drainage swales along side lot or back lot lines or site boundaries would provide positive gravity drainage to streets.

With regard to inlets and parallel roadside culverts, such as driveway culverts, it was assumed that these system components would be designed to provide sufficient capacity to intake and pass all flow in the tributary gutters or swales from storms up to and including the 10-year recurrence interval event.

Roadside Swales

At the systems planning level, only recommendations relating to the general configuration, size, approximate depth, slope, and type of roadside swales are provided. More detailed engineering at the project development level will be needed to determine precise depth, location, and horizontal and vertical alignment of the swales, and the best response to constraints posed by structures and utilities.

In the systems planning, the Manning equation was used together with the cross-sectional area of flow to determine the required hydraulic capacity of swales. A Manning's "n" value corresponding to retardance level "D" in Figure 7 was assumed for well-constructed, properly maintained, frequently mowed, grass-lined roadside drainage swales, such as may be expected to exist adjacent to front yards in residential areas.

A Manning's "n" value corresponding to retardance level "C" in Figure 7 was assumed for properly constructed, less frequently maintained (one- to two-month mowing cycle), grass-lined roadside drainage swales commonly found in rural areas.

The following criteria and assumptions relating to the details of the grass-lined storm drainage swales and channels in and along street rights-of-way were used in the development of the stormwater management plan:

1. Swales were assumed generally to be located in public street rights-of-way and to follow the street alignments and gradients.

2. Swale cross-sections were assumed to be triangular with side slopes no steeper than one vertical on three horizontal. Where practicable and cost-effective, a trapezoidal cross-section was assumed with the bottom width selected to promote infiltration.

3. Swales were designed to accommodate the peak runoff expected from a minor—that is, a 10-year recurrence interval—storm when flowing full and without freeboard.

4. Swales were designed to provide a maximum flow velocity of five feet per second during the design storm event.

5. The minimum depth of swales below street shoulder was assumed to be one and one-half feet, while the maximum depth was assumed to be three feet.

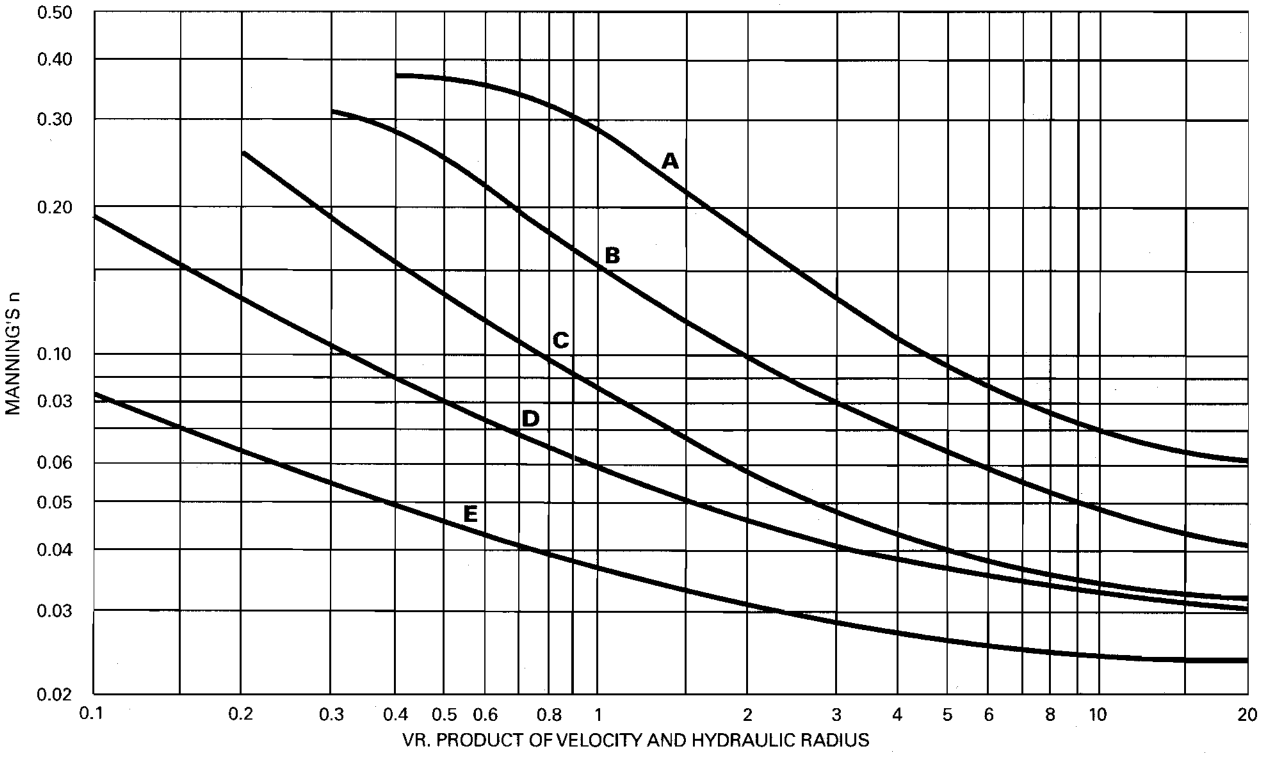
Cross Culverts

Cross culverts, which are a common feature of open drainage systems, are used to convey stormwater under a street, highway, railroad, or embankment. At the systems planning level, recommendations concerning the location, size, and type of material of cross culverts are provided. More detailed engineering at the project development level will be needed to determine the precise depth, location, and horizontal and vertical alignment of the culverts and the best response to constraints posed by structures and utilities.

The hydraulic capacity of any culvert is affected by its cross-sectional area, shape, entrance geometry, length, slope, construction material, and depth of ponding at the inlet and outlet, details which must be addressed at the project development level. Culvert flows are classified as having either inlet or outlet control—that is, according to whether the discharge capacity is controlled by the inlet or outlet characteristics. Typical inlet control and outlet control

Figure 7

MANNING'S "n" FOR VEGETATION-LINED CHANNELS FOR VARIOUS RETARDANCE LEVELS



Source: U.S. Soil Conservation Service.

culvert conditions are shown in Figure 8. Under inlet control conditions, the discharge capacity of a culvert is controlled at its entrance by the depth of headwater, the entrance shape and cross-sectional area, and the type of entrance edge. Under outlet control conditions, the discharge capacity of a culvert is influenced by the headwater depth, tailwater depth, entrance shape and cross-sectional area, and type of entrance edge, by the cross-sectional area, shape, slope, and length, and by the roughness of the culvert barrel.

In planning the system, required culvert sizes were determined by evaluating multiple constraints and selecting an appropriate size which appeared to best meet all requirements. Nomographs and capacity charts are available in the literature for varying pipe shapes, sizes, materials of construction, and entrance conditions.

For both annular corrugated metal pipe with a corrugation depth of 0.5 inch and helical corrugated metal pipe with a corrugation depth of one inch or less, a Manning's "n" value of 0.024 was assumed. For annular corrugated metal pipe with a corrugation depth of one inch, a Manning's "n" value of 0.027 was assumed. For annular corrugated metal pipe with a corrugation depth of more than one inch a Manning's "n" value of 0.032 was assumed. A Manning's "n" value of 0.013 was assumed for well-constructed, precast, concrete pipe culverts flowing full.

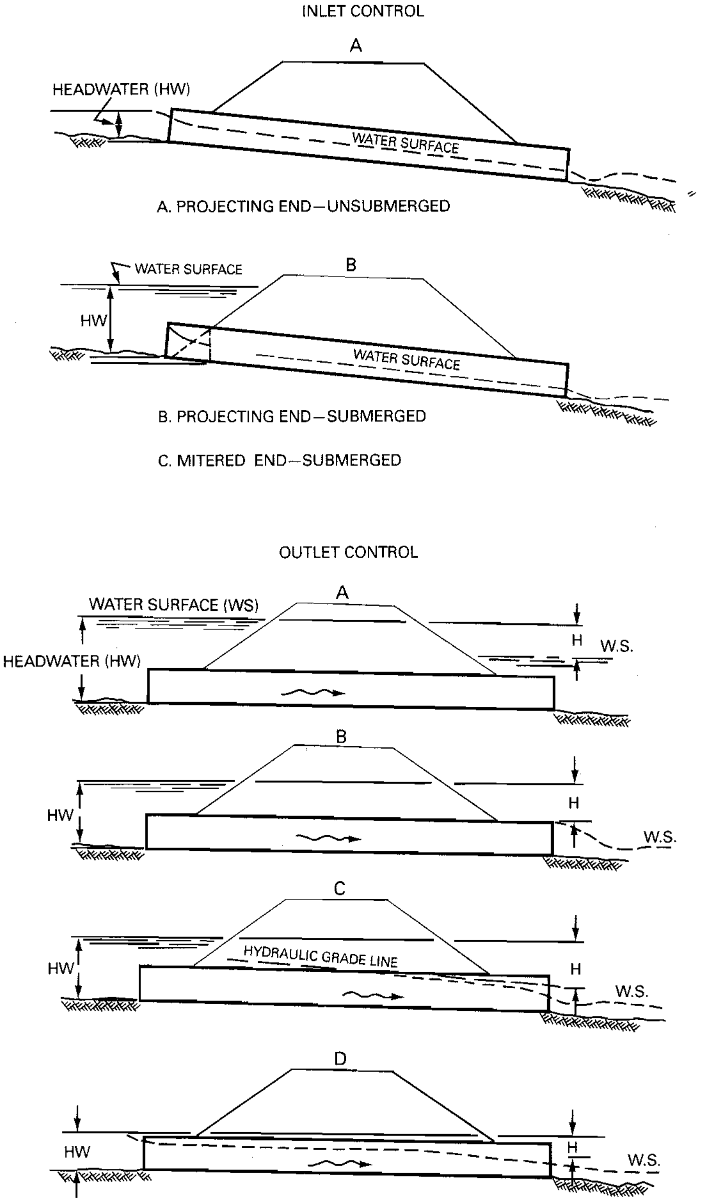
The following criteria and assumptions were used in the development of culvert sizes for the stormwater management system plan:

1. The culvert location should provide a direct exit, avoiding an abrupt change in direction at the outlet end and, preferably, at the inlet end.

2. The minimum culvert size used was 12 inches in diameter.

Figure 8

CULVERT HYDRAULIC CONDITIONS



Source: American Iron & Steel Institute.

3. The culverts were assumed to be laid on a constant gradient.

4. In all areas with rural street cross-sections, new cross culverts were generally assumed to be circular pipes or pipe arches, constructed of corrugated metal. Cross culverts under streets with urban cross-sections were assumed to be constructed of reinforced concrete. New ditch enclosures involving longer runs of continuous pipe, were assumed to be circular, arch, or horizontal elliptical reinforced concrete pipe.

5. Culvert inlets were assumed to be unblocked.

6. Culverts were assumed to have an unsubmerged outlet during a minor—that is, a 10-year recurrence interval storm event.

During the facility design phase subsequent to the adoption of the system plan, the following additional criteria should be considered:

1. Appropriate energy dissipation and/or erosion protection should be provided at culvert inlets and outlets. The type of protection will be dictated by site-specific hydraulic considerations.

2. In streams with an existing or potential valuable fishery, the bottoms of culverts should be designed to allow for the free passage of aquatic organisms for a variety of flow extremes. Typical culvert installations to permit fish passage are shown in Figure 9.

Open Drainage Channels

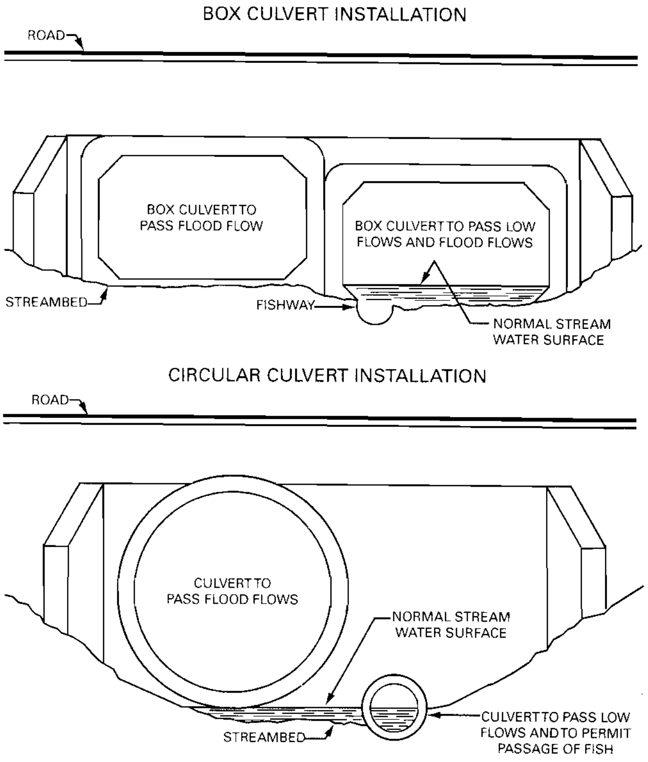
Open drainage channels in and along exclusive rights-of-way are a necessary and appropriate component of the total stormwater drainage system. In some areas of the stormwater management study area, open drainage channels, together with roadside swales, may serve as the sole component of the engineered stormwater drainage system which conveys surface runoff to the receiving natural stream system.

At the systems planning level, recommendations are provided with respect to the general location, cross-section bottom width and approximate bottom elevation depth, side slopes, gradient, and type of open drainage channels. More detailed engineering at the project development level will be needed to determine the precise location and horizontal and vertical alignment of the channels, the need for and type of channel lining, and the best response to constraints posed by structures, other utilities, and street layout.

In the system planning, the Manning's equation was used to determine the hydraulic capacity of open channels. Careful consideration was given to allowable grades and depths of flow to prevent unacceptable velocities and damage to the facilities

Figure 9

TYPICAL CULVERT INSTALLATIONS TO PROVIDE FOR FISH PASSAGE



Source: SEWRPC.

and adjacent land uses. Where flood hazard areas were delineated, the HEC-RAS step backwater simulation model was used.

The following criteria relating to the details of the open drainage channels were used in the development of the stormwater management plan and/or can serve as guidelines in the facility design:[9]

1. All open drainage channels which are part of the major stormwater drainage system were designed to accommodate the peak runoff from a 100-year recurrence interval storm under planned land use and channel conditions.
2. Features to mitigate adverse impacts on fish and wildlife habitat should be considered in the design of channel modifications in streams with an existing or potential valuable fishery.
3. Manning's "n" values in the range from 0.030 to 0.045 were used for modified existing or recommended new open channels which were assumed to be lined with turf or grasses, depending on anticipated vegetative growth and frequency of maintenance. Manning's "n" values in the range from 0.035 to 0.05 were used for modified existing or recommended new open channels which were assumed to be lined with riprap.
4. The maximum allowable flow velocity for modified channels lined with turf or grasses was assumed to be about six feet per second (fps). The maximum allowable flow velocity for modified channels lined with riprap was assumed to be about 10 fps.
5. Where necessary, grade control structures were provided to reduce the channel gradient and obtain flow velocities within the accepted limits. Channel bottom drop structures were not used in streams with existing or potential valuable fisheries.
6. Appropriate energy dissipation and erosion protection should be provided at any grade control structures. The type of protection will be dictated by site-specific hydraulic considerations.
7. Channel bends should have a minimum radius equal to twice the design flow top width, or 100 feet, whichever is greater.

Storm Sewers

At the systems planning level, only recommendations for the general configuration, size, approximate invert elevation, slope, and type of storm sewer facilities are provided. More detailed engineering at the facility design level will be needed to determine the precise invert elevation, location, and horizontal and vertical alignment of the sewer, the type of material used for the sewer, and the best response to constraints posed by structures and other utilities.

In the systems planning, the hydraulic capacity of sewers was determined using the EXTRAN hydraulic

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[9] *These criteria relate to small channels which function as part of the stormwater management system.*

routine within the XP-SWMM model. Values for the Manning's roughness coefficient "n" vary with the type and conditions of the sewer, the depth of flow in the sewer, and the diameter of the sewer. A Manning's "n" value of 0.013 was assumed typical of well-constructed, precast, concrete pipe sewer lines. A Manning's "n" value of 0.024 was assumed for existing corrugated metal storm sewer lines.

The following criteria and assumption relating to the details of the storm sewers were used in the development of the stormwater management plan:

1. Storm sewers were assumed generally to be located in public street rights-of-way and to follow the street alignments and gradients.

2. All storm sewers should be designed to accommodate the peak runoff expected from a minor—that is, a 10-year recurrence interval—storm when flowing full.

3. New storm sewers were assumed to be constructed of reinforced concrete pipe.

4. The minimum pipe size should be 12 inches in diameter.

5. The minimum desirable velocity during the design storm event should be 2.5 feet per second.

6. Planned storm sewer outlet invert elevations should be above the channel bottom elevations of the receiving watercourses.

7. The minimum depth of cover over the top of the sewer should be three feet.

Stormwater Storage Facilities

Natural storage of stormwater is provided in surface depressions, vegetated areas, and pervious soils. Natural storage can be enhanced by preserving open areas, woodlands, wetlands, ponds, and areas with large infiltration capacities. These attributes can usually be incorporated into a stormwater management system at less cost than would be required for the incorporation of artificial storage facilities. Artificial storage facilities include constructed onsite swales, roadside swales, temporary storage facilities on parking lots and other open areas, and retention and detention basins.

Under this system planning effort, stormwater storage facilities were considered for the purposes of stormwater drainage, nonpoint source pollution control, peak flow reduction to control streambank erosion and streambed scour, or a combination of those functions. The three types of facilities considered include: 1) retention basins, 2) dry detention basins, and 3) wet detention basins. The term retention basin is used for a facility which stores runoff, but does not release the runoff during a storm. Runoff stored in such a facility is either pumped out, released after the storm through the operation of a gated outlet, or passively released through a combination of evaporation and infiltration. Such facilities may serve either a quantity or a quality control function, or both purposes. When a retention basin serves a quality control function through infiltration, it is also called an *infiltration basin*. The term dry detention basin is used to identify a stormwater storage facility which drains between storm events and has no permanent pond. Such facilities are primarily for the control of peak rates of runoff, rather than significant control of nonpoint source pollution. The term wet detention basin is used to identify a storage facility which has a permanent pond and generally provides control of nonpoint source pollution. Variations on wet and dry detention basins, which are designed to improve the pollutant removal efficiency of the basins, are extended dry and extended wet detention basins. In those types of basins, the amount of time for which runoff is detained is extended beyond that for a standard basin. Additional variations on the wet basin include constructed wetland basins, pond/wetland systems, and extended detention wetlands. At the systems planning level of detail, reference is only made to dry and wet detention basins.

Recommendations concerning the location, type, approximate size, and capacity of storage facilities and outlet flow constraints are provided in this report. More detailed engineering at the project development level will be needed to precisely locate, configure, and size storage facilities and to specify such details as the inlet and outlet control facilities. Modifications to the basic basin configurations for the purpose of enhancing removal of nonpoint source pollutants would also be addressed at the project design level. In planning the system, required quantity control storage volumes were calculated using the XP-SWMM simulation model. Required wet detention basin sizes for nonpoint source pollution control were determined using the SLAMM program. The following criteria relating to storage facilities were used in the development of the stormwater management system plan:

1. Storage facilities were sized to control a range of storms depending on intended purposes. Storage facilities intended to serve as components of the minor drainage system were sized to control storms with recurrence intervals ranging from two to 10 years, under planned land use and channel system conditions. Storage facilities designed as components of the major drainage system were sized to control storms with recurrence intervals ranging from two to 100 years, under planned land use and channel system conditions. Storage systems planned for water quality purposes were designed to control storms with recurrence intervals up to, and including two years.

2. Where practical, storage facilities for stormwater drainage purposes were designed to limit the design outflow to no more than the capacity of the existing downstream conveyance and storage systems.

3. Where modification to, or replacement of, the existing downstream conveyance and storage system is necessary, any proposed upland storage facilities that are required should be sized to minimize the costs of the combined storage and conveyance system.

4. The effects of storage facilities on the frequency, duration, and magnitude of downstream flooding under future conditions as compared to existing conditions were carefully examined. Routing through a storage facility significantly flattens the outflow hydrograph in comparison to the inflow hydrograph. Peak flows are reduced and the duration of peak, or near-peak, flows increased. When prolongation of near-peak flows causes those flows to coincide with near-peak flows of upstream or downstream tributaries, the storage facilities should be designed so as not to increase combined future downstream peak flows to an unacceptable level.

5. Storage depths on parking lots, truck stopping areas, and similar open spaces were assumed to not exceed six inches during the design flood event.

6. Storage facilities that include dams or earth embankments which detain runoff were assumed to include an emergency spillway to safely pass flows up to, and including, those resulting from a 100-year recurrence interval storm, with appropriate freeboard.

Stormwater Pumping Facilities

At the systems planning level, only recommendations concerning the location, type, and capacity of the pumping facility are provided. More detailed engineering at the project development level will be needed to determine the type of pumps, type of drives and motor requirements, type of electrical controls, and size and configuration of intake facilities.

The following criteria and assumptions relating to stormwater pumping facilities should be considered in the development of the stormwater management system plans and may be used as guidelines in facilities design:

1. Consideration should always be given to the feasibility of providing gravity drainage as an alternative to pumping facilities.

2. An evaluation should be made of the ability of the pumping station and any associated gravity drainage facilities to provide protected areas with relief from flooding during storms ranging up to and including the 100-year recurrence interval storm.

3. The pumping station should be designed with a gravity overflow to the major drainage system.

Urban Nonpoint Source Pollution Control Measures

Adequate control of urban nonpoint source pollution requires construction site erosion and sediment control and control of pollutants contained in runoff from developed land. Detailed criteria for construction site erosion and sediment control are given in the Wisconsin Department of Natural Resources, Wisconsin Construction Site Best Management Practice Handbook (latest revision November 1993). Design considerations and criteria for control of nonpoint source pollution from developed land are given in Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban BMPs, Metropolitan Washington Council of Governments, 1987. The following general criteria for nonpoint source control measures were considered in the development of this stormwater management plan and can serve as guidelines in the facilities design phase.

1. Pretreatment of storm runoff to infiltration devices was considered to minimize clogging and reduce maintenance. Such pretreatment was assumed to consist typically of grass filter strips. The addition of a sedimentation-flotation basin to trap oil and grease was considered when the infiltration device would be constructed in a commercial area.

2. Where compatible with the goal of efficiently transporting stormwater runoff, infiltration through grass swales was maximized by using a maximum longitudinal slope of less than 5 percent.

3. Where feasible, to avoid short circuiting of flow and to maximize the efficiency of wet detention basins, the minimum basin length-to-width ratio was set at three to one, or baffles were assumed to be provided to increase the flow length.

4. The depths of wet detention basins were assumed to range between three and eight feet, with an average depth of five feet. A three-foot minimum depth is needed to minimize scour and resuspension of deposited sediments, and an eight-foot maximum depth will aid in reducing aquatic plant growth.

5. The design of retention basins and other infiltration systems at the facilities level requires site-specific investigations to establish design parameters and to avoid groundwater contamination. Important considerations related to the assessment of the potential for groundwater contamination are the soil permeability, the depth to the water table, the depth to bedrock, and the existing and potential uses of the receiving groundwater. For this system planning effort, the location of infiltration systems was limited to areas covered by relatively permeable Hydrologic Soil Group A or B soils, where the depth to the seasonally high water table is greater than five feet, and where the tributary land slopes do not exceed 5 percent.

6. The maximum area draining to a single infiltration trench was assumed to be five acres.

Stormwater Management Facility Safety Design Criteria

Because of the detailed nature of the design of most safety measures for stormwater management facilities, such design is most appropriately accomplished at the final design stage rather than at the systems planning stage. The following criteria and assumptions relating to wet detention basins were considered in the development of the stormwater management system plan and may be used as guidelines in facilities design. Additional, site- and case-specific measures should be incorporated in the detailed design.

1. For wet detention basins, a 10-foot-wide, essentially level terrace should be provided around the perimeter of the permanent pond above the permanent water level and another such terrace should be provided around the perimeter at a depth of about one foot below the water level.

2. Detention basin side slopes should be no steeper than one vertical on three horizontal and preferably flatter.

3. Removable safety cages or grates should be provided on the outlets of storage facilities and on entrances to large storm sewers which may pose a safety hazard. Such grates should be inspected monthly and after each storm totaling 1.5 inches or more of runoff in 24 hours. Maintenance to clear the grates should be performed as appropriate.

4. Signs should be posted at detention storage facilities indicating that they will occasionally store water, presenting a safety hazard.

ECONOMIC EVALUATION

It is customary to evaluate plans for water resource development projects on the basis of benefits and costs. This is particularly appropriate if the prospective development represents opportunities for investments to provide economic return to the public and if a comparison of alternative investments is desirable. In the case of stormwater management systems, however, it is assumed that such systems must be provided to fulfill a fundamental need of the community, and consequently, they do not compete with alternatives of investment in other economic sectors. Accordingly, it is assumed that the least costly alternative system that meets the stormwater management objectives set forth in this chapter will be the most desirable alternative economically.

The economic evaluations conducted under this stormwater management planning program include capital cost estimates and annual operation and maintenance cost estimates. Capital costs include construction contract costs plus engineering, inspection, and contract administration costs. Cost data for stormwater drainage and flood control measures are presented in Appendix A. Cost data for urban nonpoint source pollution control measures were obtained from SEWRPC Technical Report No. 31,[10] but were updated to reflect 1998 costs.

Where feasible, construction cost curves for entire components are presented in Appendix A. Such curves are given for surface storage facilities, storm sewers, circular culverts, and pumping stations. For other structural stormwater management measures, unit construction costs for each element of the particular measure are tabulated. Unit cost tabulations are provided for site work, such as clearing, grubbing, and excavation; erosion protection, such as riprap and gabions; landscaping; and reinforced concrete. Unit costs of construction are also provided for concrete box culverts, corrugated metal pipe arch culverts, structural plate pipe arch culverts, reinforced concrete pipe arches, and horizontal elliptical pipes. Where site-specific conditions were expected to result in unit costs that would vary from the generalized data of Appendix A, unit costs were adjusted appropriately.

Figures A-1 through A-6 and Tables A-1 through A-10 in Appendix A represent 1998 construction or operation and maintenance costs based on an Engineering News-Record, Construction Cost Index (CCI) of 6,740. When estimating total project costs, the costs obtained from those figures and tables should be adjusted using the CCI for the year of the estimate and, unless noted otherwise, increased by 35 percent to account for engineering, administration, and contingencies. Where applicable, the cost of land acquisition or easements should be added.

The cost data presented in Appendix A were obtained from bid tabulations for recent stormwater and floodland management projects within the Region, from past Regional Planning Commission studies, and from studies conducted by the U.S. Army Corps of Engineers. Cost data for the structural measures considered were adopted after comparison and evaluation of data from these sources.

The adopted base cost data are those that are considered the most applicable to the types of projects considered for the Dousman Ditch and Underwood Creek stormwater and floodland management plan. The cost data presented in Appendix A were used in the economic evaluation of alternative systems plans, and are not intended to be used for project estimating purposes. Actual costs will vary from these estimates, reflecting site-specific conditions, local availability and supply of materials, and labor costs. Any necessary land acquisition costs were estimated utilizing real estate cost estimates provided by the City of Brookfield and the Village of Elm Grove.

SUMMARY

The process of formulating objectives and standards for stormwater and floodland management is an essential part of the planning process. To reflect the basic needs and values of the community, it is necessary that these objectives and standards be prepared within the context of, and be fully consistent with, proposed land use conditions and broad community development objectives.

The following seven stormwater and floodland management objectives were formulated to guide the design, test, and evaluation of alternative stormwater management plans and the selection of a recommended plan from among the alternatives considered:

1. The development of a stormwater and floodland management system which reduces the exposure of people to drainage-related inconvenience and to health and safety hazards and which reduces the exposure of real and personal property to damage through inundation resulting from flooding and inadequate stormwater drainage.

2. The development of a system which will effectively serve existing and planned future land uses and will promote implementation of

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

the adopted land use plan set forth in the Waukesha County development plan.

3. The development of a system which will abate nonpoint source water pollution and help achieve the recommended water use objectives and supporting water quality standards for surface waterbodies.

4. The development of a stormwater and floodland management system which will maintain or enhance existing terrestrial and aquatic biological communities, including fish and wildlife.

5. The development of a stormwater and floodland management system which will be flexible and readily adaptable to changing needs.

6. The development of a stormwater and floodland management system which will not pollute the groundwater aquifers serving the City and the Village.

7. The development of a stormwater and floodland management system which will efficiently and effectively meet all of the other stated objectives at the lowest practicable cost.

Complementing each of the foregoing objectives is a set of quantifiable standards which can be used to evaluate the relative or absolute ability of alternative plan designs to meet the objective. The objectives and standards, which are set forth in Table 12, incorporate the goals, objectives, and policies of the 1995 City stormwater management guide, where appropriate.

In addition to presenting the objectives and standards established for the Dousman Ditch and Underwood Creek subwatersheds stormwater and floodland management plan for the City of Brookfield and the Village of Elm Grove, this chapter presents the engineering design criteria and analytic procedures that were used to design and size the alternative plan elements and which will serve as a basis for the more detailed design of stormwater and floodland management system components. Criteria and procedures were developed for estimating stormwater flow rate and volume and for designing street cross-sections, swales, culverts, open channels, storm sewers, storage facilities, pumping facilities, and urban nonpoint source pollution control measures. In addition, stormwater management facility safety design criteria are presented.

Consistent with existing City and Village policies, and with good engineering practice, a 10-year recurrence interval design storm was selected for the evaluation and design of the components of the minor, or convenience, stormwater management system. A 100-year recurrence interval storm was selected for use in evaluating the floodland management system and the major, or emergency, stormwater management system, in delineating areas of potential inundation along the stormwater drainage and stream system, and to size some elements of the system.

The hydrologic and hydraulic modeling of the subwatersheds under existing and full development conditions was accomplished with the XP-SWMM Stormwater Management Model computer program the USEPA HSPF continuous simulation program, and the U.S. Army Corps of Engineers HEC-RAS River Analysis System water surface profiles computer program. Estimation of nonpoint source pollution loads was accomplished using the Source Loading and Management Model (SLAMM).

The economic evaluations conducted under this stormwater management planning program include capital cost estimates and annual operation and maintenance cost estimates. Construction cost and operation and maintenance data which were used in the economic evaluation of alternative systems plans are presented in Appendix A.

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Chapter IV

WATER QUALITY MANAGEMENT PLAN ELEMENT

INTRODUCTION

This chapter describes and evaluates alternative water quality management plans designed to serve the Dousman Ditch and Underwood Creek subwatersheds under planned buildout development conditions.

The alternative nonpoint source pollution control plans are evaluated within the context of the Menomonee River watershed plan;[1] the regional water quality management plan for southeastern Wisconsin, as amended;[2] and the Menomonee River priority watershed nonpoint source control plan[3].

The components of the alternative nonpoint source pollution control plans developed for the subwatersheds are described below and capital and operation and maintenance costs are provided.

The recommended stormwater drainage, nonpoint source pollution control, and floodland management measures are integrated into a recommended stormwater management plan for the subwatersheds as set forth in Chapter VI. The design of the recommended plan was based on consideration of many factors, with primary emphasis, however, upon the degree to which the recommended stormwater management objectives and supporting standards are satisfied. Most important among the considerations were those relating to cost, to the ability of the system components to accommodate flows resulting from the design storm events without exacerbating downstream drainage and flooding problems, and to the ability of the system components to abate nonpoint source pollution.

WATER USE OBJECTIVES AND WATER QUALITY STANDARDS

The water use objectives and supporting water quality standards to be met by surface waters in the study area are set forth in Chapter III of this report. The levels of control of nonpoint source pollutants determined to be needed to meet those objectives and standards provide the basis for selection of the recommended water quality management plan.

The entire length of Underwood Creek in the study area is recommended to meet the warmwater forage fish and limited recreational water use objectives. The stream is currently only partially meeting its water use objectives. The full achievement of the recommended water use objectives is limited by: 1) loss of aquatic habitat due to sedimentation, streamflow fluctuations, partial concrete lining of a limited reach of the stream, and enclosure of a portion of the stream; 2) high bacteria levels from fecal material; and 3) toxicity from heavy metals.

The entire length of Dousman Ditch is recommended to meet the limited forage fish and limited recreational water use objectives. The stream is currently only partially meeting its water use objectives. The full achievement of the recommended water use objectives is limited by loss of aquatic habitat due to streamflow and temperature fluctuations.

POLLUTANT LOADING ANALYSIS

Critical Land Uses within the Study Area

The 1992 priority watershed study identified commercial, industrial, governmental and institutional, freeway, and high-density residential uses as critical land uses contributing to nonpoint source pollution in the study area. As set forth in Table 4 of Chapter II and shown graphically on Map 2, under 1990 land use conditions, about 70 percent of the Dousman Ditch

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[1] *SEWRPC Planning Report No. 26,* A Comprehensive Plan for the Menomonee River Watershed, *Volume Two,* Alternative Plans and Recommended Plan, *October 1976.*

[2] *SEWRPC Memorandum Report No. 93,* A Regional Water Quality Management Plan for Southeastern Wisconsin: An Update and Status Report, *March 1995.*

[3] *Wisconsin Departments of Natural Resources and Agriculture, Trade and Consumer Protection,* A Nonpoint Source Control Plan for the Menomonee River Priority Watershed Project, *March 1992.*

subwatershed was developed in urban land uses. In1990, about 17 percent of the subwatershed was in critical land uses. Upon full buildout of the subwatershed, it is anticipated that about 81 percent of the subwatershed would be developed in urban land uses and about 20 percent of the subwatershed would be in critical urban uses. Under 1990 land use conditions, about 78 percent of the Underwood Creek subwatershed was developed in urban land uses, including about 10 percent of the subwatershed in critical land uses. Upon full buildout of the subwatershed, it is anticipated that about 86 percent of the subwatershed would be developed in urban land uses and about 11 percent of the subwatershed would be in critical urban uses. In the interim period between 1990 and the present, much of the planned buildout development has occurred in the subwatersheds. Overall, about 14 percent of the entire study area, including both subwatersheds, would be developed in critical land uses under buildout conditions. The water quality management plan element focuses primarily on providing treatment of runoff from critical land uses under buildout conditions as shown on Map 9.

Quantification of Existing (1990) and Planned Buildout Condition Loadings of Nonpoint Source Pollutants

As described in Chapter III, the Source Loading and Management model (SLAMM) was used to estimate average annual loadings of total suspended solids, total phosphorus, lead, copper, and zinc under both existing (1990) and planned buildout land use conditions with existing controls in the subwatersheds. A comparison of estimated annual loadings is set forth in Tables 18 and 19 and the hydrologic units used in the SLAMM analysis are shown on Map 9.

There are significant existing controls in the subwatersheds, including 15 ponds that collect runoff from a total area of about one square mile, or about 9 percent of the study area;[4] grassed roadside swales with culverts or grassed swales with underlying storm sewer ditch enclosures that serve almost the entire study area; and a program of sweeping streets once in spring and once in fall in the City of Brookfield and once in late winter and once in spring in the Village of Elm Grove. The effects of those controls were considered in the determination of the existing condition loadings. The SLAMM results indicate that the existing ponds would be expected to be from about 65 to 95 percent effective in reducing nonpoint source pollutant loadings under existing land use conditions.

For the study area as a whole under buildout conditions, the annual loadings of sediment and phosphorus would be expected to increase by about 6 percent and 12 percent, respectively, relative to 1990 land use conditions. The annual loadings of lead, copper, and zinc would be expected to increase between 6 and 14 percent relative to 1990 land use conditions.

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

With regard to the targeted nonpoint source pollutant loading reductions, the measures considered were directed toward reducing the pollutant loadings on the basis of two separate planning efforts. The primary objective was to provide reductions in nonpoint source pollutant loadings to the levels set forth in the regional water quality management plan as amended. That level of control, when combined with the recommended level of control of point source loadings, would achieve the water quality standards associated with the water use objectives described earlier. These recommendations were based upon analyses, including extensive in-stream water quality simulation modeling conducted to establish needed pollutant reductions on a major subwatershed basis, and were recommended to be refined by subsequent second-level, more site-specific planning programs. For the Dousman Ditch and Underwood Creek subwatersheds, the recommended level of control was determined to be a reduction of about 25 percent of the nonpoint source loadings estimated under planned land use conditions, in addition to urban construction site erosion control and streambank erosion controls.

The water quality modeling conducted to develop these recommendations included simulation of temperature, biochemical oxygen demand, dissolved oxygen, fecal coliforms, ammonia nitrogen, and phosphorus.

In addition to the recommendations developed in the regional water quality management plan, nonpoint

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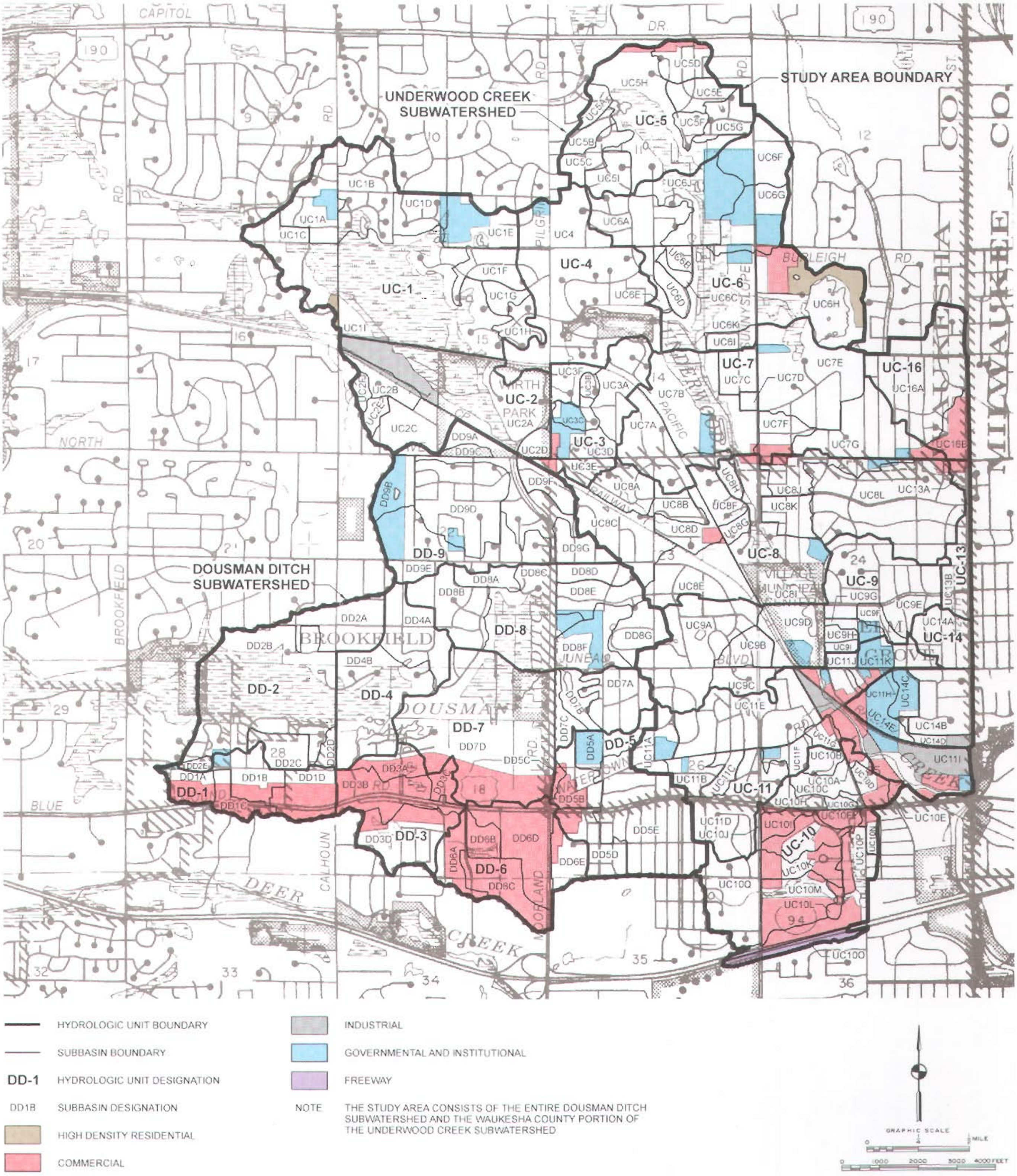
[4] *One of the existing ponds in the City of Brookfield was constructed to serve a new low-density residential area that was developed after 1990.*

Map 9

CRITICAL LAND USES FOR CONTROL OF NONPOINT SOURCE POLLUTION



Source: SEWRPC.

Table 18

ANNUAL NONPOINT SOURCE POLLUTANT LOADINGS TO UNDERWOOD CREEK AND DOUSMAN DITCH UNDER EXISTING (1990) AND PLANNED BUILDOUT LAND USE CONDITIONS WITH EXISTING CONTROLS[a]

Subbasin	Drainage Area (acres)	Total Solids (pounds)			Particulate Solids (pounds)			Total Phosphorus (pounds)			Copper (pounds)			Lead (pounds)			Zinc (pounds)		
		Existing (1990) Land Use	Planned Buildout Land Use	Percent Change	Existing (1990) Land Use	Planned Buildout Land Use	Percent Change	Existing (1990) Land Use	Planned Buildout Land Use	Percent Change	Existing (1990) Land Use	Planned Buildout Land Use	Percent Change	Existing (1990) Land Use	Planned Buildout Land Use	Percent Change	Existing (1990) Land Use	Planned Buildout Land Use	Percent Change
UC-1	571.1	494,570	505,420	2	144,490	155,910	8	326	371	14	503	451	-10	206	183	-11	228	343	50
UC-2	228.6	186,310	210,310	13	64,470	74,300	15	174	187	7	338	274	-19	249	89	-64	123	130	6
UC-3	141.9	126,860	126,860	0	43,560	43,560	0	119	119	0	146	146	0	68	68	0	104	104	0
UC-4	238.0	242,280	242,280	0	89,960	89,960	0	214	214	0	276	276	0	124	124	0	152	152	0
UC-5	266.1	265,830	299,360	13	82,760	94,470	14	165	226	37	285	333	17	154	173	12	157	186	18
UC-6	429.0	368,080	405,410	10	105,110	120,980	15	296	369	25	300	335	12	150	163	9	202	309	53
UC-7	455.2	445,640	438,360	-2	136,560	148,850	9	369	437	18	496	551	11	237	196	-17	300	310	3
UC-8	557.4	498,320	503,330	1	172,790	175,580	2	457	474	4	546	552	1	251	256	2	346	346	0
UC-9	391.0	314,760	315,150	0	91,490	91,890	0	301	301	0	270	274	1	125	129	3	207	207	0
UC-10	379.2	389,820	429,250	10	119,070	129,690	9	300	334	11	307	288	-6	296	326	10	254	300	18
UC-11	454.7	356,030	416,510	17	140,050	164,600	18	409	464	13	377	441	17	205	300	46	282	323	15
UC-13	43.5	33,670	33,670	0	14,180	14,180	0	38	38	0	48	48	0	21	21	0	27	27	0
UC-14	158.4	134,960	142,240	5	46,730	49,580	6	130	141	8	101	116	15	67	74	10	112	109	-3
UC-16	164.7	152,680	152,680	0	58,470	58,470	0	180	180	0	135	135	0	97	97	0	119	119	0
Subtotal	4,478.8	4,009,810	4,220,830	5	1,309,690	1,412,020	8	3,478	3,855	11	4,128	4,220	2	2,250	2,199	-2	2,613	2,965	13
DD-1	146.6	153,930	194,680	26	46,330	55,560	20	108	145	34	104	119	14	164	179	9	108	138	28
DD-2	324.3	281,820	303,540	8	88,860	98,260	11	208	201	-3	328	302	-8	101	126	25	233	178	-24
DD-3	148.5	192,750	216,960	13	79,740	86,280	8	160	218	36	140	140	0	214	252	18	111	144	30
DD-4	170.5	134,700	164,870	22	36,830	50,980	38	68	116	71	155	184	19	58	75	29	56	102	82
DD-5	235.4	239,640	277,070	16	94,160	112,520	19	311	358	15	268	292	9	177	202	14	169	264	56
DD-6	193.6	302,400	317,890	5	115,190	120,420	5	275	292	6	184	186	1	283	281	-1	203	217	7
DD-7	349.1	461,860	422,060	-9	125,680	132,310	5	258	290	12	426	642	51	168	482	187	244	248	2
DD-8	315.6	310,550	320,330	3	107,940	115,510	7	256	287	12	322	325	1	120	139	16	215	224	4
DD-9	360.4	245,790	265,610	8	90,460	88,660	-2	303	324	7	274	274	0	133	141	6	151	187	24
Subtotal	2,244.0	2,323,440	2,483,010	7	785,190	860,500	10	1,947	2,231	15	2,201	2,464	12	1,418	1,877	32	1,490	1,702	14
Total	6,722.8	6,333,250	6,703,840	6	2,094,880	2,272,520	8	5,425	6,086	12	6,329	6,684	6	3,668	4,076	11	4,103	4,667	14

[a] *Existing controls consists of street sweeping twice a year, grassed swales, and 15 ponds.*

Source: SEWRPC.

Table 19

ANNUAL UNIT AREA LOADINGS OF NONPOINT SOURCE POLLUTANTS EXISTING (1990) AND PLANNED BUILDOUT LAND USE CONDITIONS WITH EXISTING CONTROLS[a]

		Total Solids (pounds per acre)			Particulate Solids (pounds per acre)			Total Phosphorus (pounds per acre)			Copper (pounds per acre)			Lead (pounds per acre)			Zinc (pounds per acre)		
Subbasin	Drainage Area (acres)	Existing (1990) Land Use	Planned Buildout Land Use	Percent Change	Existing (1990) Land Use	Planned Buildout Land Use	Percent Change	Existing (1990) Land Use	Planned Buildout Land Use	Percent Change	Existing (1990) Land Use	Planned Buildout Land Use	Percent Change	Existing (1990) Land Use	Planned Buildout Land Use	Percent Change	Existing (1990) Land Use	Planned Buildout Land Use	Percent Change
UC-1	571.1	866	885	2	253	273	8	0.57	0.65	14	0.88	0.79	-10	0.36	0.32	-11	0.40	0.60	50
UC-2	228.6	815	920	13	282	325	15	0.76	0.82	8	1.48	1.20	-19	1.09	0.39	-64	0.54	0.57	6
UC-3	141.9	894	894	0	307	307	0	0.84	0.84	0	1.03	1.03	0	0.48	0.48	0	0.73	0.73	0
UC-4	238.0	1,018	1,018	0	378	378	0	0.90	0.90	0	1.16	1.16	0	0.52	0.52	0	0.64	0.64	0
UC-5	266.1	999	1,125	13	311	355	14	0.62	0.85	37	1.07	1.25	17	0.58	0.65	12	0.59	0.70	19
UC-6	429.0	858	945	10	245	282	15	0.69	0.86	25	0.70	0.78	11	0.35	0.38	9	0.47	0.72	53
UC-7	455.2	979	963	-2	300	327	9	0.81	0.96	19	1.09	1.21	11	0.52	0.43	-17	0.66	0.68	3
UC-8	557.4	894	903	1	310	315	2	0.82	0.85	4	0.98	0.99	1	0.45	0.46	2	0.62	0.62	0
UC-9	391.0	805	806	0	234	235	0	0.77	0.77	0	0.69	0.70	1	0.32	0.33	3	0.53	0.53	0
UC-10	379.2	1,028	1,132	10	314	342	9	0.79	0.88	11	0.81	0.76	-6	0.78	0.86	10	0.67	0.79	18
UC-11	454.7	783	916	17	308	362	18	0.90	1.02	13	0.83	0.97	17	0.45	0.66	47	0.62	0.71	15
UC-13	43.5	774	774	0	326	326	0	0.87	0.87	0	1.10	1.10	0	0.48	0.48	0	0.62	0.62	0
UC-14	158.4	852	898	5	295	313	6	0.82	0.89	9	0.64	0.73	14	0.42	0.47	12	0.71	0.69	-3
UC-16	164.7	927	927	0	355	355	0	1.09	1.09	0	0.82	0.82	0	0.59	0.59	0	0.72	0.72	0
DD-1	146.6	1,050	1,328	26	316	379	20	0.74	0.99	34	0.71	0.81	14	1.12	1.22	9	0.74	0.94	27
DD-2	324.3	869	936	8	274	303	11	0.64	0.62	-3	1.01	0.93	-8	0.31	0.39	26	0.72	0.55	-24
DD-3	148.5	1,298	1,461	13	537	581	8	1.08	1.47	36	0.94	0.94	0	1.44	1.70	18	0.75	0.97	29
DD-4	170.5	790	967	22	216	299	38	0.40	0.68	70	0.91	1.08	19	0.34	0.44	29	0.33	0.60	82
DD-5	235.4	1,018	1,177	16	400	478	20	1.32	1.52	15	1.14	1.24	9	0.75	0.86	15	0.72	1.12	56
DD-6	193.6	1,562	1,642	5	595	622	5	1.42	1.51	6	0.95	0.96	1	1.46	1.45	-1	1.05	1.12	7
DD-7	349.1	1,323	1,209	-9	360	379	5	0.74	0.83	12	1.22	1.84	51	0.48	1.38	188	0.70	0.71	1
DD-8	315.6	984	1,015	3	342	366	7	0.81	0.91	12	1.02	1.03	1	0.38	0.44	16	0.68	0.71	4
DD-9	360.4	682	737	8	251	246	-2	0.84	0.90	7	0.76	0.76	0	0.37	0.39	5	0.42	0.52	24

[a] *Existing controls consists of street sweeping twice a year, grassed swales, and 15 ponds.*

Source: SEWRPC.

source pollutant reduction goals were established for the study area under the aforementioned priority watershed planning program. The latter nonpoint source pollutant reduction goals were established by the Wisconsin Department of Natural Resources (WDNR) staff, and considered primarily sediment, phosphorus, and lead, as an indicator for metal loadings. The pollutant reduction goals were established on the basis of Department staff judgment, and considered field observations, stormwater quality sampling, and estimates of the degree of improvement needed for achievement of desired recreation and aquatic life uses of the surface waters in the study area.

The priority watershed planning program recommended that sediment loadings be reduced under planned conditions to about 50 percent of the 1985 condition loads, that phosphorus loads be reduced from 50 to 75 percent, and that metals be reduced by about 45 percent in the Dousman Ditch subwatershed and 51 percent in the Underwood Creek subwatershed.

Under the current planning process, consideration was given to achieving the levels of nonpoint source pollution control recommended under both planning efforts described above. However, experience indicates that the levels of pollutant reduction recommended under the enhancement objective set forth in the priority watershed planning program are not likely to be practically achievable. The inability to achieve the recommended reductions is due to conditions in the watersheds which constitute physical constraints on the locations of control measures. Such constraints include limitations on the provision of effective best management practices in areas of existing urban development where there may not be sufficient open lands to accommodate such practices.

EVALUATION OF STREAMBANK EROSION

The Menomonee River priority watershed study quantified the estimated contribution of sediment from streambank erosion as a percentage of the overall sediment loads in the Dousman Ditch and Underwood Creek subwatersheds. It was concluded that streambank erosion was not a significant sediment source (0 percent of the total sediment load) in the Dousman Ditch subwatershed under either 1985 or planned 2000 land use conditions. It was also concluded that streambank erosion was only a minor sediment source (3 percent of the total sediment load) in the Underwood Creek subwatershed under either 1985 or planned 2000 land use conditions. Inventories conducted under the priority watershed study identified four reaches of eroding streambanks in the Underwood Creek subwatershed. One of those sites, which had a length of 55 feet, was classified in that study as being in Management Category I. Three other sites with a total length of 100 feet were classified as being in Management Category II. Category I sites exhibit moderate to severe lateral bank recession rates and contribute five or more tons of sediment a year to the stream. Category II sites exhibit low to moderate lateral bank recession rates and contribute less than five tons of sediment a year to the stream. Control of Category I sites was assigned a priority for control ahead of Category II sites.

The potential for streambank erosion in the streams of the study area was evaluated using the results of the hydrologic and hydraulic models developed under this stormwater management plan. The observation of the priority watershed study that streambank erosion is not, and is not anticipated to be, a major source of sediment in the subwatersheds was verified. It was found that, under planned land use conditions, streamflow velocities would generally be in the nonerosive range during more frequent floods with recurrence intervals of two years or less.[5]

Thus, while localized bank protection projects, using more natural bioengineering techniques wherever practical, should be undertaken to control streambank erosion, widespread corrective measures are not needed in the subwatersheds.

CONSTRUCTION EROSION CONTROL ORDINANCES

The City of Brookfield has a construction erosion control ordinance that requires the provision of erosion control practices consistent with the WDNR *Construction Site Best Management Practices Handbook*. The Village of Elm Grove has an ordinance based on the State of Wisconsin Model Construction Site Erosion Control Ordinance. Strict application and enforcement of those ordinances would be expected to

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[5] *The more frequent floods are considered to be those which have the most impact on the configuration of a stream's low-flow channel.*

enable achievement of a 75 percent reduction in sediment transported from construction sites relative to uncontrolled conditions. Such strict adherence to the ordinance requirements is, therefore, an essential part of the nonpoint source control plan for the study area.

WINTER MANAGEMENT OF ROADWAYS

It is recommended that the City and Village investigate alternatives to the application of sand on roadways in the winter. Reductions in the amounts applied would be beneficial in reducing sediment loads to streams and in reducing the accumulation of sediment in grass swales, at culverts, in storm sewers, and in ditch enclosures.

STATE OF WISCONSIN STORMWATER DISCHARGE PERMITTING PROGRAM

Both the City and the Village have participated in the submittal of a group application for a Wisconsin Pollutant Discharge Elimination Systems (WPDES) stormwater discharge permit as required under Chapter NR 216, "Storm Water Discharge Permits," of the *Wisconsin Administrative Code.* The group permit was submitted on February 11, 2000, by eight Menomonee River watershed communities, including the Cities of Brookfield, Greenfield, and Wauwatosa and the Villages of Butler, Elm Grove, Germantown, Menomonee Falls, and West Milwaukee. The permit to be issued by the WDNR will specify conditions intended to control nonpoint source pollution from all areas within the municipalities. The recommendations of this plan would be expected to be an integral part of the permit requirements.

PROPOSED STATE NONAGRICULTURAL RUNOFF PERFORMANCE STANDARDS

The State of Wisconsin has proposed the implementation of water quality performance standards addressing surface water and groundwater issues. The standards would apply to runoff from existing and new nonagricultural development, redevelopment sites, and construction sites. As of the date of this report, draft standards were still being evaluated through the public hearing process. Those draft standards will be subject to change during the legislative approval process.

ALTERNATIVE WATER QUALITY MANAGEMENT PLANS

Introduction

Alternative water quality management plans for the control of nonpoint source pollutants were developed and evaluated to achieve the water quality objectives presented in Chapter III of this report wherever practicable. The alternative measures considered represent a refinement of the more generalized recommendations presented in the regional water quality management plan for southeastern Wisconsin. Furthermore, the measures considered are consistent with the Menomonee River watershed nonpoint source control plan, recognizing the constraints imposed by specific conditions in the study area. The water quality management measures considered are also coordinated and combined with the drainage recommendations made in Chapter V so as to provide multiple water quantity and water quality benefits and to minimize costs. This section describes alternative water quality management plans, estimates pollutant loadings to the surface waters under each of these alternatives, and presents the estimated cost of each alternative.

Each of the potentially available water quality management measures provides unique benefits with respect to the plan objectives. Yet, each measure also has limitations resulting from the physical constraints imposed by the watershed. The recommended water quality management plan will be selected on the basis of the desired reduction in pollutant loadings, the cost-effectiveness of the measures, the availability of suitable sites, and compatibility with the aforementioned stormwater drainage recommendations. Five general types of control measures could be expected to be effective and could potentially have application in the Dousman Ditch and Underwood Creek subwatersheds. These measures are: 1) wet detention basins, 2) maintenance of grassed swales in areas of suburban low-, and medium-density urban development, 3) increased street sweeping in certain areas of critical land uses, 4) construction site erosion control measures implemented as required by the City and Village construction erosion control ordinances, and 5) limited streambank stabilization. Items 2, 4, and 5 above would be components of any nonpoint source control plan for the study area and they are discussed below following the description and evaluation of alternative plans.

Infiltration facilities, such as infiltration trenches and basins, porous pavement, and onsite seepage pits, remove waterborne pollutants by capturing surface water runoff and filtering it through the soil or other substrate material. Such facilities have been found to be effective in certain urban areas where the soils and drainage system are suitable and there are no significant sources of toxic pollutants which could contaminate underlying groundwater resources. Within the Dousman Ditch and Underwood Creek subwatersheds, however, infiltration facilities were not found to be a viable alternative because over 90 percent of the study area is covered by poorly drained or very poorly drained soils and because significant sanitary sewer backup problems have occurred in the study area, related in part to sanitary sewer inflow and infiltration. Under these soil conditions, infiltration rates would be relatively low, and the removal of pollutants through infiltration into the soil would be limited. However, in this regard, the study area contains about 890 acres of wetland and other open space uses which would remove nonpoint source pollutants in stormwater through infiltration, filtration, and/or biological uptake.

Descriptions of Alternative Plans

The alternatives focus on practices that would control nonpoint source pollution from critical existing land uses. Review of Maps 2 and 3 in Chapter II, along with consideration of the land that has developed since 1990 emphasizes the relatively small amount of land available for future development as well as the general lack of available sites in the study area for the location of large-scale best management practices that would provide significant control of pollutants from critical land uses.

A common component of each alternative plan that was developed is a wet detention basin along Dousman Ditch in its upper reach. Because that basin would function as a dual-purpose facility for both water quantity and quality control, alternative basin configurations are described in detail in Chapter V, "Alternative and Preliminary Recommended Stormwater and Floodland Management Plans." The preliminary recommended wet detention basin described in Chapter V would treat runoff from about 40 percent of the critical land use area in the study area, including a large portion of the commercial development along W. Bluemound Road.

Another common component of each alternative nonpoint source pollution control plan that was developed for the subwatersheds is the control of nonpoint source pollution from all remaining areas to be developed, or from areas of redevelopment. Such control would be achieved through a combination of 1) construction of the Dousman Ditch wet detention basin, 2) construction site erosion control measures, and 3) site-specific best management practices to reduce the washoff of pollutants. The approximate areas of incremental planned development occurring between 1990 and the achievement of buildout conditions which would be treated by the detention basin include 78 acres in commercial uses, two acres in governmental and institutional uses, and 113 acres in medium- and low-density residential uses

The possibility of constructing additional wet detention basins in locations where they could effectively control runoff from critical land uses was investigated. Aside from the basin along Dousman Ditch, it was found that there would be only one suitable open space site for a wet basin that would receive runoff from critical land uses, but it was eliminated from consideration for the following reasons: 1) the potential loading reductions would be extremely small relative to the overall watershed loadings and 2) the site is on the grounds of an existing church and its development would restrict the current use of those grounds.

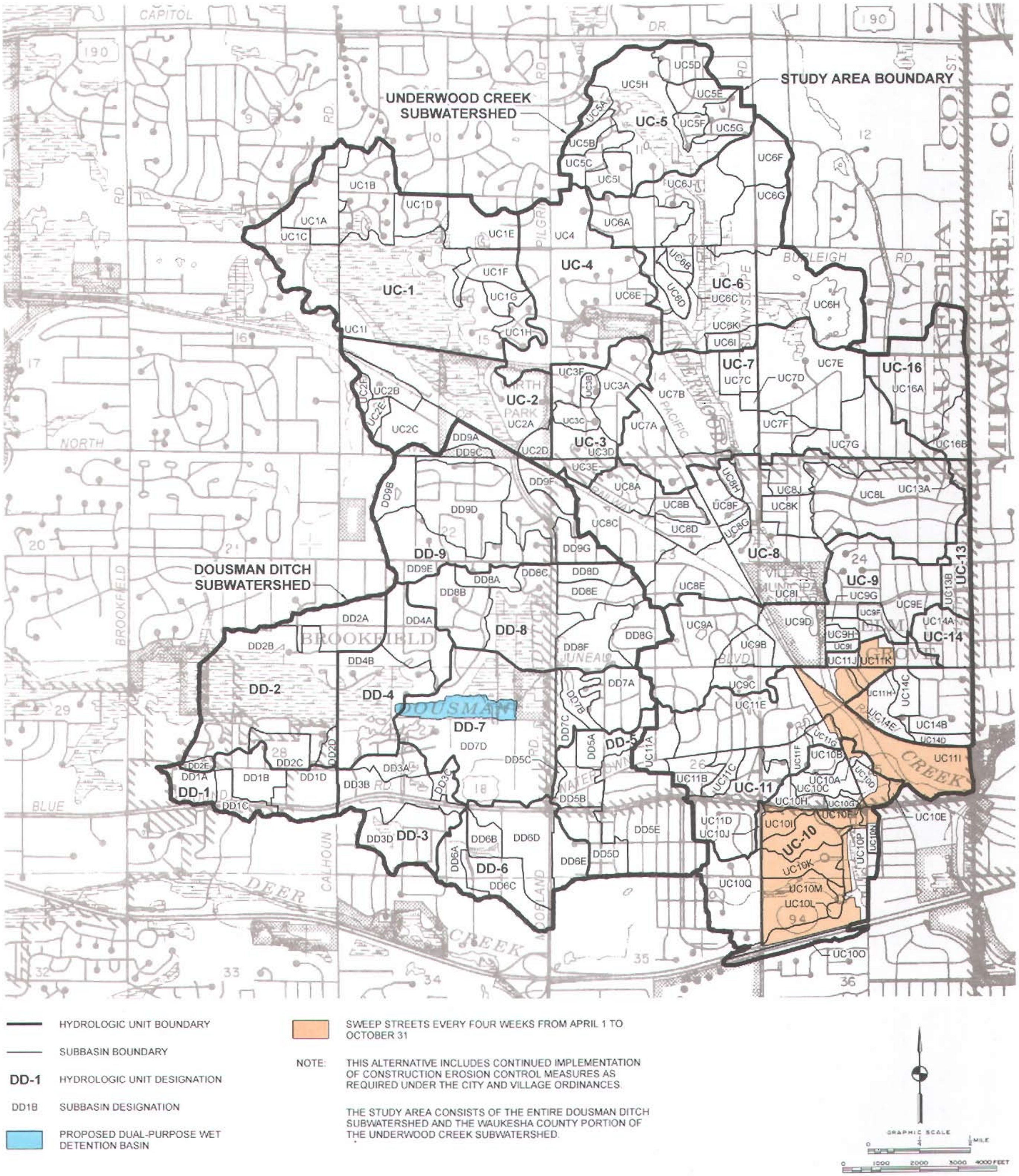
Several additional options that are available for the control of nonpoint source pollution from critical land use areas include: 1) increased street sweeping in areas with urban street cross sections and curb and gutter; 2) reduced application of sand on streets in the winter; and 3) public information and education efforts to promote good urban "housekeeping" practices that reduce nonpoint source pollution.

Water Quality Alternative Plan No. 1—Dousman Ditch Detention Basin with Increased Street Sweeping In Critical Areas

As shown on Map 10, Alternative No. 1 includes the continued implementation of construction erosion control measures, maintenance of the existing 15 ponds, construction of a 19-acre wet detention basin with a permanent pond volume of about 87 acre-feet along the upper reach of Dousman Ditch, and increasing the frequency of street sweeping in Hydrologic Units UC-10 and 11 from twice a year to once every four weeks between April 1 and October 31. This alternative would provide controls on runoff from about 73 percent of the critical land uses in the study area.

Map 10

WATER QUALITY ALTERNATIVE PLAN NO. 1—DOUSMAN DITCH DETENTION BASIN WITH INCREASED STREET SWEEPING IN CRITICAL AREAS



HYDROLOGIC UNIT BOUNDARY

SUBBASIN BOUNDARY

DD-1 HYDROLOGIC UNIT DESIGNATION

DD1B SUBBASIN DESIGNATION

PROPOSED DUAL-PURPOSE WET DETENTION BASIN

SWEEP STREETS EVERY FOUR WEEKS FROM APRIL 1 TO OCTOBER 31

NOTE: THIS ALTERNATIVE INCLUDES CONTINUED IMPLEMENTATION OF CONSTRUCTION EROSION CONTROL MEASURES AS REQUIRED UNDER THE CITY AND VILLAGE ORDINANCES.

THE STUDY AREA CONSISTS OF THE ENTIRE DOUSMAN DITCH SUBWATERSHED AND THE WAUKESHA COUNTY PORTION OF THE UNDERWOOD CREEK SUBWATERSHED.

Source: SEWRPC.

Table 20

ANNUAL TOTAL NONPOINT SOURCE LOADINGS TO DOUSMAN DITCH AND UNDERWOOD CREEK UNDER ALTERNATIVE WATER QUALITY MANAGEMENT PLANS

Element	Existing (1990) Load (pounds)	Planned No Action (pounds)	Alternative No. 1			Alternative No. 2		
			Load (pounds)	Percent Change[a]	Percent Change[b]	Load (pounds)	Percent Change[a]	Percent Change[b]
Total Solids	6,333,250	6,703,840	6,138,951	-3	-8	6,141,346	-3	-8
Particulate Solids	2,094,880	2,272,520	1,713,292	-18	-25	1,712,478	-18	-25
Total Phosphorus....	5,425	6,086	5,182	-5	-15	5183	-5	-15
Total Copper...........	6,329	6,684	5,291	-16	-21	5287	-17	-21
Total Lead...............	3,668	4,076	2,934	-20	-28	2933	-20	-28
Total Zinc................	4,103	4,667	3,966	-3	-15	3966	-3	-15

[a]Relative to the 1990 loading.

[b]Relative to the Planned No Action loading.

Source: SEWRPC.

The increased street sweeping was limited to those areas of critical land uses that have urban street cross sections with curb and gutter and that would not be tributary to wet detention basins under alternative plan conditions. Increased street sweeping was not proposed in areas tributary to detention basins because the pollutants removed by sweepers, generally the larger particles, would also readily settle out in wet basins. Increased sweeping was also not proposed for residential streets because most of those areas are served by roadside swales and little additional control of pollutants would be expected through sweeping of the low-density residential streets. The effectiveness of street sweeping would be greatest during spring and fall and would be greatly enhanced through the use of regenerative air sweepers. Increased cleaning of catch basins and improved leaf collection would be associated with increased street sweeping.[6]

As seen from Table 20, implementation of this alternative plan would result in pollutant loading reductions relative to 1990 land use conditions in the study area of 3 percent for total solids, 18 percent for particulate solids, 5 percent for phosphorus, 16 percent for copper, 20 percent for lead, and 3 percent for zinc. Relative to planned buildout conditions in the absence of further controls, the expected reductions due to implementation of this alternative plan would be 8 percent for total solids, 25 percent for particulate solids, 15 percent for phosphorus, 21 percent for copper, 28 percent for lead, and 15 percent for zinc.

As set forth in Table 21, the total capital cost of this alternative plan is estimated to be $4,096,000. Utilizing an annual interest rate of 6 percent, a project life and amortization period of 50 years, and an estimated annual operation and maintenance cost of $7,000, the average annual cost of the alternative plan is estimated at $276,000.

Water Quality Alternative Plan No. 2—Dousman Ditch Detention Basin with Additional Increased Street Sweeping in Critical Areas

As shown on Map 11, Alternative No. 2 includes the wet detention basin and construction erosion control measures set forth in Alternative No. 1 plus street sweeping in Hydrologic Unit UC-10 once every two weeks between April 1 and October 31. This alternative would also control runoff from about 73 percent of the critical land uses in the study area, but the level of control would be somewhat greater than under Alternative No. 1.

As seen from Table 20, implementation of this alternative plan would result in pollutant loading reductions relative to 1990 land use conditions in the

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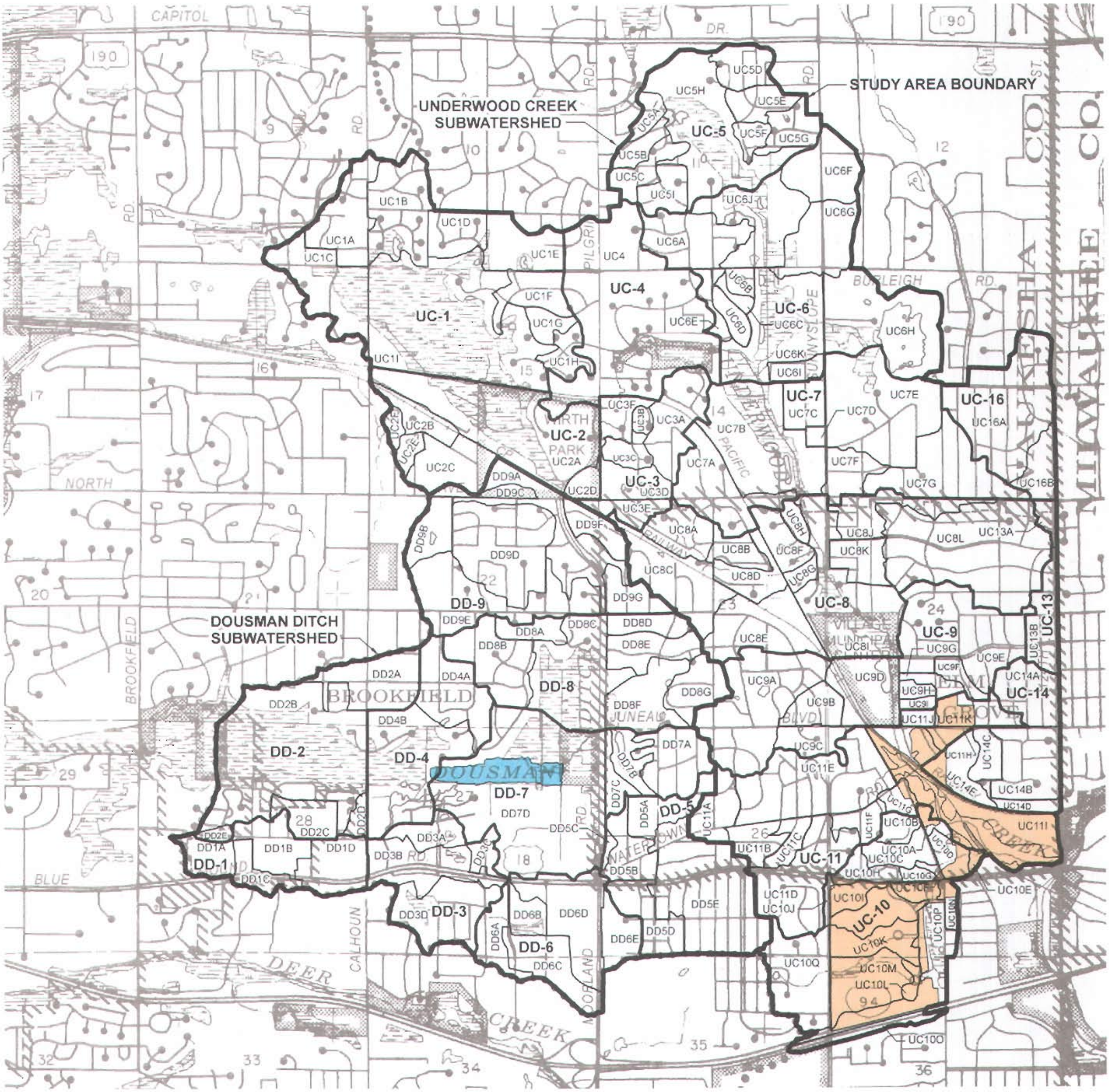
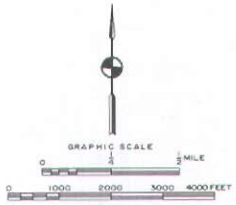
[6] *The City of Brookfield has established a policy of requiring the installation of catch basins in the storm sewer systems for new development.*

Map 11

WATER QUALITY ALTERNATIVE PLAN NO. 2—DOUSMAN DITCH DETENTION BASIN WITH ADDITIONAL INCREASED STREET SWEEPING IN CRITICAL AREAS





━━	HYDROLOGIC UNIT BOUNDARY
──	SUBBASIN BOUNDARY
DD-1	HYDROLOGIC UNIT DESIGNATION
DD1B	SUBBASIN DESIGNATION
🟦	PROPOSED DUAL-PURPOSE WET DETENTION BASIN
🟧	SWEEP STREETS EVERY TWO WEEKS FROM APRIL 1 TO OCTOBER 31

NOTE: THIS ALTERNATIVE INCLUDES CONTINUED IMPLEMENTATION OF CONSTRUCTION EROSION CONTROL MEASURES AS REQUIRED UNDER THE CITY AND VILLAGE ORDINANCES.

THE STUDY AREA CONSISTS OF THE ENTIRE DOUSMAN DITCH SUBWATERSHED AND THE WAUKESHA COUNTY PORTION OF THE UNDERWOOD CREEK SUBWATERSHED.

Source: SEWRPC.

study area of 3 percent for total solids, 18 percent for particulate solids, 5 percent for phosphorus, 17 percent for copper, 20 percent for lead, and 3 percent for zinc. Relative to planned buildout conditions in the absence of further controls, the expected reductions due to implementation of this alternative plan would be 8 percent for total solids, 25 percent for particulate solids, 15 percent for phosphorus, 21 percent for copper, 28 percent for lead, and 15 percent for zinc.

As set forth in Table 21, the total capital cost of this alternative plan is estimated to be $4,102,000. Utilizing an annual interest rate of 6 percent, a project life and amortization period of 50 years, and an estimated annual operation and maintenance cost of $14,000, the average annual cost of the alternative plan is estimated at $283,000.

Evaluation of Water Quality Management Alternatives

The two alternative water quality management plans were evaluated with respect to pollutant removal effectiveness and cost.

Pollutant Removal Effectiveness

The alternative plans essentially provide the same degree of control of nonpoint source pollution.

Cost

The estimated capital, annual operation and maintenance, and equivalent annual costs of each alternative plan are presented in Table 21. The costs of the alternative plans are almost equal, with the cost of Alternative No. 1 being slightly lower than that of Alternative No. 2.

Selection of the Preliminary Recommended Alternative Plan for Control of Nonpoint Source Pollution within the Study Area

Based on consideration of the level of reduction in pollutant loadings and equivalent annual cost, nonpoint source pollution control Alternative Plan No. 1, Dousman Ditch Detention Basin with Increased Street Sweeping in Critical Areas, is the selected as the preliminary recommended alternative. In addition to those components set forth above, the preliminary recommended alternative plan would also include: 1) measures to control nonpoint source pollution from all remaining areas to be developed, or from areas of redevelopment. Such control would be achieved through a combination of construction site erosion control measures and site-specific best management practices to reduce the washoff of pollutants; 2) development and/or expansion of public education programs to encourage good urban "housekeeping" practices; 3) strict enforcement of the existing construction erosion control ordinances; 4) limited streambank stabilization; and 5) reduced application of sand on streets in the winter and possibly the use of alternative road deicing chemicals that are less environmentally damaging than calcium chloride.

Public information and education programs are recommended to promote the acceptance and understanding of the proposed pollution abatement measures, the importance of water quality protection, and the establishment of good urban "housekeeping" practices. Urban housekeeping practices and source controls include restricted use of fertilizers and pesticides, improved pet waste and litter control, the reduced use of galvanized steel roof materials and gutters, proper disposal of motor vehicle fluids, increased leaf collection and catch basin cleaning, and reduced use of street-deicing salt. Particular attention should be given to reducing pollutant loadings from high pollutant loading areas, such as industrial and commercial sites, parking lots, and material storage areas. To the extent practicable, rooftop and parking lot stormwater runoff should be diverted to pervious soil and vegetated areas, rather than being directly discharged to a storm sewer. Special spill control or containment facilities, such as earthen berms, may be used to reduce the discharge of such spilled substances as oil and grease into water-ways. Material storage areas may be enclosed or periodically cleaned and diversion of stormwater away from these sites may further reduce pollutant loadings.

Other measures, such as reduced use and the current elimination of leaded gasoline and increased air pollution control, which may be implemented on a regional, State, or national level, may also be expected to reduce loadings of certain pollutants including metals. For example, the reduced use of leaded gasoline since 1974 has contributed to reduced dissolved lead levels in nearly two-thirds of the major rivers within the United States.[7]

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[7] *R. B. Alexander and R. A. Smith, "Trends in Lead Concentrations in Major U.S. Rivers and Their Relation to Historical Changes in Gasoline Lead Consumption,"* Water Resources Bulletin, *Vol. 24, No. 3, June 1988, pp. 557-569.*

Table 21

PRINCIPAL FEATURES AND COSTS OF ALTERNATIVE WATER QUALITY MANAGEMENT PLANS FOR THE DOUSMAN DITCH AND UNDERWOOD CREEK SUBWATERSHEDS IN THE CITY OF BROOKFIELD AND THE VILLAGE OF ELM GROVE

Alternative	Water Quality Control Costs[a]				
	Description	Capital	Amortized Capital[b]	Annual Operation and Maintenance	Total
No. 1—Dousman Ditch Detention Basin with Increased Street Sweeping In Critical Areas	19-acre, 87-acre-foot detention basin	$3,780,000[c]	- -	$ 9,000	- -
	Access roads/ baffles	120,000	- -	- -	- -
	Open channel to convey runoff to pond	100,000	- -	- -	- -
	Land acquisition	90,000	- -	- -	- -
	Street sweeping[d] (23 curb-miles)	6,000	- -	7,000	- -
Total	- -	$4,096,000	$260,000	$16,000	$276,000
No. 2—Dousman Ditch Detention Basin with Additional Increased Street Sweeping In Critical Areas	19-acre, 87-acre-foot detention basin	$3,780,000[c]	- -	$ 9,000	- -
	Access roads/ baffles	120,000	- -	- -	- -
	Open channel to convey runoff to pond	100,000	- -	- -	- -
	Land acquisition	90,000	- -	- -	- -
	Street sweeping[e] (23 curb-miles)	12,000	- -	14,000	- -
Total	- -	$4,120,000	$260,000	$23,000	$283,000

NOTE: Costs are based upon 1998 *Engineering News Record* Construction Cost Index = 6,740.

[a] *If during the facilities design phase, it is determined that an impervious liner is required for the wet detention basin, the water quality control cost of Alternative Nos. 1 and 2 would be increased by about $600,000.*

[b] *Amortized capital cost is based on an interest rate of 6 percent and a project life of 50 years.*

[c] *Includes both quantity and quality cost components from Chapter V. The quantity component was split out in that chapter to enable comparison of quantity alternatives on a consistent basis. This cost represents the estimated total cost to construct the wet detention basin.*

[d] *Sweep every four weeks between April 1 and October 31.*

[e] *Sweep every two weeks between April 1 and October 31.*

Source: SEWRPC.

Table 22

REDUCTION IN NONPOINT SOURCE POLLUTANT LOADINGS

Pollutant	Reductions in Nonpoint Source Pollutant Loadings under Planned Land Use Conditions			
	Regional Water Quality Management Plan (percent)	Priority Watershed Plan[a] (percent)	Preliminary Recommended Plan Relative to Buildout Conditions (percent)	Preliminary Recommended Plan Relative to Existing Conditions (percent)
Sediment	25	50	8	3
Phosphorus	25	50 to 70	15	5
Lead	- -[b]	51	28	20
Copper	- -[b]	50[c]	21	16
Zinc	- -[b]	50[c]	15	3

[a] *Reduction relative to 1985 conditions.*

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

[c] *Approximate reduction. Actual reduction to meet acute effluent toxicity standards should be determined on a case-by-case basis.*

Source: SEWRPC.

COMPARISON OF NONPOINT SOURCE POLLUTION REDUCTIONS WITH THOSE RECOMMENDED UNDER THE REGIONAL WATER QUALITY MANAGEMENT PLAN AND THE PRIORITY WATERSHED STUDY

Table 22 sets forth a comparison of the preliminary recommended plan minimum loading reductions with the reductions recommended under the regional water quality management plan and under the priority watershed study. The preliminary recommended control measures, if fully implemented, would reduce nonpoint source pollutant loadings to the streams in the study area under buildout land use conditions by a minimum of 8 to 28 percent relative to the loadings under buildout conditions without the recommended controls. The loadings would be expected to decrease from 3 to 20 percent relative to those estimated for 1990 land use conditions with existing controls.

The minimum loading reductions anticipated if the preliminary recommended plan were implemented fall short of the recommendations of both the regional water quality management plan and the priority watershed study. However, when the additional recommended measures, including construction erosion control, reduced application of sand on streets, public information and education efforts, sound household land management practices, and industrial onsite nonpoint source pollution control measures are considered, the estimated reductions would be closer to the water quality management plan goals of both plans.

INTEGRATION OF THE PRELIMINARY RECOMMENDED STORMWATER DRAINAGE AND WATER QUALITY MANAGEMENT PLANS INTO A PRELIMINARY RECOMMENDED STORMWATER MANAGEMENT PLAN

The preliminary recommended water quality management plan is compatible with the preliminary recommended stormwater drainage and floodland management plans set forth in Chapter V of this report. The Dousman Ditch detention basin, which is the major structural component of the water quality management plan, was integrated into the preliminary recommended stormwater and floodland management plan as described in Chapter V. The construction erosion control, street sweeping, and limited streambank stabilization components are essentially independent of the drainage and floodland measures and are readily implementable under the preliminary recommended stormwater and floodland management plan.

Chapter V

ALTERNATIVE AND PRELIMINARY RECOMMENDED STORMWATER AND FLOODLAND MANAGEMENT PLANS

INTRODUCTION

This chapter presents the findings of an inventory and evaluation of the existing stormwater drainage and floodland management systems serving the Underwood Creek and Dousman Ditch subwatersheds in the City of Brookfield and the Village of Elm Grove and describes and evaluates alternative stormwater drainage and floodland management plans to serve those subwatersheds under full development conditions.

Following this introductory section, the second section of this chapter presents the findings of the inventory and evaluation of the existing stormwater drainage and floodland management systems in the subwatersheds. As indicated in Chapter III of this report, a 10-year recurrence interval storm event was used to evaluate the minor drainage system components consisting of roadside swales and cross culverts; curbs, gutters, and storm sewers; and certain natural or constructed areas that store runoff. A 50-year recurrence interval storm was used to evaluate the adequacy of culverts under arterial highways. A 100-year recurrence interval storm was used to evaluate the major system components, including the entire street cross-section, interconnected drainage swales and watercourses, and the overland flow paths which connect the street system with watercourses.

The third section briefly summarizes alternative conceptual approaches to stormwater management and floodland management and assesses their applicability to the solution of drainage and flooding problems in the Underwood Creek and Dousman Ditch subwatersheds. Based on that assessment, the set of alternative drainage and floodland management approaches which is best suited to addressing conditions in the subwatersheds was selected. The floodland management alternatives were selected after consideration of the recommendations of the Commission's 1976 Menomonee River watershed study,[1] a 1979 Dousman Ditch detention basin study prepared by Donohue & Associates, Inc.,[2] a 1986-87 land use study of the Bluemound Road/Wisconsin Avenue development corridor prepared by Howard Needles Tammen & Bergendoff,[3] the Commission's 1990 stormwater drainage and flood control system plan prepared for the Milwaukee Metropolitan Sewerage District (MMSD),[4] and the 1991 park and open space plan for the City of Brookfield.[5] The alternatives were also selected within the context of current regulatory policies which restrict and constrain activities in and along navigable streams and wetlands. The fourth section includes descriptions of alternative and recommended flood control plans developed under past planning efforts for the subwatersheds, presents 11 alternative plans to address flooding problems along Underwood Creek, and integrates those plans with pertinent components of the preliminary recommended water quality

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[1] *SEWRPC Planning Report No. 26,* A Comprehensive Plan for the Menomonee River Watershed, *October 1976.*

[2] *Donohue & Associates, Inc., Consulting Engineers,* Dousman Ditch Detention Basin Study, *prepared for the City of Brookfield and the Village of Elm Grove, May 25, 1979.*

[3] *Howard Needles Tammen & Bergendoff,* A Three-Phase Comprehensive Land-Use Study of the Bluemound Road-Wisconsin Avenue Development Corridor, *prepared for the City of Brookfield, May 1986-July 1987.*

[4] *SEWRPC Community Assistance Planning Report No. 152 (CAPR No. 152),* A Stormwater Drainage and Flood Control System Plan for the Milwaukee Metropolitan Sewerage District, *December 1990.*

[5] *SEWRPC Community Assistance Planning Report No. 108 (CAPR No. 108),* A Park and Open Space Plan for the City of Brookfield, *August 1991.*

management plan described in Chapter IV. The components of each of those alternatives are described and estimated and capital and annual operation and maintenance costs are set forth. This section also includes an evaluation of the alternative floodland management plans with consideration given to: 1) their relative abilities to reduce downstream flood damages; 2) their relative capital and annual operation and maintenance costs; 3) their consistency with City and Village development policies established over time; 4) their ability to incorporate the nonpoint source pollution control measures considered in Chapter IV of this report; and 5) their ability to be implemented based on the requirements of *Wisconsin Statutes*, administrative rules, and policies regarding activities in and along navigable streams and wetlands. Based on that evaluation, a preliminary recommended floodland management plan was selected.

The fifth section presents alternative and preliminary recommended plans to address stormwater drainage problems in the Underwood Creek and Dousman Ditch subwatersheds. The components of each of those alternatives are described and estimated capital and annual operation and maintenance costs are set forth. The alternative stormwater drainage plans are evaluated based on: 1) their relative abilities to reduce stormwater drainage problems; 2) their relative capital and annual operation and maintenance costs; 3) their ability to incorporate the nonpoint source pollution control measures considered in Chapter IV of this report; 4) their relationship to the preliminary recommended floodland management measures; and 5) their ability to be implemented. The alternatives to be considered for inclusion in the recommended plan, as set forth in Chapter VI of this report, are selected by hydrologic unit, resulting in a plan which consists of the combination of alternatives which best meets the objectives and supporting standards established in Chapter III.

EVALUATION OF THE EXISTING STORMWATER DRAINAGE AND FLOODLAND MANAGEMENT SYSTEM IN THE SUBWATERSHEDS

Introduction

In order to characterize the existing stormwater drainage system, the components of that system must be definitively described. The digital stormwater infrastructure system maps prepared by the City and the Village, as described in Chapter II of this report, provide such a definitive description which enables the hydraulic capacities of the existing conveyance and storage facilities to be evaluated under the design storms and existing and planned buildout land use development conditions in the tributary catchment areas. The components which are found to have inadequate capacity can then be addressed in the design of alternative stormwater drainage system plans.

The evaluation of the existing stormwater drainage system was directed toward the storm sewers, storage facilities, open channels, roadside swales, and culverts which may be components of both the minor and major systems and toward the open watercourses and related bridges and culverts of the major system. In the evaluation it was assumed that the backyard and sideyard drainage swales and the storm sewer inlets would have adequate capacity to convey the stormwater flows generated by storms up to and including the 10-year recurrence interval event to the receiving conveyance and storage facilities of the minor system.

The magnitude of existing flooding problems due to overflow from the major streams in the subwatersheds was characterized based on historical observation and computer simulation of flood profiles. Consistent with standard engineering practice and State and Federal floodplain management policies, flooding conditions were evaluated during floods with recurrence intervals up to, and including, 100 years.[6]

Physical Characteristics

The 10.8-square-mile study area, which encompasses the entire Dousman Ditch subwatershed and that portion of the Underwood Creek subwatershed within the City of Brookfield and the Village of Elm Grove, was divided into 605 subbasins for analytical purposes, as shown on Map 12. Those catchment areas were aggregated into 23 hydrologic units.

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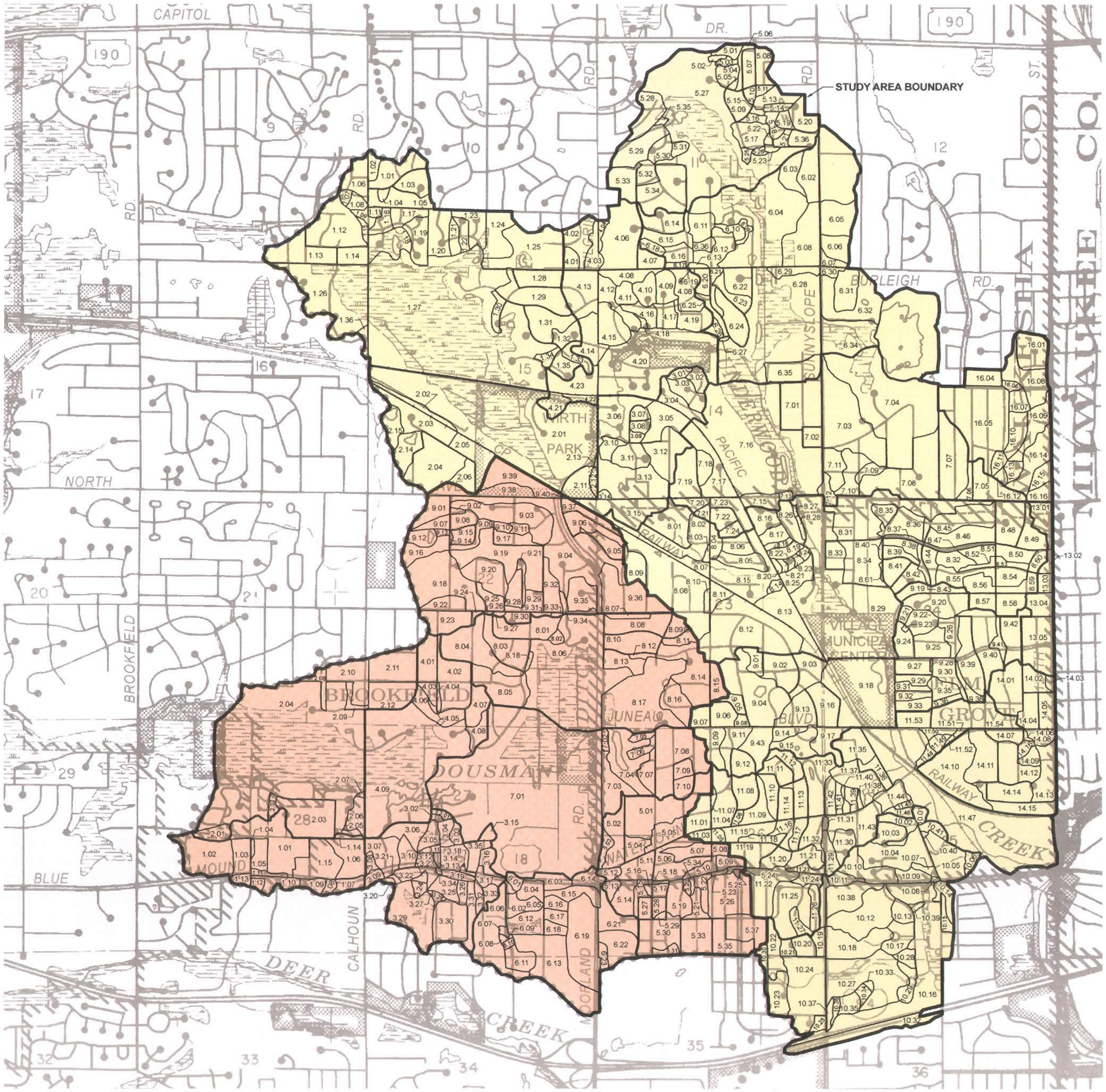
[6] *Appendix B presents specific findings relative to the effect on flood stages of a constructed berm in the Elm Grove Village Park. That situation was investigated at the request of the Village of Elm Grove staff in response to citizen concerns.*

Map 12

SUBBASINS WITHIN THE DOUSMAN DITCH AND UNDERWOOD CREEK SUBWATERSHEDS IN THE CITY OF BROOKFIELD AND THE VILLAGE OF ELM GROVE



HYDROLOGIC UNIT BOUNDARY

SUBBASIN BOUNDARY

6.33 UNDERWOOD CREEK SUBWATERSHED AND SUBBASIN DESIGNATION

8.17 DOUSMAN DITCH SUBWATERSHED AND SUBBASIN DESIGNATION

NOTE: THE STUDY AREA CONSISTS OF THE ENTIRE DOUSMAN DITCH SUBWATERSHED AND THE WAUKESHA COUNTY PORTION OF THE UNDERWOOD CREEK SUBWATERSHED.

Source: SEWRPC.

The existing stormwater drainage system in the portion of the City of Brookfield within the study area consists of a combination of: 1) roadside swales and open channels with associated culverts; 2) "ditch enclosures," consisting of roadside swales with underlying storm sewers; and 3) roadway curbs and gutters, storm sewer inlets, and storm sewers, together with the streams to which the outlets of the engineered and constructed system components discharge. The system in Elm Grove consists primarily of roadside swales and open channels with associated culverts. There are storm sewer systems and urban street cross sections in limited areas such as along W. Bluemound Road. The existing stormwater drainage systems are described in more detail in Chapter II of this report.

Hydraulic Capacities of Conveyance Systems and Comparison with Anticipated Storm Flows

Peak rates and critical volumes of stormwater runoff, as determined by the hydrologic and hydraulic characteristics of each subbasin, were estimated using the XP-SWMM computer simulation model described in Chapter III of this report. Where the capacities of conveyance facilities were exceeded, surface ponding, flooding, and surcharging of upstream or downstream drainage facilities may be expected to occur.

Identified Problem Areas

Map 7 in Chapter II shows the general locations of existing stormwater drainage and flooding problems within the subwatershed as identified by the City and Village based on historic observations. The hydrologic and hydraulic analyses conducted for this study verified the existence of the most significant problems shown on that map and identified additional system components that have inadequate hydraulic capacity under existing and/or planned land use conditions.

Major floods occurred along Underwood Creek on March 30, 1960; September 18, 1972; April 21, 1973; August 6, 1986; June 20-21, 1997; and August 6, 1998.[7] The June 20-21, 1997, and August 6, 1998, floods are described below.

Flooding and Stormwater Drainage Problems Resulting from the Storm of June 20-21, 1997

The heavy thunderstorms of June 20-21, 1997, caused severe stormwater drainage and flooding problems in Milwaukee, Ozaukee, Washington, and Waukesha Counties. Analysis of rain gage data for numerous sites within the Region indicates that, over the Underwood Creek and Dousman Ditch subwatersheds, the maximum 26-hour rainfall ranged from about five to six inches. The recorded rainfall total at the rain gage operated by the Milwaukee Metropolitan Sewerage District at the Elm Grove Village Hall was 5.97 inches in 26 hours. That rainfall total has a recurrence interval of about 170 years, while the most intense period of rainfall recorded at the Village Hall (5.01 inches in eight hours) has a recurrence interval of over 300 years.

Because of the interaction of many complex processes in the conversion of rainfall to runoff and in the conveyance and storage of that runoff in a stream system, it is expected that the recurrence interval of the flood flows produced by a given storm would differ from the recurrence interval of the rainfall amounts associated with the flood flows. Based on the correlation between June 21, 1997, high water mark elevations surveyed by the Wisconsin Department of Natural Resources (WDNR) along Underwood Creek at W. North Avenue and Wall Street, the peak recorded flow at U.S. Geological Survey (USGS) streamflow gage No. 04087088 located on Underwood Creek downstream from the study area at USH 45 in Wauwatosa, flood profiles computed by the Commission staff, observations by the Commission staff during the flood, and observations of residents and staff of the City and the Village, it is estimated that the June 21, 1997, flood on Underwood Creek within the study area had a recurrence interval of less than 100 years.

As shown on Map 7, the major stormwater drainage and/or flooding problems reported in the City of Brookfield portion of the study area on June 21 were in the vicinity of Lilly Road and W. North Avenue, including Adelaide, Eastwood, Oak Hill, and Tru Lanes and Carson Court; along San Juan Trail north of W. Burleigh Road; at Brookfield East High School, located northwest of the intersection of Lilly Road and W. Burleigh Road; along Pomona Road and Clearwater Drive adjacent to, or within, the floodplain of Underwood Creek; along Hillsdale Drive, located northeast of the intersection of W. North Avenue and

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[7] *The effects of the 1960, 1972, and 1973 floods along Underwood Creek in the City of Brookfield and the Village of Elm Grove are described in the Commission's 1976 Menomonee River watershed study. The 1986 event produced localized drainage and flooding problems in the City and the Village, but its most severe impact occurred to the east in Milwaukee County.*

N. Calhoun Road; along Indianwood Drive near Onondoga Circle; and along Calhoun Road south of Burleigh Road.

The major stormwater drainage and/or flooding problems reported in the Village of Elm Grove on June 21 were in the vicinity of Verdant Drive, west of Pilgrim Parkway; the Squires Grove Subdivision, including Briaridge Court, Hidden Glen Court, Red Fox Lane, and Terrace Drive; along Elmhurst Parkway and near the intersection of Elmhurst Parkway and Notre Dame Boulevard; along Dunwoody Drive, Lee Court, and Wrayburn Road between Hollyhock Lane and Fairhaven Boulevard; in the vicinity of Pilgrim Park Middle School and Victoria Circle North; southwest of the intersection of Cascade Drive and Pilgrim Parkway; at Rock Court and Woodlawn Circle, north of Juneau Boulevard; and along Pilgrim Parkway south of Gebhardt Road where the roadway flooded and was impassable at the intersection with Cascade Drive and at the north entrance drive to Pilgrim Park Middle School.

Flooding of streets and buildings, primarily basements, was reported in the study area as a result of the June 20-21 storm. Several types of structure flooding occurred. One major source of basement flooding problems was surcharging of sanitary sewers and resultant backups into basements. Another source of basement flooding was sump pump failure due to electrical power outages. Those two problems are interrelated. If sump pumps cannot operate and the volume of clear water collected by a building's foundation drain system exceeds the capacity of the sump crock, water will overflow from the crock into the basement. That clear water may then flow into the basement floor drain, which is connected to the sanitary sewer. Excessive flows of such clear water into the sanitary sewers can quickly exceed the capacity of those relatively small-diameter sewers, leading to surcharging and backup of a combination of sanitary sewage and clear water into basements connected to the surcharged sewers. Additional sources of clear water inflow to sanitary sewers were through: 1) flooding of basements due to surface runoff, 2) excessive amounts of water collecting in streets or roadside swales and entering sanitary sewer manholes through unsealed lids and frames, 3) sanitary sewer manhole lids which were disturbed, and 4) missing caps on sanitary sewer lateral cleanouts located in roadside swales. It is also likely that increased infiltration of clear water occurred as a result of saturation of the ground adjacent to sanitary sewers.

The City and the Village have completed a study of sanitary sewer backup problems associated with the Underwood sanitary trunk sewer (Underwood interceptor) and have implemented a program to rehabilitate trunk sewer manholes to reduce infiltration and inflow to the Underwood trunk sewer. That program included the installation of solid, gasketed lids on some manholes, raising manhole lids and frames above 100-year recurrence interval flood stages and adding berms around manholes that are located in identified floodplains, providing internal or external seals between manhole chimneys and frames, and grouting the interiors of manhole chimneys, where necessary. In addition, the City is conducting studies of critical areas of sanitary sewer backups along the local sanitary sewer system and in late 1997 it initiated a two-year program to investigate and study the potential for infiltration and inflow and backup problems throughout the entire sanitary sewer system of the City.

This stormwater management plan does not directly address the issue of sanitary sewer backup, however, an important component of a strategy to alleviate such backup is the reduction of stormwater drainage and flooding problems. The reduction of such problems eliminates or reduces the magnitude of certain sources of inflow to sanitary sewers. Those inflow sources addressed by this plan include flooding of basements with clear water and excessive accumulation and ponding of storm runoff in streets and roadside swales.

In identifying problems in the existing system, consideration was given to the potential impact of excessive amounts of runoff. In some cases, problems would not be anticipated, even though the capacity of the system component would be exceeded. Examples of this are inundated areas that are, or would be, in open space use and in which no buildings, transportation facilities, or other damage-prone improvements would be affected; and areas where Standard No. 3 of Objective No. 1 in Chapter III, relating to acceptable levels of street flooding during a 10-year recurrence interval event, was satisfied.

Flooding and Stormwater Drainage Problems Resulting from the Storm of August 6, 1998

The heavy thunderstorms of August 6, 1998, caused severe stormwater drainage and flooding problems in Milwaukee and Waukesha Counties. Analysis of rain gage data indicates that, over the Underwood Creek and Dousman Ditch subwatersheds, the maximum seven-hour rainfall ranged from about 8.28 inches at the MMSD rain gage at the Elm Grove Village Hall to about 11.8 inches near the intersection of N. Calhoun Road and W. North Avenue. Those rainfall amounts have recurrence intervals in excess of 500 years and they were more severe than the rains that occurred in June 1997.

Based on the correlation between August 6, 1998, high water mark elevations surveyed along Underwood Creek and Dousman Ditch by the Regional Planning Commission staff and Ruekert & Mielke, Inc., the Elm Grove Village engineer; the peak recorded flow at the USGS streamflow gage on Underwood Creek in Wauwatosa; flood profiles computed by the Commission staff; observations by the Commission staff during the flood; and observation of residents and staff of the City and the Village, it is estimated that the August 6, 1998, flood on Underwood Creek within the study area had a recurrence interval close to 500 years.

The major stormwater drainage and/or flooding problem areas reported in the portions of the City of Brookfield in the study area and in the Village of Elm Grove included those areas that experienced problems in June of 1997; however, the 1998 flooding was much more extensive, due to the concentration of heavier rains over the subwatersheds. It is estimated that as many as one-half of the properties in the Village of Elm Grove and approximately 550 residences in the City of Brookfield received damages from the overflow of streams, stormwater runoff, or sanitary sewer backup.[8]

The Village of Elm Grove sent a questionnaire to each residence in the Village to gather information relative to the problems experienced as a result of the storm of August 6, 1998. Responses were received from 1,321 residences, or approximately 60 percent of those in the Village. The responses to the survey are summarized graphically on Maps 13, 14, 15, 16, and 17, that were prepared by Ruekert & Mielke, Inc., the Village engineer. About 50 percent of the respondents reported experiencing basement flooding. About one-third of the respondents reported losing electrical power during the storm, with the majority of those losing power for more than three hours.[9] About one-half of the respondents reported that their sump pump was operable when basement flooding occurred. About one-fourth of the respondents experienced clearwater overflow into the basement from the sump crock. That overflow may have been due to loss of power or inflow to the crock in excess of the capacity of the sump pump. About one-third of the respondents reported inflow through basement walls or floors and one-fifth reported inflow to the basement through window wells. One-fifth of the respondents reported experiencing sanitary sewer backup. The survey results illustrate that power failures and saturated ground conditions, as evidenced by sump crock overflow and leakage through basement walls or floors, were major sources of basement flooding problems. Sanitary sewer backup and surface water inflow through basement windows were also significant sources of flooding, although to a lesser degree than loss of power and saturated soils.

The results of the survey indicate the need for a coordinated approach to the solution of flooding, drainage, and sanitary sewer backup problems. The stormwater management and floodland management recommendations presented in this report are one component of such an approach. However, a comprehensive solution to the problems will require additional actions, such as localized yard grading, redirection of downspouts, floodproofing measures at individual homes outside delineated floodplains, modifications to the sanitary sewer system, and the provision of reliable power sources, either through distribution system upgrades or individual residents obtaining backup generators. The upgrades to reduce

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[8] *The estimate of the number of affected residences in Brookfield is primarily based on a City survey of refuse placed at the curb immediately following the August 6, 1998 storm.*

[9] *The area in the northwestern portion of the Village of Elm Grove approximately bounded by Pilgrim Parkway, W. North Avenue, Highland Drive, and Gebhardt Road experienced a loss of power that contributed to basement flooding. Widespread drainage problems would not normally be expected to occur in that area.*

infiltration and inflow to the Underwood trunk sewer, which are described above, were completed prior to the August 1998 storm. The recurrence of sanitary sewer backups in 1998 indicates that there are significant additional sources of infiltration and inflow to the sanitary sewer system.

Flooding of streets and basements were the predominant types of flooding experienced in 1998, but significant first-floor flooding was also experienced at buildings along the entire reach of Underwood Creek in Elm Grove, in the Verdant Drive area in Elm Grove, at a house near the intersection of Clearwater Drive and Pomona Road, and at houses along the east side of San Juan Trail north of W. Burleigh Road in the City of Brookfield. Additional areas of flooding on August 6, 1998, that were not reported in June of 1997 included the basement garages of two apartment buildings located east of Elm Grove Road along the Bishops Woods Tributary, the vicinity of Elmhurst Parkway and N. 124th Street, and the vicinity of the intersection of Greenway Terrace and Crestwood Court, all in the Village of Elm Grove, and overland flooding of an office building along Bishops Way in the Bishops Woods Office Park in the City of Brookfield. Due to the extreme and unprecedented intensity of the rainfall, scattered problems occurred in locations throughout the City and Village, even in upland areas.

Several bridges along Underwood Creek sustained damage, including the Park and Shop enclosure, the Wall Street bridge, the downstream Canadian Pacific railway bridge, and the United Parcel Service entrance drive bridge, all in Elm Grove. A private bridge over Underwood Creek near Jodon Court in Brookfield was washed out.

The Village of Elm Grove staff reported that the flooding also resulted in the deposition of sediment and debris in Underwood Creek at several locations. The Village removed obstructions where such removal could be accomplished without obtaining a permit from the State of Wisconsin under Chapter 30 of the *Wisconsin Statutes*, and applications were made for permits from the State for the removal of accumulated sediment.

Roadway and drainage improvements were undertaken by the City of Brookfield along Calhoun Road south of Burleigh Road following the June 1997 flood. Those improvements included modification of the open channel on the east side of the road and raising the road grade. As a result, the roadway was not flooded on August 6, 1998.

Underwood Creek Flooding Task Force

In response to the significant flooding and drainage problems that occurred in 1997 and 1998, the City of Brookfield and the Village of Elm Grove formed a joint task force to address issues related to flooding, drainage, and sanitary sewer backup problems in the Underwood Creek and Dousman Ditch subwatersheds. Each community appointed six residents to serve on the Task Force. A list of the Task Force members is set forth in Appendix C of this report. The City and Village staffs; the staff of Ruekert & Mielke, Inc., the Village engineer; and the Commission staff served as the primary technical resources for the Task Force. In addition, informational presentations were also made by the staffs of the Milwaukee Metropolitan Sewerage District and the Wisconsin Department of Natural Resources. The first Task Force meeting was held on November 2, 1998, and meetings were held about once a month thereafter. The Task Force developed a set of recommended policies to guide the City and Village in their efforts to resolve flooding, drainage, and sanitary sewer backup problems in the subwatersheds. The Task Force representatives from each community also met separately on several occasions to consider problems more specifically related to their individual communities. Alternative floodland management plans No. 10 and 11, as described in a subsequent section of this report, were developed at the request of the Task Force.

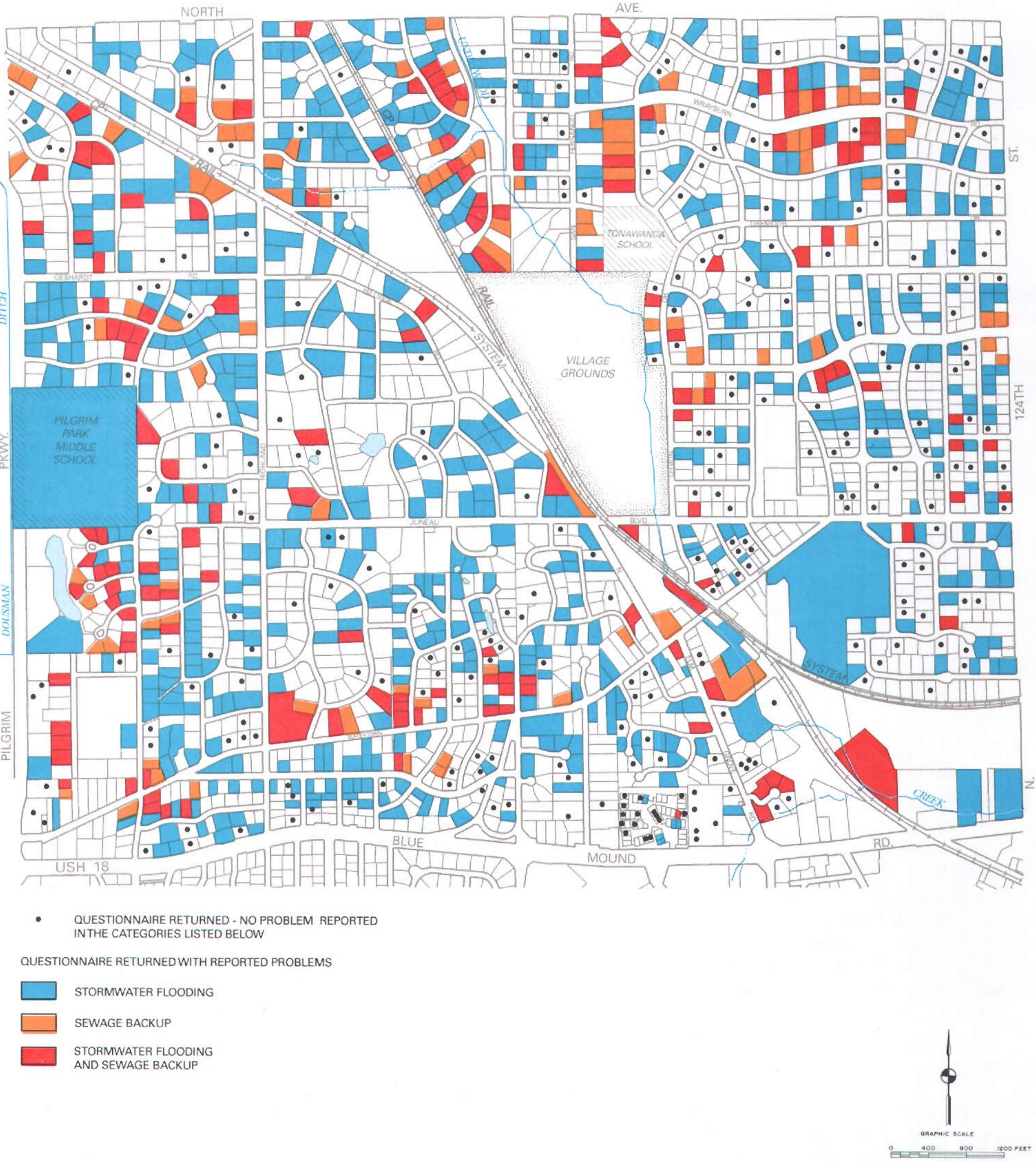
DESCRIPTION AND EVALUATION OF ALTERNATIVE STORMWATER AND FLOODLAND MANAGEMENT APPROACHES

Introduction

To abate existing, as well as future, stormwater management and flooding problems, several approaches were considered. These approaches were first evaluated on a conceptual basis, considering the technical feasibility, applicability, and advantages and disadvantages of each approach. Elements of the most feasible approaches were then incorporated into systems-level alternative stormwater and floodland management plans for the Underwood Creek and Dousman Ditch subwatersheds.

Map 13

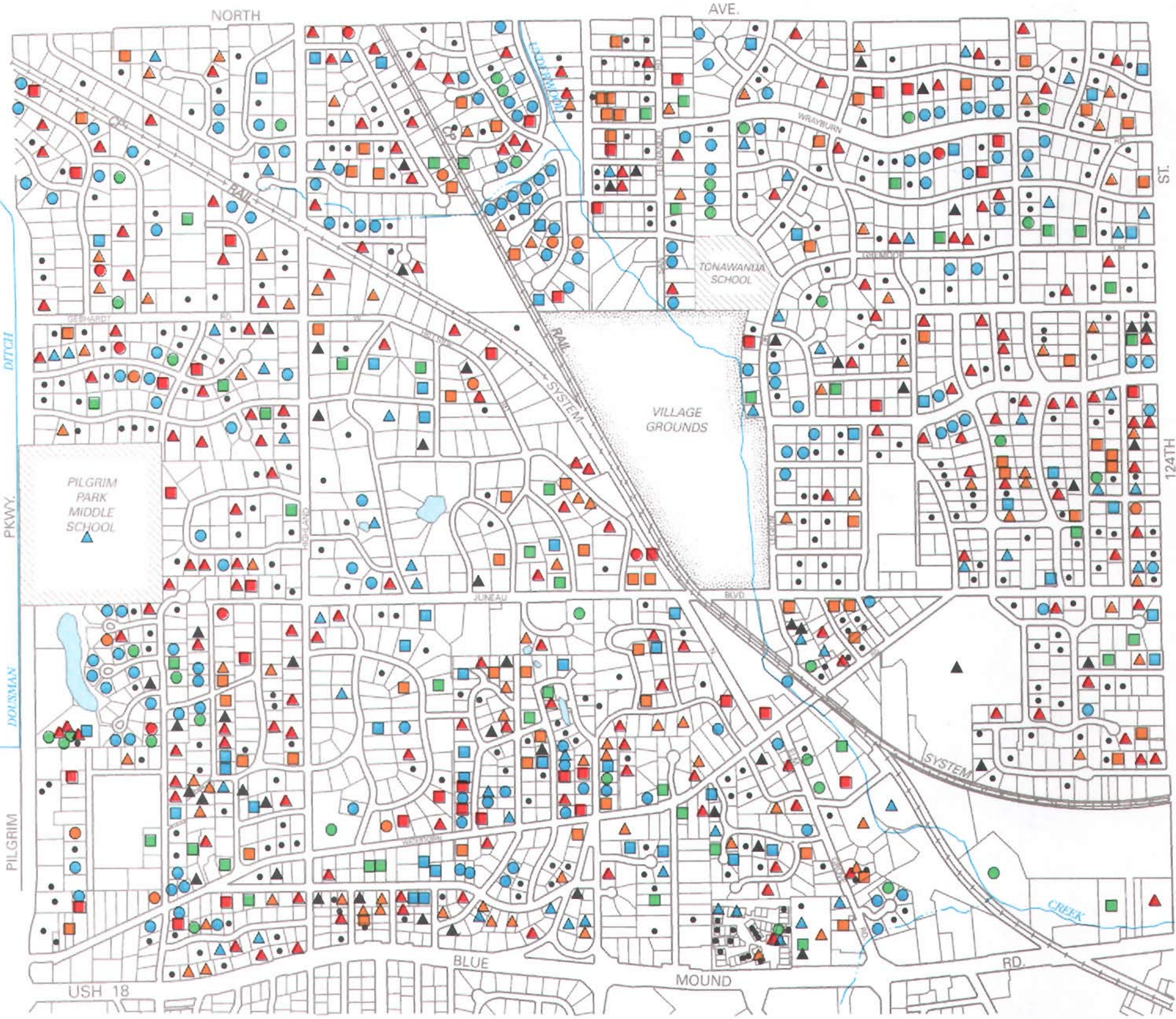
AUGUST 6, 1998: STORMWATER FLOODING AND SEWAGE BACKUP–VILLAGE OF ELM GROVE



Source: Ruekert & Mielke, Inc. and SEWRPC.

Map 14

AUGUST 6, 1998: WATER INTO BASEMENT AND PONDING NEXT TO FOUNDATION–VILLAGE OF ELM GROVE



● QUESTIONNAIRE RETURNED - NO PROBLEM REPORTED IN THE CATEGORIES LISTED BELOW

QUESTIONNAIRE RETURNED WITH REPORTED PROBLEMS

🔴 SEWAGE BACKED UP FROM BASEMENT FLOOR DRAIN AND WATER ENTERED BASEMENT THROUGH WINDOW WELLS

🟠 SEWAGE BACKED UP FROM BASEMENT FLOOR DRAIN AND WATER ENTERED BASEMENT THROUGH WINDOW WELLS, WALLS, OR FLOOR.

🔵 SEWAGE BACKED UP FROM BASEMENT FLOOR DRAIN AND WATER ENTERED BASEMENT THROUGH WINDOW WELLS, WALLS, OR FLOOR, AND STORMWATER PONDED NEXT TO FOUNDATION

🟢 SEWAGE BACKED UP FROM BASEMENT FLOOR DRAIN AND WATER ENTERED BASEMENT THROUGH WALLS OR FLOOR

🟥 SEWAGE BACKED UP FROM BASEMENT FLOOR DRAIN, AND STORMWATER PONDED NEXT TO FOUNDATION

🟧 WATER ENTERED BASEMENT THROUGH WINDOW WELLS

🟦 WATER ENTERED BASEMENT THROUGH WINDOW WELLS, WALLS, OR FLOORS

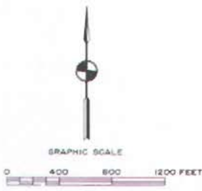
🟩 WATER ENTERED BASEMENT THROUGH WINDOW WELLS, WALLS, OR FLOOR, AND STORMWATER PONDED NEXT TO FOUNDATION

▲ WATER ENTERED BASEMENT THROUGH WINDOW WELLS, AND STORMWATER PONDED NEXT TO FOUNDATION

▲ WATER ENTERED BASEMENT THROUGH BASEMENT WALLS OR FLOOR

▲ WATER ENTERED BASEMENT THROUGH BASEMENT WALLS OR FLOOR AND STORMWATER PONDED NEXT TO FOUNDATION

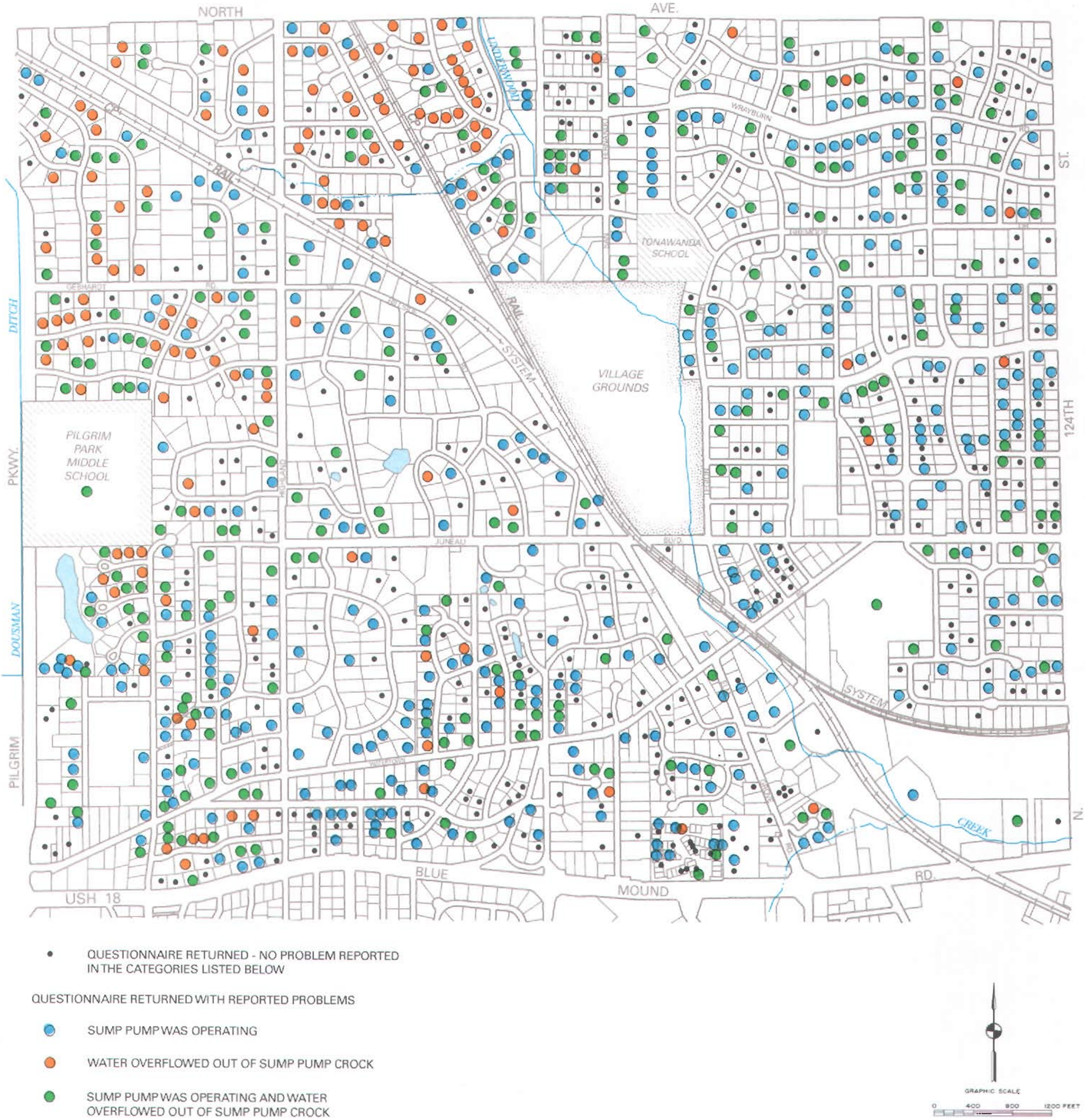
▲ STORMWATER PONDED NEXT TO FOUNDATION



Source: Ruekert & Mielke, Inc. and SEWRPC.

Map 15

AUGUST 6, 1998: SUMP PUMP OPERATING AND SUMP PUMP OVERFLOW–VILLAGE OF ELM GROVE



● QUESTIONNAIRE RETURNED - NO PROBLEM REPORTED IN THE CATEGORIES LISTED BELOW

QUESTIONNAIRE RETURNED WITH REPORTED PROBLEMS

● SUMP PUMP WAS OPERATING

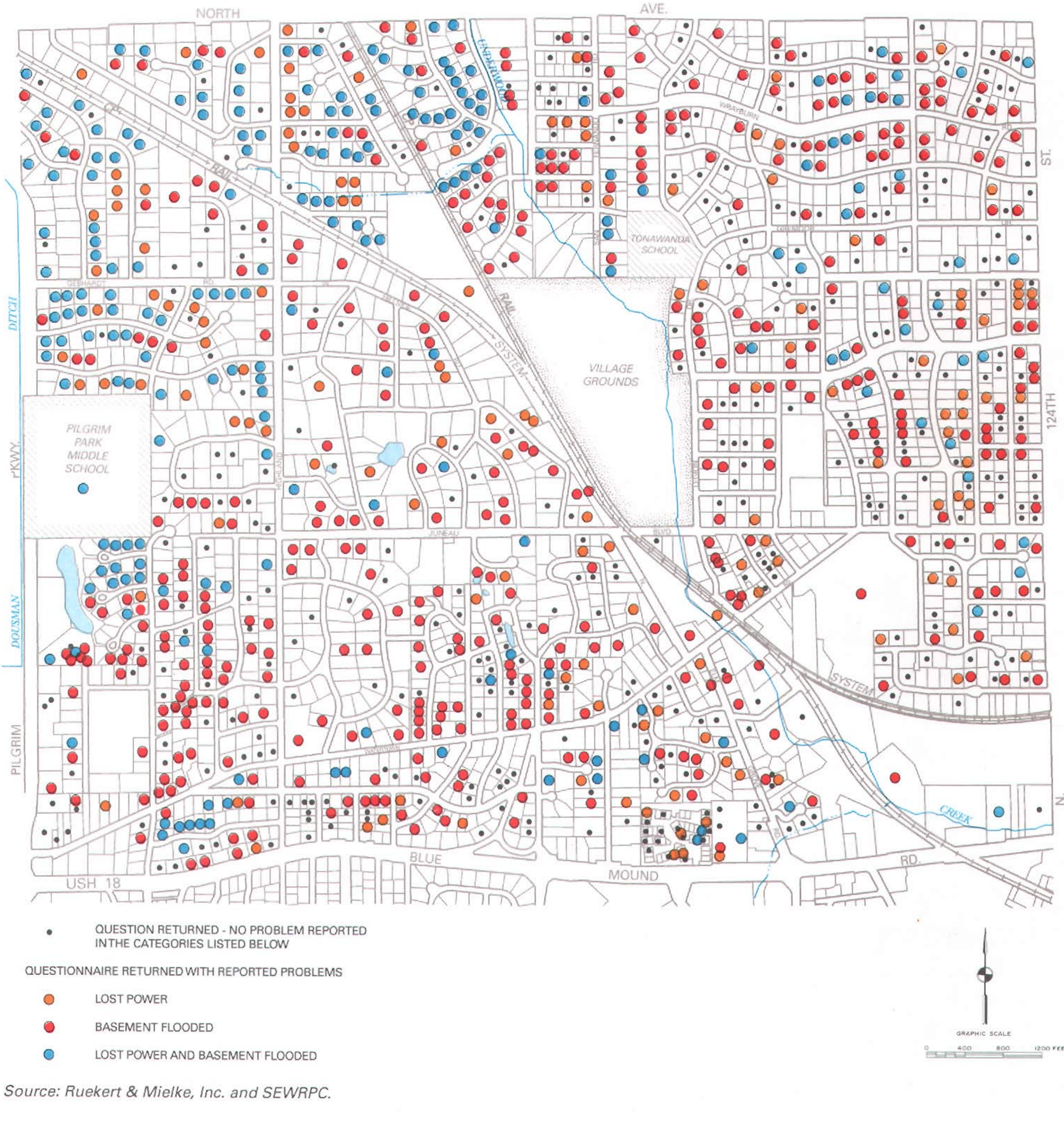
● WATER OVERFLOWED OUT OF SUMP PUMP CROCK

● SUMP PUMP WAS OPERATING AND WATER OVERFLOWED OUT OF SUMP PUMP CROCK

Source: Ruekert & Mielke, Inc. and SEWRPC.

Map 16

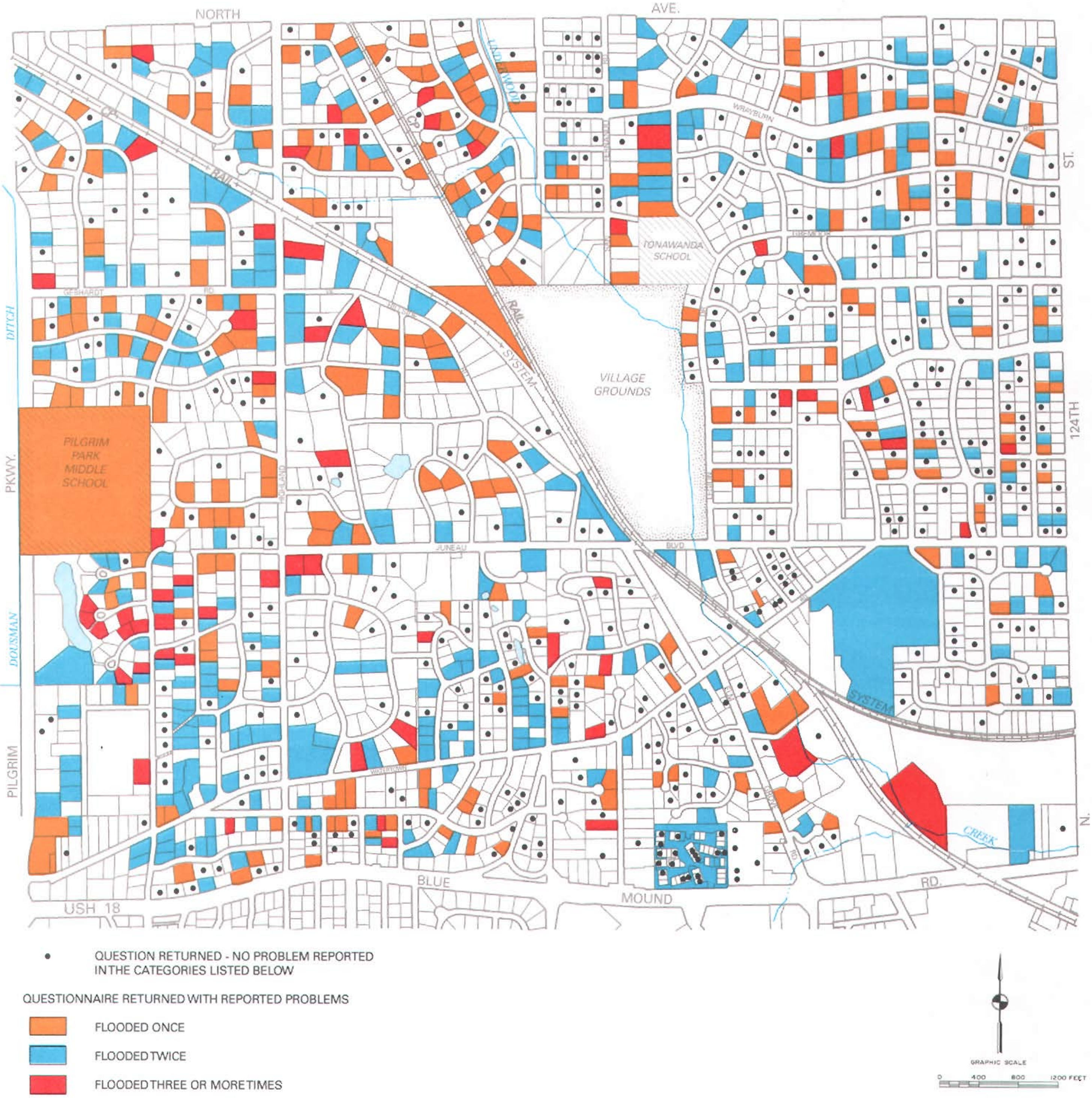
AUGUST 6, 1998: POWER OUT AND BASEMENT FLOODING–VILLAGE OF ELM GROVE



Source: Ruekert & Mielke, Inc. and SEWRPC.

Map 17

AUGUST 6, 1998: NUMBER OF TIMES FLOODED–VILLAGE OF ELM GROVE



Source: Ruekert & Mielke, Inc. and SEWRPC.

Alternative Stormwater and Floodland Management Approaches

Alternative approaches to stormwater and floodland management that were considered include conventional conveyance, centralized detention, decentralized or onsite detention, "natural" systems, and nonstructural measures. Because the study area is almost fully developed, the character of the stormwater drainage system has largely been established. Thus, opportunities to significantly alter that system are somewhat limited. However, the existing system does include components characteristic of most of the alternative approaches described below.

Storm Sewer Conveyance

This conveyance approach would utilize storm sewers and turf-, grass-, or riprap-lined channels and related appurtenances to provide for the collection and rapid conveyance of stormwater runoff to the receiving streams within the urban service area. Nonpoint source pollution abatement measures can be adapted to this type of system.

The major advantages of this type of system are the minimization of onsite inconvenience because the water is rapidly collected and conveyed downstream, and ready applicability to both existing and newly developing urban areas. Properly designed, constructed, and maintained storm sewers present no hazard to the public health and safety; help to lower groundwater levels, thereby helping to stabilize pavements and other structures; help to maintain dry basements, minimizing the need for the energy inefficient operation of sump pumps; and minimize the infiltration and inflow of clear water into sanitary sewerage systems.

The disadvantages of the conveyance approach, when applied in the absence of mitigating storage of runoff, are that downstream peak flows and stages may be increased, leading to a possible increase in areas of inundation and in the potential for streambank erosion, streambed scour, and loss of habitat; stream baseflows may be reduced due to the loss of some stormwater infiltration when open channels and grassed swales are replaced with storm sewers; there is little potential for multi-purpose uses of the system; and this approach usually has a high capital cost.

Given the advantages of the conveyance approach, and because such a system is already in place over much of the study area, especially in the City of Brookfield, such an approach was considered in the development of the alternative stormwater management plans.

Roadside Swale Conveyance

This conveyance approach would utilize roadside swales and grass-lined or natural channels to provide collection and conveyance of stormwater runoff to receiving streams. The system provides control of nonpoint source pollution through infiltration and filtering in the swales.

The major advantages of this type of system are relatively low capital cost, some reduction in peak flow rates and volumes during more frequent storms in comparison with storm sewer conveyance due to increased flow travel times, inline storage, and infiltration of runoff through the swale sides and bottom;[10] and maintenance of stream baseflow through infiltration of runoff.

The disadvantages of this approach include potential safety hazards, relatively high maintenance costs, difficulties in adapting such a system to areas of medium- and high-density development where right-of-way is limited and driveway culverts are closely spaced, and the potential for groundwater contamination, particularly when used in industrial areas.

At present, there is extensive application of roadside swale conveyance systems within the areas of existing low-density residential development within the subwatersheds. The general policies of the City and the Village are to retain the existing roadside swales in areas of existing low-density development. Since

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[10] *Because most of the soils occurring in the subwatersheds are classified as poorly or very poorly drained, infiltration of stormwater runoff through the sides and bottom of grassed roadside swales is limited. Based on hydrologic modeling conducted for the nearby Lilly Creek subwatershed, which has similar soil characteristics, roadside swale conveyance would be expected to reduce peak flow rates or volumes by only 10 percent or less during large storms with recurrence intervals ranging from 10 to 100 years. In general, this degree of peak flow reduction would not be sufficient to reduce the size of the conveyance and storage components of the stormwater management system. (See SEWRPC Community Assistance Planning Report No. 190,* A Stormwater Management and Flood Control Plan for the Lilly Creek Subwatershed, *February 1993.)*

about 1963, the City has required urban street cross-sections with curb and gutter and storm sewers in areas of new development. Also, in certain problem areas, the City has constructed ditch enclosures to retrofit swales with underlying storm sewers such that runoff is collected in the swales and conveyed to the storm sewer inlets. Given the potential advantages of the roadside swale conveyance approach and its existing widespread application in the study area, it was considered in the development of the alternative stormwater management plans, particularly in areas of existing low-density residential development.

Centralized Detention

A centralized detention approach would utilize major surface or subsurface detention facilities to provide temporary storage of stormwater runoff for subsequent slow release to downstream channels or storm sewers. The centralized detention facilities would be located on a limited number of strategic sites to maximize benefits, yet not all areas would drain to a centralized facility. Nonpoint source pollution control can be provided through the inclusion of a permanent pond within the detention facility.

The major advantages of a centralized detention approach are that, if properly applied, the facilities can limit the effects of urban development on discharges, areas of inundation, streambank erosion, streambed scour, and aquatic habitat; a substantial amount of nonpoint source pollutants can be removed; the size and resultant cost of downstream conveyance facilities can be reduced and the need for upgrading existing facilities can sometimes be avoided; the facilities can be combined with recreation and open space areas to provide multi-purpose areas; and habitat can be provided for wildlife and waterfowl.

The disadvantages of a centralized detention approach are that large, relatively level, open areas are usually required, thereby severely reducing the availability of potential sites in areas of existing development; the facility may not be cost-effective if the site costs cannot be offset by the savings of providing smaller conveyance facilities downstream; the operation and maintenance requirements may be substantial; for a permanent pool facility, the ponded water may be perceived as a public health and safety hazard; and odor and insect problems may be produced. While readily applicable as an integral part of large-scale urban development proposals, the approach is more difficult to apply to areas of existing urban development.

Within the study area, centralized detention facilities could be used to abate some of the existing and potential stormwater management problems, therefore, the approach was considered in the development of the alternative stormwater management and floodland management plans.

Onsite Detention

Like centralized detention, onsite detention provides for the temporary storage of stormwater runoff, but the storage sites are located close to, or at, the source of runoff generation. Such facilities are generally implemented through local ordinances or guidelines that apply a "policy" approach whereby the provision of detention storage is arbitrarily required for each development. Onsite detention facilities are often required to provide a standard degree of control of runoff, for example, control of the peak 100-year post-development rate of runoff to the peak two- or 10-year pre-development rate. Nonpoint source pollution control can be provided through the inclusion of a permanent pond within the detention facility.

The advantages of the onsite detention approach may be similar to those of the centralized detention approach with regard to downstream water quality control and to the potential for reducing the size of conveyance systems located immediately downstream of the basin. Onsite facilities, however, have smaller unit site requirements than do centralized facilities, and therefore may be more readily applicable, although not totally without difficulty, in existing as well as newly developing urban areas.

The disadvantages of the onsite detention approach are that maintenance requirements may be substantial; the ponded water in a detention pond may cause localized inconvenience and represent a health and safety hazard; odor and insect problems may be produced; the facilities may not be suitable for multi-purpose uses such as recreation and open space; and the costs may be high if not offset by smaller downstream conveyance systems. Also, because onsite facilities are often required based on the "policy" approach described above, the need for the facility is not logically determined. As a result, the degree of control is often established at a conservatively high level to avoid creating problems by increasing flood flows in receiving streams when basins are not judiciously located within a watershed. That overly conservative approach is generally not cost effective.

Because of the relatively small potential for additional urban development in the study area and because of the lack of suitable sites for significant onsite detention in areas of existing development, the onsite detention approach is not likely to be highly effective in the overall study area. Since it has the potential to abate existing and potential stormwater runoff problems in certain localized areas, the onsite detention approach was considered in the development of the alternative stormwater management plans. However, this option was not considered where more effective and efficient centralized storage sites were available.

Natural System

The natural, or "blue-green" stormwater management system consists of vegetation-lined channels, preferably natural or "free-form," and interconnected, natural surface depressions, and wetlands. Such a system provides for the temporary storage and conveyance of stormwater runoff in the vegetation-lined channels and associated depression and wetland areas, which slow the runoff and allow ponding and infiltration. The drainage system of an area may consist almost entirely of "blue-green" channels, or it may be supplemented by other management measures including storm sewers.

The advantages of the natural system approach are that downstream peak flows may be reduced; pollutants in storm runoff may be removed by filtration through the soil and vegetation, by biological uptake, and by sedimentation; the "free-form" open channels and related drainage areas can serve as part of park and open space sites following the multi-use concept; habitat areas for wildlife and waterfowl can be maintained or enhanced; construction costs may be lower than those of systems relying more heavily on constructed facilities; and the aesthetic qualities of a natural drainage system may be particularly attractive to some citizens.

The disadvantages of the natural system approach are that it may make it difficult to develop an open-channel system which can effectively accommodate the high peak flows generated from medium- to high-density urban areas served by storm sewers; the flowing channels may be perceived as a safety hazard; the channels are difficult to properly clean and maintain; and some citizens and local public officials may oppose open-channel flow in urban areas.

Within the study area there are extensive natural system components, including channels and wetlands, which serve to abate stormwater runoff problems. Although there may be some citizen opposition to the short-term standing and flowing water, and to the more extensive land areas required, the maintenance and use of the existing natural system features were considered in the development of each of the alternative stormwater management and floodland management plans.

Nonstructural Measures for Control of Stormwater Runoff and Floods

The nonstructural approach to the control of stormwater runoff and flooding primarily involves reducing damages from unusually high stormwater runoff and inundation rather than controlling the runoff rates or inundation levels themselves. Nonstructural measures include, structure floodproofing or elevation, relocation of structures, land use regulations, and open space and floodland preservation.

The advantages of the nonstructural approach are that the measures are suitable for use in existing urban areas, the measures are highly flexible and adaptable to different situations, the cost of many nonstructural measures is relatively low, the measures can often be used to create needed park and open space, and there are few hazards associated with nonstructural measures.

The disadvantages of the nonstructural approach are that downstream water quantity may not be controlled to the same degree as with structural measures; many stormwater problems, such as street flooding, are not abated; condemnation of private property may be necessary; and full implementation of such measures may be difficult.

Because of their adaptability and potential for cost savings, nonstructural measures were considered in the development of the alternative stormwater management plans.

DESCRIPTION AND EVALUATION OF ALTERNATIVE FLOODLAND MANAGEMENT PLANS FOR THE MAIN STEMS OF DOUSMAN DITCH AND UNDERWOOD CREEK

Introduction

Alternative flood control plans for the main stems of Dousman Ditch and Underwood Creek were originally developed under the Commission's 1976 Menomonee River watershed study. The recommended plan which was selected from the alternative plans called for the construction of a large detention storage facility along Dousman Ditch in the City of Brookfield and floodproofing, elevation, and removal of buildings along Underwood Creek. Refinements to that plan were made under a 1979 Dousman Ditch detention basin study prepared by Donohue & Associates, Inc.[11] and the Commission's 1990 stormwater drainage and flood control system plan prepared for the Milwaukee Metropolitan Sewerage District. The detention storage alternatives are consistent with the recommendations of the Brookfield park and open space plan which calls for the detention basin site to be purchased by the City and to be preserved in open space use.

Summary of Flood Control Alternatives Considered under Past Studies

Menomonee River Watershed Study

The following is a general summary of the various flood control alternatives that were considered for Underwood Creek under the 1976 Commission Menomonee River watershed study. Two classes of alternatives were investigated: 1) those which most completely address the flooding problem and 2) those which partially address the flooding problem.

These alternatives are presented to provide a historical perspective on the flood control planning process for the subwatersheds and to indicate the broad range of solutions that has been investigated. The alternative plans described below were considered by the Menomonee River Watershed Committee, which included representatives from the City, the Village, and the Wisconsin Department of Natural Resources, and a recommended plan was selected by that committee. The Village of Elm Grove expressed its formal opposition to channel modification during the committee deliberations. That position was reflected by the final recommended plan which called for detention storage along Dousman Ditch and for structure floodproofing and removal along Underwood Creek. Subsequent to the adoption of the watershed study, additional flood control and floodland management planning for the Dousman Ditch and Underwood Creek subwatersheds has refined the recommended plan set forth in the watershed study.

During the more than 20-year period since adoption of the watershed study, Federal and State floodland management policies have evolved. Federal policy encourages, and in some cases may provide funding for, nonstructural floodland management methods, including structure floodproofing, elevation, or removal. State policy discourages the implementation of channel modification projects which result in significant disturbance and alteration of stream channels[12] and encourages nonstructural floodland management and stormwater management measures. Thus, some of the alternatives explored under the watershed study are no longer considered to be desirable from a regulatory standpoint. However, the recommended plan developed under the watershed study is consistent with current Federal and State policies.

Menomonee River Watershed Plan Alternatives Which Most Completely Address the Flooding Problem

- Floodproofing and Removal of Structures—Remove 36 structures and floodproof 268 in the

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[11] *Donohue & Associates, Inc., Consulting Engineers,* Dousman Ditch Detention Basin Study, *prepared for the City of Brookfield and the Village of Elm Grove, May 25, 1979.*

[12] *Wisconsin Department of Natural Resources, "Guidance on Department Regulation of Stream Channelization Projects for Urban Flood Control," memorandum from Department Secretary C.D. Besadny, November 23, 1987.*

primary and secondary flooding zones.[13] The estimated capital cost of this alternative, updated to 1998 dollars is $8,000,000.

- Major Channel Modification, Structure Floodproofing, and Bridge Replacement—Construct a 5.4-mile-long concrete-lined trapezoidal channel and lower the streambed from 1.5 to eight feet. The modified channel would have a 20-foot-wide bottom and side slopes of one vertical on three horizontal. Bridges or culverts would be replaced at the upstream Canadian Pacific Railway culvert in Brookfield near Indian Creek Parkway, W. North Avenue, Marcella Drive, the Village Hall access road, Juneau Boulevard, the middle Canadian Pacific Railway bridge, one private bridge, Watertown Plank Road, and the downstream Canadian Pacific Railway bridge. The existing channel enclosure south of Watertown Plank Road would be replaced with an open channel section. The downstream 0.75 mile of Underwood Creek would be realigned along the railway embankment. Two structures in Brookfield would be removed and 44 would be floodproofed. The estimated capital cost of this alternative, updated to 1998 dollars is $13,000,000.

- Dikes, Floodwalls, Structure Floodproofing, and Bridge Replacement—Construct 3.8 miles of dikes and 1.7 miles of concrete or steel sheet floodwalls along both sides of Underwood Creek in much of the reach extending from Willaura Court in Brookfield to the eastern corporate limits of Elm Grove. Barrier heights would range from two to 11 feet. Six replacement public bridges, eight replacement private bridges, and 11 major stormwater pumping stations would be constructed. Those bridges would be designed to enable road closure during a flood. The upstream Canadian Pacific Railway bridge in Brookfield would be replaced. Floodproofing would be required for seven structures in the secondary flooding zone in Brookfield. The estimated capital cost of this alternative, updated to 1998 dollars is $16,000,000.

- Storage, Major and Intermediate Channel Modification, Structure Floodproofing and Removal, and Bridge Replacement—A 215-acre-foot detention basin would be constructed along Dousman Ditch in Brookfield along with appurtenant stormwater pumping facilities. There would be major channel modification with a concrete lining along the 0.91-mile-reach extending from the Milwaukee-Waukesha County line to Juneau Boulevard. A two-foot-high drop structure would be constructed in the stream channel at Juneau Boulevard. Bridges would be replaced at the upstream Canadian Pacific Railway crossing in Brookfield, Juneau Boulevard, the middle Canadian Pacific Railway bridge, one private bridge, Watertown Plank Road, and the downstream Canadian Pacific Railway bridge. The existing channel enclosure south of Watertown Plank Road would be replaced with an open channel section. Upstream of Juneau Boulevard, 1.14 miles of turf-lined channel with a 10-year flood capacity would be constructed; necessary alterations would be made to hydraulic structures accommodate the channel modifications; 170 structures would be floodproofed; and seven structures would be removed. The estimated capital cost of this alternative, updated to 1998 dollars is $16,000,000.

- Detention Storage, Bridge Replacement, Structure Floodproofing, Elevation, and Removal—A 215-acre-foot detention storage facility would be constructed along Dousman Ditch in Brook-

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[13] *The Menomonee River watershed study addressed both primary overland flooding and possible secondary flooding of buildings due to infiltration of water into basements and also to sanitary sewer backup. The City and Village are currently pursuing programs to address sanitary sewer backup problems as distinguished from overland flooding problems. Thus, the stormwater management and floodland management measures considered under the Dousman Ditch and Underwood Creek stormwater and floodland management plan do not address sanitary sewer backup directly, although the potential connection between overland flooding and infiltration and inflow to sanitary sewers is recognized. Because the stormwater plan does not consider secondary flooding and because of improvements to the hydrologic and hydraulic models used for floodplain delineation since the time of the watershed identified under this stormwater plan cannot be directly compared to those developed under the watershed study.*

field along with appurtenant stormwater pumping facilities. The upstream Canadian Pacific Railway bridge in Brookfield near Indian Creek Parkway would be replaced. Eight houses would be moved or removed and 229 houses and 23 commercial structures would be floodproofed.[14] This alternative was recommended for implementation by the Menomonee River Watershed Committee.

Menomonee River Watershed Plan Alternatives Which Partially Address the Flooding Problem

- Bridge and Culvert Alteration or Replacement—Replace the following six bridges along Underwood Creek which were found to create backwater of more than one foot under the watershed study:

  — Santa Maria Court, Indian Creek Parkway, two private bridges in Elm Grove, the downstream Canadian Pacific Railway bridge, and the Marcella Avenue bridge. The net effect was to lower 100-year flood stage by only one foot in Elm Grove and to provide a flood stage reduction in only a very short reach of stream in Brookfield. The potential flood stage reductions were not large enough to offer significant abatement of flood damages.

- Minor Channelization—Clear obstructions along with minor deepening and shaping in the 1.92-mile-long reach of Underwood Creek from Juneau Boulevard in Elm Grove to Clearwater Road in Brookfield. This would result in a negligible reduction in the 100-year flood stage and no significant flood damage reduction.

1990 Milwaukee Metropolitan Sewerage District Stormwater Drainage and Flood Control System Plan Recommendation

- Detention Storage with Structure Floodproofing and Elevation—Construct one 50-acre-foot detention basin and one 280-acre-foot detention basin in Brookfield along Dousman Ditch, floodproof 38 structures; and elevate three structures.[15] This plan recommendation reflects an update of the 1979 City of Brookfield study.

Current Alternative Floodland Management Plans Developed under the StormwaterManagement Plan for Dousman Ditch and Underwood Creek

Summary of Potential Flood Damages

The hydrologic and hydraulic analyses performed for the study presented herein identified a total of 51 buildings, including 34 residential, 17 industrial or commercial buildings, which would lie in the 100-year recurrence interval floodplain under planned land use and existing channel conditions. Table 23 indicates the number of buildings located in the floodplain in Brookfield and Elm Grove and the estimated flood damages under various flood conditions.[16] The total damages due to direct overland flooding to those buildings under 100-year recurrence interval flood conditions may be expected to approximate $2,075,000 and the average annual flood damages may be expected to approximate $135,000.

Eleven alternative floodland management plans were evaluated for the abatement of overland flooding damages from storms with recurrence intervals up to and including a 100-year recurrence interval event

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[14] *An estimated capital cost of this alternative in 1998 dollars is not provided because this alternative has been significantly refined since the watershed study was prepared and several different configurations of this alternative were considered in developing the recommendations for the Dousman Ditch and Underwood Creek stormwater management plan presented herein.*

[15] *Consistent with the approach of the Underwood Creek and Dousman Ditch stormwater management plan, this plan only addresses buildings that would potentially be affected by primary overland flooding, as opposed to secondary flooding.*

[16] *As additional data became available during review of the alternative plans by the Underwood Creek Flooding Task Force, refinements were made to the total number of buildings in the 100-year recurrence interval floodplain and to the dollar amount of potential flood damages. The information presented here was used for comparison of alternative plans. The final data on the number of flooded buildings and damage amounts is presented in Chapter VI, "Recommended Stormwater Management System Plan."*

Table 23

POTENTIAL FLOODING ALONG UNDERWOOD CREEK IN THE CITY OF BROOKFIELD AND THE VILLAGE OF ELM GROVE: PLANNED LAND USE, EXISTING CHANNEL CONDITIONS[a]

Location	100-Year Recurrence Interval Flood				Average Annual Damages	Percent of Total Average Annual Damages
	Number of Buildings Flooded			Total Damages		
	Houses	Commercial	Total			
City of Brookfield...............	8	1	9	$ 135,000	$ 5,000	7
Village of Elm Grove...........	25[b]	16	41	1,940,000	130,000	93
Total	33	17	50	$2,075,000	$135,000	100

[a] *As additional data became available during review of the alternative plans by the Underwood Creek Flooding Task Force, including the acquisition of new large-scale topographic maps, refinements were made to the total number of buildings in the 100-year floodplain. The information presented in this table was used for comparison of alternative plans. The final data on the number of flooded buildings is presented in Chapter VI, "Recommended Stormwater and Floodland Management System Plan."*

[b] *Includes four apartment buildings.*

Source: SEWRPC.

under planned land use conditions. Those alternative floodland management plans include: 1) Structure Floodproofing, Elevation, and Removal; 2) Acquisition and Removal of Floodprone Structures; 3) Limited Detention Storage with Structure Floodproofing, Elevation, and Removal; 4) Detention Storage with Excavation Minimized, No Wetland Disturbance, and Structure Floodproofing, Elevation, and Removal; 5) Expanded Detention Storage with Excavation Minimized and Structure Floodproofing, Elevation, and Removal; 6) Expanded Detention Storage with Excavation Maximized and Structure Floodproofing, Elevation, and Removal; 7) Expanded Two-Basin Detention Storage with Excavation Minimized and Structure Floodproofing, Elevation, and Removal; 8) Expanded Two-Basin Detention Storage with Excavation Maximized and Structure Floodproofing, Elevation, and Removal; 9) Two-Basin Detention Storage with Excavation Minimized, No Wetland Disturbance, and Structure Floodproofing and Elevation; 10) Limited Dousman Ditch Detention Storage, Maximum On-Line Storage, Bridge and Culvert Modification, and Structure Floodproofing, Elevation, and Removal; and 11) Limited Dousman Ditch Detention Storage, Underwood Creek Overflow Channel and Diversion, and Compensating Storage with Structure Floodproofing and Removal. The detention storage called for under nine of the 11 alternative plans would be provided within the primary environmental corridor along the upper reach of Dousman Ditch in the area west of Pilgrim Parkway and north of Wisconsin Avenue extended.[17] The alternative plans provide

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[17] *Three additional sites in the Underwood Creek subwatershed were considered for the provision of centralized detention storage for floodland management purposes. The staff of the City of Brookfield asked that consideration be given to providing detention storage along the North Branch of Underwood Creek. The North Branch of Underwood Creek was rejected as a centralized detention storage site for the following reasons: 1) there is a substantial amount of existing natural flood storage in the floodplain wetlands along the North Branch of Underwood Creek and it is unlikely that the available storage could be significantly enhanced through construction of a detention facility and 2) the construction of such a facility in the wetlands would be difficult to justify according to the requirements of Chapter NR 103 of the* Wisconsin Administrative Code, *"Water Quality Standards for Wetlands." The Sileno quarry, which is located east of the North Branch of Underwood Creek, was also investigated as a detention storage site. Development of that site for detention storage would be expensive and hydrologic modeling indi-*

(Footnote – continued on page 102)

abatement of flood damages along Underwood Creek, where all of the primary flood damages due to direct overland flooding would be expected to occur.

Flood flows used in the alternatives analysis were simulated using the U.S. Environmental Protection Agency (USEPA) Hydrological Simulation Program-Fortran (HSPF) model.[18] The HSPF model simulates streamflow and stage on a continuous basis using recorded climatological data as input. The model was run for the 49-year period from January 1940 through September 1988. The annual flood peaks computed for the 49-year period were then input to the U.S. Army Corps of Engineers HEC-FFA flood frequency analysis program to determine flood frequencies using the log-Pearson Type III method, consistent with the procedures of U.S. Water Resources Council Bulletin 17-B. Flood profiles for the two-, 10-, 25-, 50-, and 100-year recurrence interval floods occurring under planned land use and alternative channel conditions were computed using the U.S. Army Corps of Engineers HEC-RAS River Analysis System computer program.[19]

Because none of the plans completely eliminates street flooding during a 100-year flood, some residual damages due to street flooding would occur with each alternative. Such damages could include disruption of transportation, damage to pavement, erosion damage to road shoulders, and potential inflow to sanitary sewers in the absence of separate remedial measures to seal sanitary sewers. Somewhat different levels of such damage would be possible under each alternative since some alternatives provide greater reductions in flood stages than others. The stormwater management component of this plan addresses street flooding outside of the 100-year floodplains of Dousman Ditch and Underwood Creek and, as noted previously, the City and Village are pursuing programs to reduce infiltration and inflow to the sanitary sewer system.

Since the Bluemound Road-Wisconsin Avenue Development Corridor Land-Use Study was prepared in 1986-1987, the City of Brookfield has planned for development in the corridor, assuming that development could occur within a zone extending 500 feet north of the planned extension of Wisconsin Avenue between Calhoun Road and Pilgrim Parkway. With the exception of Alternative Plan Nos. 1 and 2, each of the alternative plans is inherently consistent with the development of the 500-foot zone. Under Alternative Plan Nos. 1 and 2 it would be necessary for individual developments within the 500-foot zone to provide compensatory floodplain storage to offset any filling in the floodplain. Separate analyses of the potential duration and frequency of flooding on the proposed Bluemound Road Golf Range site, which is located within the limits of the alternative detention basins, are described in Appendix D.

(Footnote 17 – continued from page 101)

cated that it would not be highly effective in reducing downstream flood flows in areas of significant structure flooding damages. The third potential detention storage site that was considered is along Underwood Creek in the Elm Grove Village Park. That site was suggested by local residents and members of the Underwood Creek Task Force. There is a substantial amount of existing natural flood storage in the floodplain within the Village Park and that storage is effective in reducing peak flood flows. The available storage could be enhanced, but such enhancement could compromise the Park's primary function as an active recreational facility and could require obtaining Federal and State permits for activities in wetlands. The creation of additional storage in the Park was examined under Alternative Plan Nos. 10 and 11. Those plans, which are described below, call for measures that would increase the hydraulic capacity along Underwood Creek in the Village of Elm Grove. The creation of additional floodwater storage is required to offset increases in flood flows that would be anticipated as a result of measures to increase the hydraulic capacity.

[18] *The USEPA HSPF (Hydrologic Simulation Program-Fortran) model developed under this study is an updated version of the Hydrocomp HSPX model originally developed for the Menomonee River watershed study as documented in SEWRPC Planning Report No. 26 and refined under the drainage and flood control study for the MMSD as documented in SEWRPC Community Assistance Planning Report No. 152.*

[19] *The base HEC-RAS model was developed under the ongoing floodplain mapping update program which the Commission is conducting for the City of Brookfield and the Village of Elm Grove.*

One potential component of each of the alternatives which call for the construction of a detention storage facility is an 19-acre, 87-acre-foot wet detention basin for the control of nonpoint source pollution. That detention basin is an integral part of the nonpoint source pollution control plan recommended in Chapter IV of this report. However, the floodland management portion of each alternative basin configuration could be constructed without construction of the permanent pond for control of nonpoint source pollution. Thus, for purposes of direct comparison of floodland management alternatives, only the alternative plan costs related to the necessary floodland management components are presented below in the alternative plan descriptions. Map 18 shows the land areas tributary to the detention basin under each alternative configuration.

In general, the detention basin alternatives may present opportunities for wetland creation within the primary environmental corridor along the upper reach of Dousman Ditch. Several of those alternatives would involve no direct disturbance of wetlands and several would involve relatively minor, localized disturbance. However, each of the detention basin alternatives could result in a gain in wetland area within the project boundaries.

The Underwood sanitary trunk sewer is located along the general alignment of Underwood Creek and Dousman Ditch in Brookfield and Elm Grove. The detention basin configurations for Alternative Plan Nos. 3 through 11 as described below all call for a detention basin with a permanent pond to be located above the trunk sewer in the upper reach of Dousman Ditch. In all cases, the basin could be constructed in a manner that would maintain adequate cover over the trunk sewer. The elevation of the permanent pond in the detention basin would be at the estimated approximate existing groundwater elevation of 824 feet above National Geodetic Vertical Datum, 1929 adjustment (NGVD29). Thus, it would not be expected that the amount of infiltration or inflow to the trunk sewer during normal low flow conditions would be changed with the detention basin in place. Under flood conditions, raising or sealing of manholes may be required to reduce inflow to the trunk sewer.

Selected characteristics and the cost of each alternative plan are provided in Table 24. Because the additional cost of the permanent pond varies slightly when that pond is added to the floodland management alternatives, Table 24 includes costs for each floodland management alternative, with and without the addition of the permanent pond.

Alternative Floodland Management Plan No. 1—Structure Floodproofing, Elevation, and Removal

As shown on Map 19, the first alternative plan considered calls for the floodproofing of five single-family residential buildings in Brookfield and 18 in Elm Grove, the elevation of two single-family residential buildings in Brookfield and three in Elm Grove, the floodproofing of four apartment buildings in Elm Grove, the floodproofing of one commercial building in Brookfield and 15 in Elm Grove, and acquisition and removal of one single-family residence in Brookfield[20]

This alternative plan also calls for raising about 400 feet of Pilgrim Parkway south of Gebhardt Road an average of about 1.3 feet to avoid inundation of the roadway during a 100-year flood. The grade raises would be located near the intersection with Cascade Drive and at the north entrance drive to Pilgrim Park Middle School. In order to provide adequate major drainage system hydraulic capacity following the road grade raise, the existing 24-inch-diameter corrugated metal pipe (CMP) culverts under Pilgrim Parkway at Cascade Drive would each be replaced. The northern CMP culvert would be replaced with a 50-foot-long, 27-inch-diameter reinforced concrete pipe (RCP) culvert and the southern CMP culvert would be replaced with a 53-foot-long, 18-inch-diameter RCP culvert. The existing 27-inch-high by 43-inch-wide corrugated metal pipe arch (CMPA) culvert under Pilgrim Parkway at the northern entrance to Pilgrim Park Middle School would be replaced with a 60-foot-long, 24-inch-high by 38-inch-wide reinforced concrete horizontal elliptical (HE) pipe culvert.

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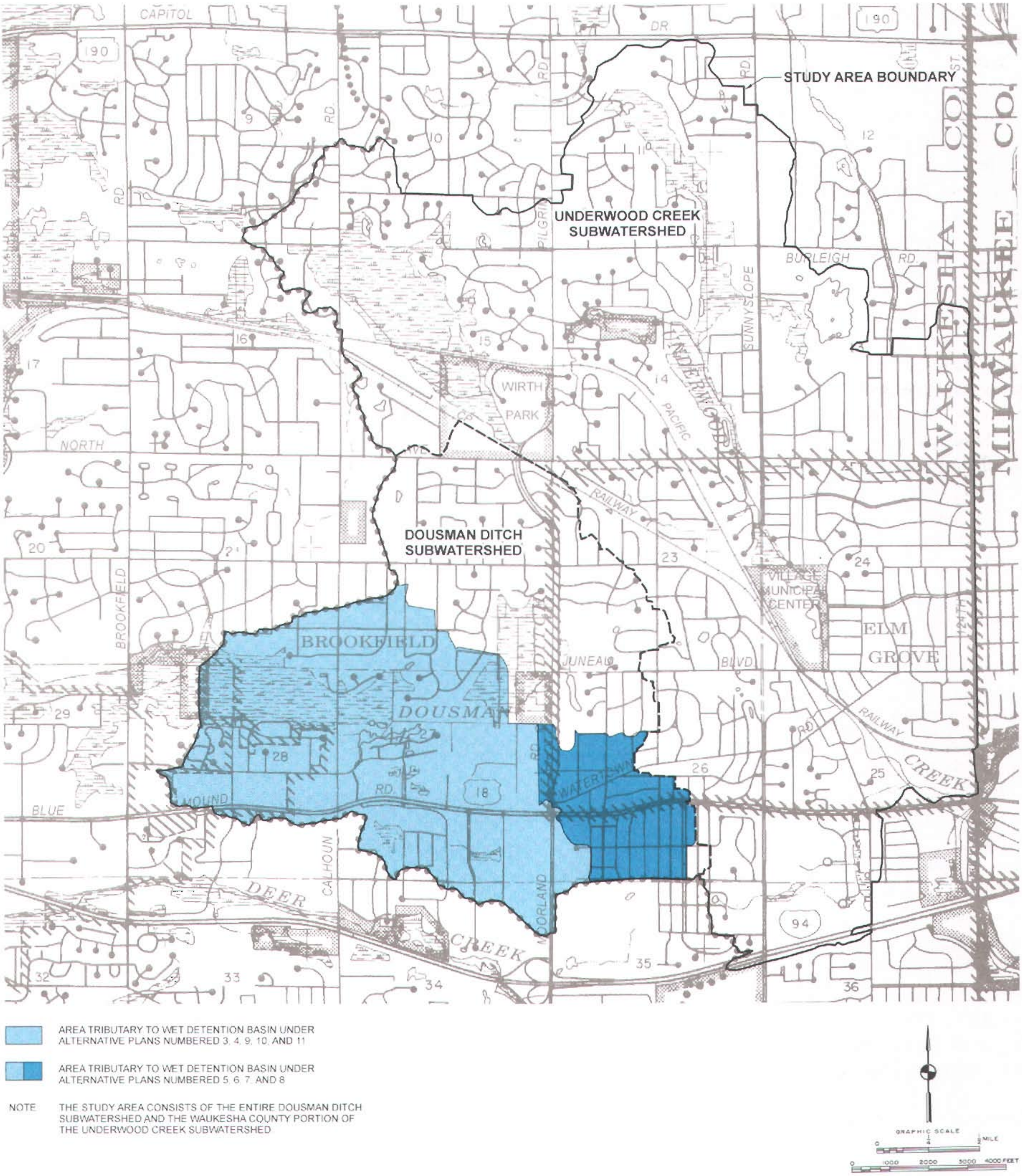
[20] *This residence was located at 13830 Adelaide Lane. Following the flood of June 21, 1997, the City of Brookfield applied for, and received, Federal Emergency Management Agency Flood Hazard Mitigation Grant Program (FEMA FHMGP) funds for the acquisition of this property. It was purchased by the City using funds from the FEMA FHMGP (75 percent of the cost), from the State of Wisconsin (12.5 percent of the cost), and from the City (12.5 percent of the cost). Work on the house removal project was completed in May of 1999.*

Map 18

AREAS TRIBUTARY TO WET DETENTION BASIN ALONG DOUSMAN DITCH



▨ AREA TRIBUTARY TO WET DETENTION BASIN UNDER ALTERNATIVE PLANS NUMBERED 3, 4, 9, 10, AND 11

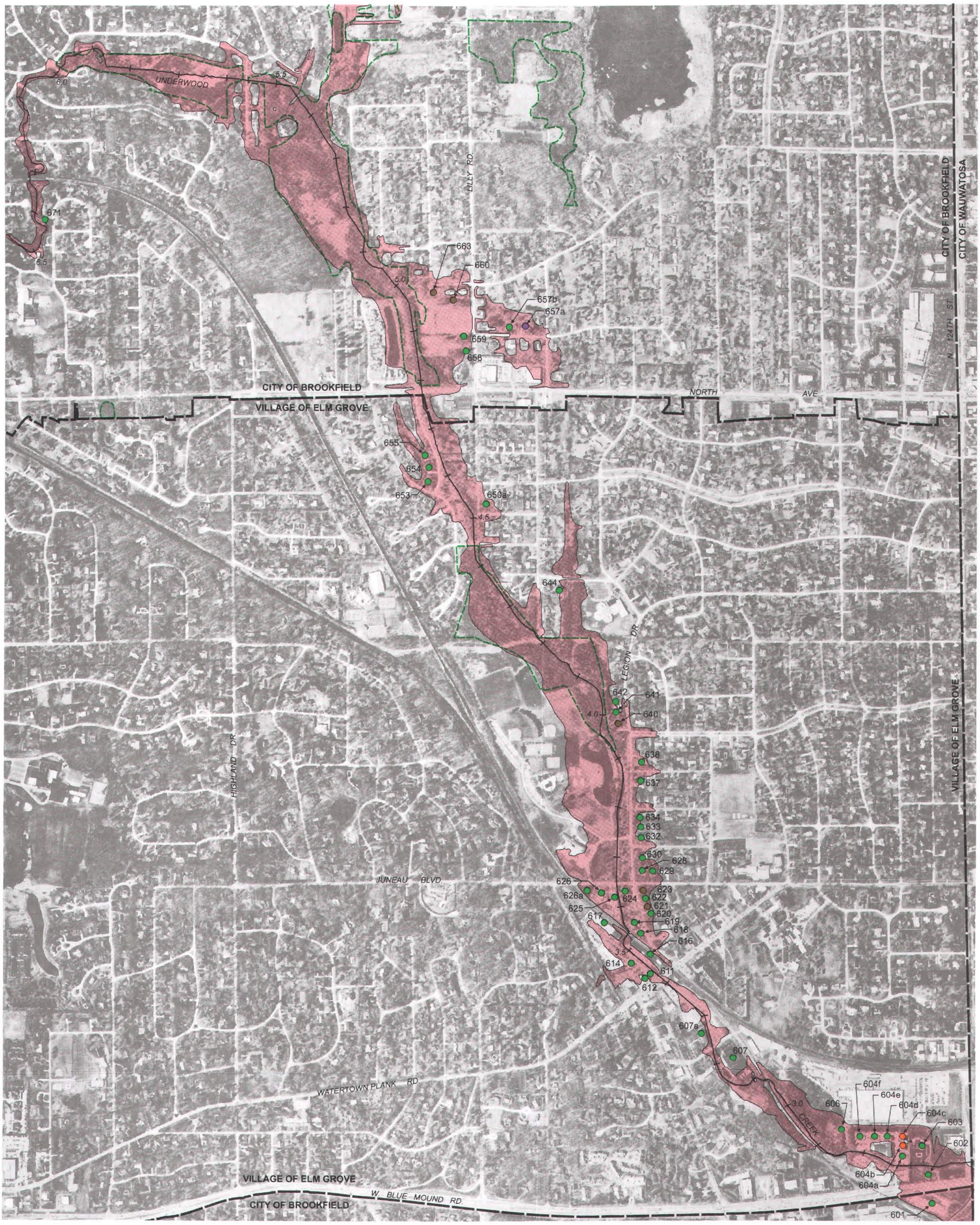
▨▨ AREA TRIBUTARY TO WET DETENTION BASIN UNDER ALTERNATIVE PLANS NUMBERED 5, 6, 7, AND 8

NOTE: THE STUDY AREA CONSISTS OF THE ENTIRE DOUSMAN DITCH SUBWATERSHED AND THE WAUKESHA COUNTY PORTION OF THE UNDERWOOD CREEK SUBWATERSHED

Source: SEWRPC.

Map 19

ALTERNATIVE FLOODLAND MANAGEMENT PLAN NO. 1
STRUCTURE FLOODPROOFING, ELEVATION, AND REMOVAL



0.5 EXISTING CHANNEL CENTERLINE AND RIVER MILE STATIONING

🟥 100-YEAR RECURRENCE INTERVAL FLOODPLAIN—PLANNED LAND USE AND EXISTING CHANNEL CONDITIONS

- - - EXISTING WETLAND BOUNDARY

607a BUILDING DESIGNATION

● BUILDING PROPOSED TO BE FLOODPROOFED

● BUILDING PROPOSED TO BE FLOODPROOFED OR ELEVATED

● BUILDING PROPOSED TO BE REMOVED

● BUILDING NEAR EDGE OF FLOODPLAIN, FLOODPROOFING MAY NOT BE REQUIRED

GRAPHIC SCALE
0 1/8 1/4 MILE
0 1000 2000 FEET

Source: SEWRPC.

Table 24

PRINCIPAL FEATURES AND COSTS OF ALTERNATIVE FLOODLAND MANAGEMENT AND ASSOCIATED NONPOINT SOURCE POLLUTION CONTROL PLANS FOR UNDERWOOD CREEK IN THE CITY OF BROOKFIELD AND THE VILLAGE OF ELM GROVE

	Water Quantity Control Costs							Water Quality Control Costs[a]						
Alternative	Description	Capital	Amortized Capital[b]	Annual Operation and Maintenance	Total	Average Annual Benefits	Benefit-Cost Ratio	Description	Capital	Amortized Capital[b]	Annual Operation and Maintenance	Total	Water Quantity and Quality Total Average Annual Cost[b]	Water Quantity and Quality Total Capital Cost
No. 1-Structure Floodproofing, Elevation, and Removal	Floodproof five houses in Brookfield and 18 in *Elm Grove*	$ 280,000	- -	- -	- -	- -	- -	- -[c]	- -	- -	- -	- -	- -	- -
	Floodproof four apartment buildings in Elm Grove	100,000	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
	Floodproof one commercial building in Brookfield and 15 in Elm Grove	1,000,000	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
	Acquire and remove one house in Brookfield	230,000	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
	Elevate two houses in Brookfield and three in Elm Grove	300,000	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
	Pilgrim Parkway road grade raise and associated culverts	55,000	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
	Total	$ 1,965,000	$ 125,000	- -	$ 125,000	$135,000	1.08	- -	- -	- -	- -	- -	$ 125,000	$ 1,965,000
No. 2—Acquisition and Removal of Floodprone Structures	Remove eight houses in Brookfield and 21 in Elm Grove	$ 7,210,000	- -	- -	- -	- -	- -	- -[c]	- -	- -	- -	- -	- -	- -
	Remove four apartment buildings in Elm Grove	1,750,000	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
	Remove one commercial building in Brookfield and 15 in Elm Grove	10,970,000	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
	Pilgrim Parkway road grade raise and associated culverts	55,000	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
	Total	$19,985,000	$1,269,000	- -	$1,269,000	$135,000	0.11	- -	- -	- -	- -	- -	$1,269,000	$19,985,000
No. 3—Limited Detention Storage with Structure Floodproofing, Elevation, and Removal	Detention basin	$ 1,870,000	- -	- -	- -	- -	- -	19-acre, 87-acre-foot detention basin	$1,910,000	- -	- -	- -	- -	- -
	Land acquisition	350,000	- -	- -	- -	- -	- -		- -	- -	- -	- -	- -	- -
	Floodproof five houses in Brookfield and 10 in Elm Grove	180,000	- -	- -	- -	- -	- -	Access roads/ baffles	120,000	- -	- -	- -	- -	- -

Table 24 (continued)

Alternative	Water Quantity Control Costs							Water Quality Control Costs[a]					Water Quantity and Quality Total Average Annual Cost[b]	Water Quantity and Quality Total Capital Cost
	Description	Capital	Amortized Capital[b]	Annual Operation and Maintenance	Total	Average Annual Benefits	Benefit-Cost Ratio	Description	Capital	Amortized Capital[b]	Annual Operation and Maintenance	Total		
No. 3 (continued)	Floodproof four apartment buildings in Elm Grove	$ 100,000	- -	- -	- -	- -	- -	Open channel to convey runoff to pond	$ 100,000	- -	- -	- -	- -	- -
	Floodproof one commercial building in Brookfield and 15 in Elm Grove	980,000	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
	Elevate two houses in Brookfield and three in Elm Grove	300,000	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
	Acquire and remove one house in Brookfield	230,000	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
	Pilgrim Parkway road grade raise and associated culverts	50,000	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
	Total	$ 4,060,000[d]	$ 258,000	- -[e]	$ 258,000	$135,000	0.52	Total	$2,130,000[f]	$135,000	$9,000	$144,000	$ 402,000	$ 6,190,000
No. 4—Detention Storage with Excavation Minimized, No Wetland Disturbance, and Structure Floodproofing, Elevation, and Removal	Dike and spillway	$ 2,720,000	- -	- -	- -	- -	- -	19-acre, 87-acre-foot detention basin	$1,910,000	- -	- -	- -	- -	- -
	Detention basin	1,920,000	- -	- -	- -	- -	- -		- -	- -	- -	- -	- -	- -
	Access roads/baffles	230,000	- -	- -	- -	- -	- -	Open channel to convey runoff to pond	100,000	- -	- -	- -	- -	- -
	Land acquisition	350,000	- -	- -	- -	- -	- -		- -	- -	- -	- -	- -	- -
	Easements	100,000	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
	Floodproof five houses in Brookfield and 11 in Elm Grove	200,000	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
	Floodproof four apartment buildings in Elm Grove	100,000	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
	Floodproof one commercial building in Brookfield and 14 in Elm Grove	950,000	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
	Elevate two houses in Brookfield and one in Elm Grove	180,000	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
	Acquire and remove one house in Brookfield	230,000	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
	Pilgrim Parkway road grade raise and associated culverts	50,000	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
	Total	$ 7,030,000[g]	$ 446,000	$10,000	$ 456,000	$135,000	0.30	Total	$2,010,000[h]	$128,000	$9,000	$137,000	$ 593,000	$ 9,040,000
No. 5—Expanded Detention Storage with Excavation Minimized and Structure Floodproofing, Elevation, and Removal	Dike and spillway	$ 2,480,000	- -	- -	- -	- -	- -	19-acre, 87-acre-foot detention basin	$1,910,000	- -	- -	- -	- -	- -
	Detention basin	2,000,000	- -	- -	- -	- -	- -		- -	- -	- -	- -	- -	- -
	Access roads/baffles	340,000	- -	- -	- -	- -	- -	Open channel to convey runoff to pond	150,000	- -	- -	- -	- -	- -
	Pilgrim Parkway road grade raise and associated culverts	270,000	- -	- -	- -	- -	- -		- -	- -	- -	- -	- -	- -
	Land acquisition	350,000	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -

Table 24 (continued)

Alternative	Water Quantity Control Costs							Water Quality Control Costs[a]					Water Quantity and Quality Total Average Annual Cost[b]	Water Quantity and Quality Total Capital Cost
	Description	Capital	Amortized Capital[b]	Annual Operation and Maintenance	Total	Average Annual Benefits	Benefit-Cost Ratio	Description	Capital	Amortized Capital[b]	Annual Operation and Maintenance	Total		
No. 5 (continued)	Easements	$ 100,000	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
	Floodproof five houses in Brookfield and 11 in Elm Grove	200,000	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
	Floodproof four apartment buildings in Elm Grove	100,000	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
	Floodproof one commercial building in Brookfield and 13 in Elm Grove	890,000	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
	Elevate two houses in Brookfield and one in Elm Grove	180,000	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
	Acquire and remove one house in Brookfield	230,000	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
	Total	$ 7,140,000[i]	$ 453,000	$11,000	$ 464,000	$135,000	0.29	Total	$2,060,000[j]	$131,000	$9,000	$140,000	$ 604,000	$ 9,200,000
No. 6—Expanded Detention Storage with Excavation Maximized and Structure Floodproofing, Elevation, and Removal	Dike and spillway	$ 2,130,000	- -	- -	- -	- -	- -	19-acre, 87-acre-foot detention basin	$1,910,000	- -	- -	- -	- -	- -
	Detention basin	4,180,000	- -	- -	- -	- -	- -		- -	- -	- -	- -	- -	- -
	Access roads/baffles	250,000	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
	Pilgrim Parkway road grade raise and associated culverts	200,000	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
	Land acquisition	350,000	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
	Floodproof five houses in Brookfield and 11 in Elm Grove	200,000	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
	Floodproof four apartment buildings in Elm Grove	100,000	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
	Floodproof one commercial building in Brookfield and 13 in Elm Grove	890,000	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
	Elevate two houses in Brookfield and one in Elm Grove	180,000	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
	Acquire and remove one house in Brookfield	230,000	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
	Total	$ 8,710,000[k]	$ 553,000	$10,000	$ 563,000	$135,000	0.24	Total	$1,910,000[l]	$121,000	$9,000	$130,000	$ 693,000	$10,620,000
No. 7—Expanded Two-Basin Detention Storage with Excavation Minimized and Structure Floodproofing, Elevation, and Removal	South Basin	- -	- -	- -	- -	- -	- -	19-acre, 87-acre-foot detention basin	- -	- -	- -	- -	- -	- -
	Dike and spillway	$ 2,480,000	- -	- -	- -	- -	- -		- -	- -	- -	- -	- -	- -
	Detention basin	2,000,000	- -	- -	- -	- -	- -	Open channel to convey runoff to pond	150,000	- -	- -	- -	- -	- -
	Access roads/baffles	340,000	- -	- -	- -	- -	- -		- -	- -	- -	- -	- -	- -
	Pilgrim Parkway road grade raise	230,000	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
	Land acquisition	350,000	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
	Easements	100,000	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
	Subtotal	$ 5,500,000	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -

Table 24 (continued)

Alternative	Water Quantity Control Costs							Water Quality Control Costs[a]					Water Quantity and Quality Total Average Annual Cost[b]	Water Quantity and Quality Total Capital Cost
	Description	Capital	Amortized Capital[b]	Annual Operation and Maintenance	Total	Average Annual Benefits	Benefit-Cost Ratio	Description	Capital	Amortized Capital[b]	Annual Operation and Maintenance	Total		
No 7 (continued)	North Basin													
	Dike and spillway	$ 1,170,000	--	--	--	--	--	--	--	--	--	--	--	--
	Land acquisition	30,000	--	--	--	--	--	--	--	--	--	--	--	--
	Pilgrim Parkway road grade raise and associated culverts	20,000	--	--	--	--	--	--	--	--	--	--	--	--
	Subtotal	$ 1,220,000	--	--	--	--	--	--	--	--	--	--	--	--
	Floodproofing, Elevation, and Removal													
	Floodproof four houses in Brookfield and 11 in Elm Grove	$ 190,000	--	--	--	--	--	--	--	--	--	--	--	--
	Floodproof four apartment buildings in Elm Grove	100,000	--	--	--	--	--	--	--	--	--	--	--	--
	Floodproof one commercial building in Brookfield and 13 in Elm Grove	890,000	--	--	--	--	--	--	--	--	--	--	--	--
	Elevate two houses in Brookfield and one in Elm Grove	180,000	--	--	--	--	--	--	--	--	--	--	--	--
	Acquire and remove one house in Brookfield	230,000	--	--	--	--	--	--	--	--	--	--	--	--
	Subtotal	$ 1,590,000	--	--	--	--	--	--	--	--	--	--	--	--
	Total	$ 8,310,000[m]	$ 528,000	$14,000	$ 542,000	$135,000	0.25	Total	$2,060,000[j]	$131,000	$9,000	$140,000	$ 682,000	$10,370,000
No. 8—Expanded Two-Basin Detention Storage with Excavation Maximized and Structure Floodproofing, Elevation, and Removal	South Basin	--	--	--	--	--	--	19-acre, 87-acre-foot detention basin	$1,910,000	--	--	--	--	--
	Dike and spillway	$ 2,130,000	--	--	--	--	--		--	--	--	--	--	--
	Detention basin	4,180,000	--	--	--	--	--	--	--	--	--	--	--	--
	Access roads/baffles	240,000	--	--	--	--	--	--	--	--	--	--	--	--
	Pilgrim Parkway road grade raise	160,000	--	--	--	--	--	--	--	--	--	--	--	--
	Land acquisition	350,000	--	--	--	--	--	--	--	--	--	--	--	--
	Subtotal	$ 7,060,000	--	--	--	--	--	--	--	--	--	--	--	--
	North Basin													
	Dike and spillway	$ 1,170,000	--	--	--	--	--	--	--	--	--	--	--	--
	Land acquisition	30,000	--	--	--	--	--	--	--	--	--	--	--	--
	Pilgrim Parkway road grade raise and associated culverts	20,000	--	--	--	--	--	--	--	--	--	--	--	--
	Subtotal	$ 1,220,000	--	--	--	--	--	--	--	--	--	--	--	--

Table 24 (continued)

	Water Quantity Control Costs							Water Quality Control Costs[a]						
Alternative	Description	Capital	Amortized Capital[b]	Annual Operation and Maintenance	Total	Average Annual Benefits	Benefit-Cost Ratio	Description	Capital	Amortized Capital[b]	Annual Operation and Maintenance	Total	Water Quantity and Quality Total Average Annual Cost[b]	Water Quantity and Quality Total Capital Cost
No. 8 (continued)	Floodproofing, Elevation, and Removal													
	Floodproof four houses in Brookfield and 11 in Elm Grove	$ 190,000	--	--	--	--	--	--	--	--	--	--	--	--
	Floodproof four apartment buildings in Elm Grove	100,000	--	--	--	--	--	--	--	--	--	--	--	--
	Floodproof one commercial building in Brookfield and 13 in Elm Grove	890,000	--	--	--	--	--	--	--	--	--	--	--	--
	Elevate two houses in Brookfield and one in Elm Grove	180,000	--	--	--	--	--	--	--	--	--	--	--	--
	Acquire and remove one house in Brookfield	230,000	--	--	--	--	--	--	--	--	--	--	--	--
	Subtotal	$ 1,590,000	--	--	--	--	--	--	--	--	--	--	--	--
	Total	$ 9,870,000[n]	$ 627,000	$13,000	$ 640,000	$135,000	0.21	Total	$1,910,000[l]	$121,000	$9,000	$130,000	$ 770,000	$11,780,000
No. 9—Two-Basin Detention Storage with Excavation Minimized, No Wetland Disturbance, and Structure Floodproofing and Elevation	South Basin	--	--	--	--	--	--	19-acre, 87-acre-foot detention basin	$1,910,000	--	--	--	--	--
	Dike and spillway	$ 2,770,000	--	--	--	--	--		--	--	--	--	--	--
	Detention basin	1,920,000	--	--	--	--	--	Open channel to convey runoff to pond	100,000	--	--	--	--	--
	Access roads/baffles	230,000	--	--	--	--	--		--	--	--	--	--	--
	Land acquisition	350,000	--	--	--	--	--	--	--	--	--	--	--	--
	Easements	100,000	--	--	--	--	--	--	--	--	--	--	--	--
	Subtotal	$ 5,370,000	--	--	--	--	--	--	--	--	--	--	--	--
	North Basin													
	Dike and spillway	$ 130,000	--	--	--	--	--	--	--	--	--	--	--	--
	Land acquisition	100,000	--	--	--	--	--	--	--	--	--	--	--	--
	Easements	90,000	--	--	--	--	--	--	--	--	--	--	--	--
	Pilgrim Parkway road grade raise and associated culverts	55,000	--	--	--	--	--	--	--	--	--	--	--	--
	Subtotal	$ 375,000	--	--	--	--	--	--	--	--	--	--	--	--
	Floodproofing and Elevation													
	Floodproof one house in Brookfield and 11 in Elm Grove	$ 150,000	--	--	--	--	--	--	--	--	--	--	--	--
	Floodproof four apartment buildings in Elm Grove	100,000	--	--	--	--	--	--	--	--	--	--	--	--

Table 24 (continued)

Alternative	Water Quantity Control Costs							Water Quality Control Costs[a]					Water Quantity and Quality Total Average Annual Cost[b]	Water Quantity and Quality Total Capital Cost
	Description	Capital	Amortized Capital[b]	Annual Operation and Maintenance	Total	Average Annual Benefits	Benefit-Cost Ratio	Description	Capital	Amortized Capital[b]	Annual Operation and Maintenance	Total		
No. 9 (continued)	Floodproofing, Elevation, and Removal (continued)													
	Floodproof one commercial building in Brookfield and 13 in Elm Grove	$ 880,000	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
	Elevate two houses in Brookfield and one in Elm Grove	180,000	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
	Subtotal	$ 1,310,000	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
	Total	$ 7,055,000[o]	$ 448,000	$11,000	$ 459,000	$135,000	0.29	Total	$2,010,000[h]	$128,000	$9,000	$137,000	$ 596,000	$ 9,065,000
No. 10—Limited Dousman Ditch Detention Storage, Bridge and Culvert Modification, and Maximum On-Line Storage with Structure Floodproofing, Elevation, and Removal	Detention basin	$ 1,870,000	- -	- -	- -	- -	- -	19-acre, 87-acre-foot detention basin	$1,910,000	- -	- -	- -	- -	- -
	Land acquisition	350,000	- -	- -	- -	- -	- -		- -	- -	- -	- -	- -	- -
	Remove and replace Wall Street and Canadian Pacific railway bridges	810,000	- -	- -	- -	- -	- -	Access roads/ baffles	120,000	- -	- -	- -	- -	- -
	Install parallel reinforced concrete box culverts at the Park and Shop, Watertown Plank Road, and the private bridge upstream of Watertown Plank Road	1,850,000	- -	- -	- -	- -	- -	Open channel to convey runoff to pond	100,000	- -	- -	- -	- -	- -
	Remove private bridge downstream from Wall Street	5,000	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
	Provide excavated storage in the Village Park	3,595,000	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
	Provide excavated storage along Underwood Parkway in Wauwatosa	185,000	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
	Floodproof five houses in Brookfield and nine in Elm Grove	170,000	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
	Floodproof four apartment buildings in Elm Grove	105,000	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
	Floodproof one commercial building in Brookfield and 10 in Elm Grove	560,000	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
	Elevate two houses in Brookfield	120,000	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
	Acquire and remove one house in Brookfield	230,000	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
	Pilgrim Parkway road grade raise and associated culverts	50,000	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
	Total	$ 9,900,000[p]	$ 629,000	$ 2,000	$ 631,000	$135,000	0.21	Total	$2,130,000[f]	$135,000	$9,000	$144,000	$ 775,000	$12,030,000

Table 24 (continued)

Alternative	Water Quantity Control Costs							Water Quality Control Costs[a]					Water Quantity and Quality Total Average Annual Cost[b]	Water Quantity and Quality Total Capital Cost
	Description	Capital	Amortized Capital[b]	Annual Operation and Maintenance	Total	Average Annual Benefits	Benefit-Cost Ratio	Description	Capital	Amortized Capital[b]	Annual Operation and Maintenance	Total		
No. 11—Limited Dousman Ditch Detention Storage, Underwood Creek Overflow Channel and Diversion, and Compensating Storage with Structure Floodproofing and Removal	Detention basin	$ 1,870,000	- -	- -	- -	- -	- -	19-acre, 87-acre-foot detention basin	$1,910,000	- -	- -	- -	- -	- -
	Land acquisition	350,000	- -	- -	- -	- -	- -		- -	- -	- -	- -	- -	- -
	Construct 4,100-foot-long, grass lined overflow channel	1,400,000	- -	- -	- -	- -	- -	Access roads/ baffles	120,000	- -	- -	- -	- -	- -
	Install three parallel 31-foot-long, four-foot-high by 10-foot-wide reinforced concrete box culverts in the overflow channel at Marcella Avenue	85,000	- -	- -	- -	- -	- -	Open channel to convey runoff to pond	100,000	- -	- -	- -	- -	- -
	Install two parallel 28-foot-long, five-foot-high by 10-foot-wide reinforced concrete box culverts in the overflow channel at the Village Hall Drive	140,000	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
	Install 5,400-foot-long, double six-foot-high by seven-foot-wide reinforced concrete box diversion culverts[q]	9,300,000	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
	Easements for diversion	100,000	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
	Provide 35 acre-feet of excavated storage in the Village Park	1,500,000	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
	Provide 14 acre-feet of excavated storage along Underwood Creek in Brookfield upstream of W. North Avenue	640,000	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
	Purchase six houses in Brookfield for construction of storage area upstream of W. North Avenue	900,000	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
	Purchase and remove one house in Brookfield	230,000	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
	Floodproof two houses in Brookfield and two in Elm Grove	45,000	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
	Floodproof three apartment buildings in Elm Grove[r]	10,000	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
	Floodproof one commercial building in Brookfield and eight in Elm Grove[s]	320,000	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
	Pilgrim Parkway road grade raise and associated culverts	$ 50,000	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
	Total	$16,940,000[t,u]	$1,076,000	$36,000	$1,112,000	$135,000	0.12	Total	$2,130,000[f]	$135,000	$9,000	$144,000	$1,256,000	$19,070,000

Table 24 (continued)

NOTE: Costs are based upon 1998 *Engineering News Record* Construction Cost Index = 6,740.

[a] *If during the facilities design phase, it is determined that an impervious liner is required for the wet detention basin, the water quality control cost of Alternative Nos. 3 through 9 would be increased by about $600,000.*

[b] *Amortized capital cost is based on an interest rate of 6 percent and a project life of 50 years.*

[c] *Wet detention basin not included under this alternative plan.*

[d] *The estimated lower limit total cost for this alternative is $3,240,000. That cost is based on an optimistic assumption that the excavated soil could be used as topsoil and/or peat for landscaping and would be hauled from the site free of charge. If the buildings to be floodproofed were purchased and demolished, the cost of this alternative plan would increase by about $15,960,000.*

[e] *Operation and maintenance cost assigned to water quality element of the plan.*

[f] *The estimated lower limit total cost for this alternative is $920,000. That cost is based on an optimistic assumption that the excavated soil could be used as topsoil and/or peat for landscaping and would be hauled from the site free of charge.*

[g] *The estimated lower limit total cost for this alternative is $4,920,000. That cost is based on an optimistic assumption that the excavated soil could be used as topsoil and/or peat for landscaping and would be hauled from the site free of charge. The lower limit cost is also based on the assumption that only five feet of subsurface excavation and backfill, rather than 10 feet, would be needed beneath the dike.*

[h] *The estimated lower limit total cost for this alternative is $800,000. That cost is based on an optimistic assumption that the excavated soil could be used as topsoil and/or peat for landscaping and would be hauled from the site free of charge.*

[i] *The estimated lower limit total cost for this alternative is $5,160,000. That cost is based on an optimistic assumption that the excavated soil could be used as topsoil and/or peat for landscaping and would be hauled from the site free of charge. The lower limit cost is also based on the assumption that only five feet of subsurface excavation and backfill, rather than 10 feet, would be needed beneath the dike.*

[j] *The estimated lower limit total cost for this alternative is $860,000. That cost is based on an optimistic assumption that the excavated soil could be used as topsoil and/or peat for landscaping and would be hauled from the site free of charge.*

[k] *The estimated lower limit total cost for this alternative is $5,880,000. That cost is based on an optimistic assumption that the excavated soil could be used as topsoil and/or peat for landscaping and would be hauled from the site free of charge. The lower limit cost is also based on the assumption that only five feet of subsurface excavation and backfill, rather than 10 feet, would be needed beneath the dike.*

[l] *The estimated lower limit total cost for this alternative is $700,000. That cost is based on an optimistic assumption that the excavated soil could be used as topsoil and/or peat for landscaping and would be hauled from the site free of charge.*

[m] *The estimated lower limit total cost for this alternative is $5,810,000. That cost is based on an optimistic assumption that the excavated soil could be used as topsoil and/or peat for landscaping and would be hauled from the site free of charge. The lower limit cost is also based on the assumption that only five feet of subsurface excavation and backfill, rather than 10 feet, would be needed beneath the dike.*

[n] *The estimated lower limit total cost for this alternative is $6,520,000. That cost is based on an optimistic assumption that the excavated soil could be used as topsoil and/or peat for landscaping and would be hauled from the site free of charge. The lower limit cost is also based on the assumption that only five feet of subsurface excavation and backfill, rather than 10 feet, would be needed beneath the dike.*

[o] *The estimated lower limit total cost for this alternative is $4,885,000. That cost is based on an optimistic assumption that the excavated soil could be used as topsoil and/or peat for landscaping and would be hauled from the site free of charge. The lower limit cost is also based on the assumption that only five feet of subsurface excavation and backfill, rather than 10 feet, would be needed beneath the dike.*

[p] *The estimated lower limit total cost for this alternative is $9,080,000. That cost is based on an optimistic assumption that the excavated soil could be used as topsoil and/or peat for landscaping and would be hauled from the site free of charge. If the buildings to be floodproofed were purchased and demolished, the cost of this alternative plan would increase by about $12,645,000.*

[q] *The overflow channel would be located on existing outlots and in the Village park. Thus, no costs were assigned to obtaining easements for the channel.*

[r] *Three additional apartment buildings in Elm Grove would be on the edge of the 100-year floodplain, but floodproofing would probably not be required.*

[s] *Three additional commercial buildings in Elm Grove would be on the edge of the 100-year floodplain, but floodproofing would probably not be required.*

[t] *The estimated lower limit cost for this alternative is $15,920,000. That cost is based on an optimistic assumption that the excavated soil could be used as topsoil and/or peat for landscaping and would be hauled from the site free of charge.*

[u] *If the buildings to be floodproofed were purchased and demolished, the cost of this alternative plan would increase by about $8,345,000.*

Source: SEWRPC.

As is the case with Alternative Plan No. 1, because planned land use, existing channel condition 100-year flood flows would not be reduced through the provision of additional flood storage under this alternative, those portions of the planned 500-foot development zone north of the planned extension of Wisconsin Avenue that are within the 100-year floodplain could not be developed unless compensatory storage were provided to offset the storage lost due to filling.

As set forth in detail in Appendix D, under this alternative plan, the frequency and duration of flooding of the proposed Bluemound Road Golf Range site would not be affected because no changes would be made to the Dousman Ditch channel.

Full implementation of this alternative plan would serve to eliminate structure flood damages due to direct overland flooding along Underwood Creek for floods up to and including the 100-year recurrence interval flood event under planned land use and channel conditions. Damages due to street flooding would not be eliminated because no change to flood flows or stages would result from implementation of this alternative.

As set forth in Table 24, the total capital cost of the structure floodproofing and elevation alternative is estimated to be $1,965,000. This cost includes $280,000 for floodproofing 23 single-family residential buildings; $100,000 for floodproofing four apartment buildings; $1,000,000 for floodproofing 16 commercial buildings; $300,000 for elevation of five single-family residential buildings; $230,000 for the acquisition and removal of one single-family residence; and $55,000 for raising the grade of Pilgrim Parkway and installing larger culverts under the roadway. Utilizing an annual interest rate of 6 percent and a project life and amortization period of 50 years, the average annual cost of the alternative plan is estimated at $125,000. The average annual flood damage abatement benefit is estimated to be $135,000, yielding a benefit-cost ratio of 1.08.

Alternative Floodland Management Plan No. 2—Acquisition and Removal of Structures

The second alternative plan considered calls for the purchase and removal of 16 commercial buildings; four apartment buildings; and 29 single-family residences which are located in the 100-year recurrence interval floodplain under planned land use and existing channel conditions, and which would be expected to incur flood damage.

This alternative plan also calls for raising about 400 feet of Pilgrim Parkway south of Gebhardt Road an average of about 1.3 feet to avoid inundation of the roadway during a 100-year flood. The grade raises would be located near the intersection with Cascade Drive and at the north entrance drive to Pilgrim Park Middle School. In order to provide adequate major system hydraulic capacity, the existing northern 24-inch-diameter CMP culvert under Pilgrim Parkway at Cascade Drive would be replaced with a 50-foot-long, 27-inch-diameter RCP culvert and the southern CMP culvert would be replaced with a 53-foot-long, 18-inch-diameter RCP culvert. The existing 27-inch-high by 43-inch-wide CMPA culvert under Pilgrim Parkway at the northern entrance to Pilgrim Park Middle School would be replaced with a 60-foot-long, 24-inch-high by 38-inch-wide reinforced concrete HE pipe culvert.

As is the case with Alternative Plan No. 1, because planned land use, existing channel condition 100-year flood flows would not be reduced through the provision of additional flood storage under this alternative, those portions of the planned 500-foot development zone north of the planned extension of Wisconsin Avenue that are within the 100-year floodplain could not be developed unless compensatory storage were provided to offset the storage lost due to filling.

As set forth in detail in Appendix D, under this alternative plan, the frequency and duration of flooding of the proposed Bluemound Road Golf Range site would not be affected because no changes would be made to the Dousman Ditch channel.

Full implementation of this alternative plan would serve to eliminate structure flood damages due to direct overland flooding along Underwood Creek for floods up to, and including, the 100-year recurrence interval flood event under planned land use and channel conditions. Damages due to street flooding would not be eliminated because no change to flood flows or stages would result from implementation of this alternative.

As set forth in Table 24, the total capital cost of the acquisition and removal alternative is estimated to be $19,985,000. This includes acquisition and removal costs of $10,970,000 for the 16 commercial buildings;

$1,750,000 for the four apartment buildings; $7,210,000 for the 29 single-family residences; and $55,000 for raising the grade of Pilgrim Parkway and installing larger culverts under the roadway.[21] Utilizing an annual interest rate of 6 percent and a project life and amortization period of 50 years, the average annual cost of the alternative plan is estimated at $1,269,000. The average annual flood damage abatement benefit is estimated to be $135,000, yielding a benefit-cost ratio of 0.11.

Alternative Floodland Management Plan No. 3—Limited Detention Storage with Structure Floodproofing, Elevation, and Removal

The third alternative plan considered calls for the provision of a net total of approximately 23 acre-feet of flood storage along Dousman Ditch upstream of the proposed detention basin outlet.[22] As shown on Map 20, the excavated flood storage would be provided above the permanent pond of the wet detention basin and additional storage would be available within the 100-year floodplain outside of the proposed 500-foot Wisconsin Avenue development zone. The excavated storage would be sufficient to offset lost storage due to development within that zone and also to provide some reduction in downstream flood flows, stages, and damages. The project would require the acquisition of about 115 acres of land.

The 100-year flood stage along Dousman Ditch upstream of the detention basin outlet structure would be reduced from 0.4 to 1.9 feet compared to the existing 100-year flood stage.[23] Along Dousman Ditch, between the basin outlet and Gebhardt Road, the 100-year flood stage would be decreased by about 0.1 foot. That reduction would marginally improve drainage of adjacent developed lands in the City of Brookfield and the Village of Elm Grove, including Indianwood and Onondaga area where significant stormwater drainage problems exist.

Outflow from the detention basin would be controlled by a v-notch weir to produce longer residence times for settling of nonpoint source pollutants during relatively low flow conditions, but under flood conditions outflow from the basin would be controlled by the hydraulic capacity of the channel and overbanks of Dousman Ditch.

This alternative plan calls for raising about 360 feet of Pilgrim Parkway south of Gebhardt Road an average of about 0.9 foot to avoid inundation of the roadway during a 100-year flood. The grade raises would be located near the intersection with Cascade Drive and at the north entrance drive to Pilgrim Park Middle School. In order to provide adequate major system hydraulic capacity, the existing northern 24-inch-diameter CMP culvert under Pilgrim Parkway at Cascade Drive would be replaced with a 50-foot-long, 27-inch-diameter RCP culvert and the southern CMP culvert would be replaced with a 53-foot-long, 18-inch-diameter RCP culvert. The existing 27-inch-high by 43-inch-wide CMPA culvert under Pilgrim Parkway at the northern entrance to Pilgrim Park Middle School would be replaced with a 60-foot-long, 24-inch-high by 38-inch-wide reinforced concrete HE pipe culvert.

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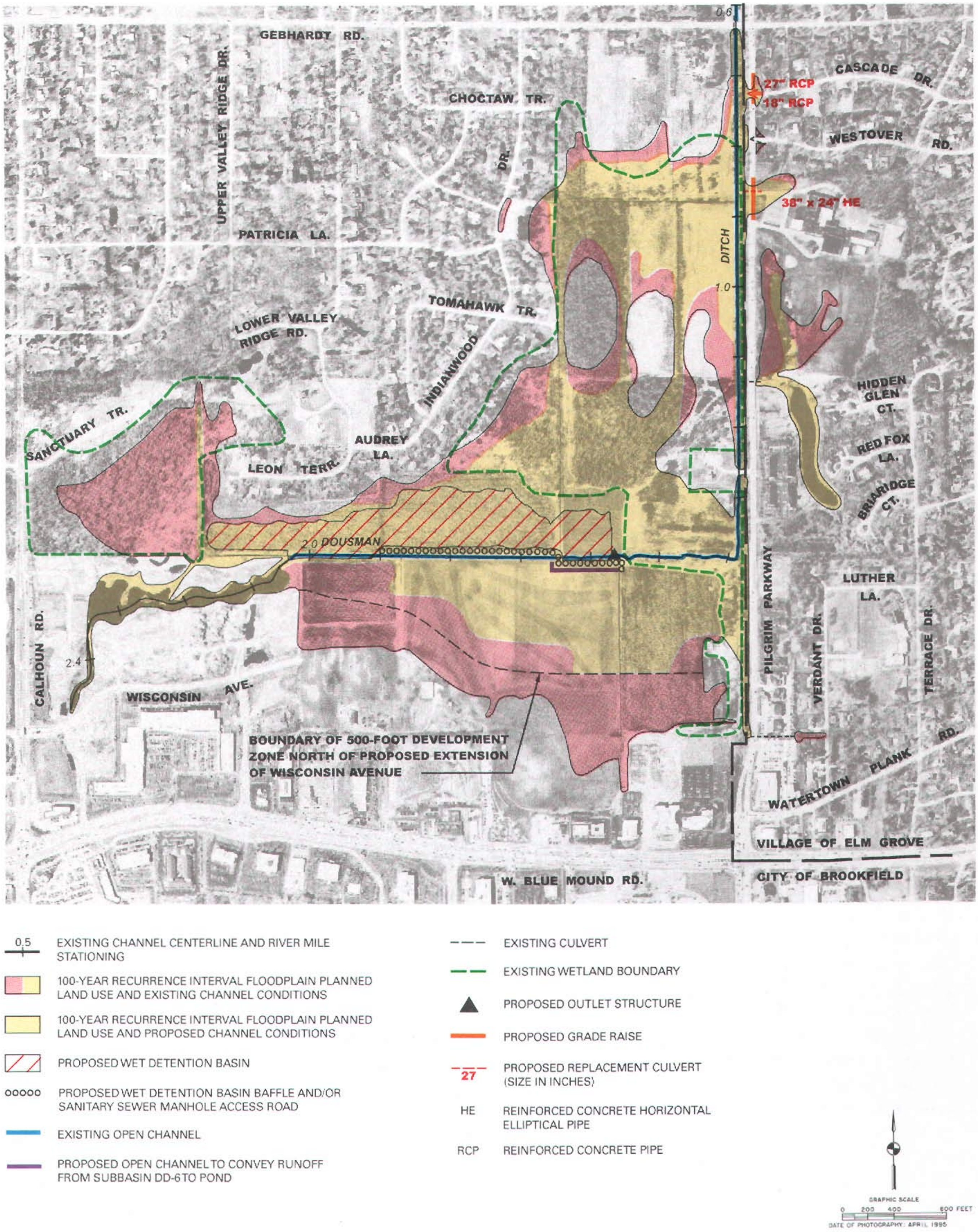
[21] *The acquisition and removal cost for single-family residential buildings was calculated as the sum of the structure and site acquisition costs, based on the fair market values obtained from tax records, and a fixed cost of $40,000 which includes the costs of utility disconnection, demolition of structures, site restoration, occupant relocation, title transfers, property surveys, and property taxes. The cost for industrial, commercial, and government buildings, was calculated in a similar manner except that a fixed cost of $70,000 per building was used. The cost computation for apartments used a fixed cost of $10,000 and a cost equal to 10 percent of the building fair market value for demolition and miscellaneous expenses.*

[22] *The total volume of soil excavated to construct the basin would be about 60 acre-feet, but the net volume of additional storage provided during a 100-year flood would be 23 acre-feet since the 100-year flood stage would be reduced in, and upstream from, the basin.*

[23] *The reported potential flood stage changes for the alternatives presented in this chapter of the report are referenced to the most recent 100-year recurrence interval flood profiles computed for Dousman Ditch by the Regional Planning Commission staff under the floodplain updating program undertaken by the City of Brookfield and the Village of Elm Grove..*

Map 20

ALTERNATIVE PLAN NO. 3
LIMITED DETENTION STORAGE



Source: SEWRPC.

The plan also calls for the floodproofing of five single-family residential buildings in Brookfield and 10 in Elm Grove, the elevation of two single-family residential buildings in Brookfield and three in Elm Grove, the floodproofing of four apartment buildings in Elm Grove, the floodproofing of one commercial building in Brookfield and 15 in Elm Grove, and the acquisition and removal of one single-family residence in the City of Brookfield.

As described in Appendix D, under this alternative plan, the frequency and duration of flooding of the proposed Bluemound Road Golf Range site would be reduced in comparison with both existing conditions and conditions under the other alternative plans. Interruptions in the use of the range due to flooding would be infrequent.

Full implementation of this alternative plan would serve to eliminate structure flood damages due to direct overland flooding along Underwood Creek for floods up to and including the 100-year recurrence interval flood event under planned land use and channel conditions. Damages due to street flooding would be reduced, but not eliminated by implementation of this plan in the absence of other measures directed toward reduction of infiltration and inflow to sanitary sewers.

As set forth in Table 24, the total capital cost of the water quantity control portion of the limited detention storage alternative is estimated to be $4,060,000. This cost includes $1,870,000 for construction of the water quantity control portion of the detention basin; $350,000 for land acquisition; $1,790,000 for structure floodproofing, elevation, and removal; and $50,000 for raising the grade of Pilgrim Parkway and installing larger culverts under the roadway. Assuming an annual interest rate of 6 percent and a project life and amortization period of 50 years, the average annual cost of the alternative plan is $258,000.[24] The average annual flood damage abatement benefit is estimated to be $135,000, yielding a benefit-cost ratio of 0.52.

Alternative Floodland Management Plan No. 4—Detention Storage with Excavation Minimized, No Wetland Disturbance, and Structure Floodproofing, Elevation, and Removal

Similar to Alternative Plan No. 3, this alternative plan calls for 60 acre-feet of excavation along Dousman Ditch above the permanent pond of the wet detention basin. As shown on Map 21, additional storage would be provided within the 100-year floodplain outside of the proposed 500-foot Wisconsin Avenue development zone. That storage would be attained through the construction of a dike with a length of about 4,200 feet. The total amount of storage provided during a 100-year flood would be about 310 acre-feet. The net increase in storage relative to existing conditions would be about 115 acre-feet, which would be sufficient to offset lost storage due to development within the 500-foot zone and also to provide reductions in downstream flood flows, stages, and damages.

The 100-year recurrence interval flood stage upstream of the detention basin outlet would be at approximate elevation 830.0 feet above NGVD29. That stage elevation represents an increase of from 0.0 to 2.4 feet in the flood stage compared to the existing 100-year flood stage. Easements for the flood stage increases would be required from affected property owners in the Clearwater Lakes condominium development and at five lots in the Sanctuary Subdivision. In addition, the project would include acquisition of about 115 acres of land. Easements would not be required at the lots along the south side of Leon Terrace in the north central portion of the detention basin because a low dike would be constructed in that area outside of the lots. While easements might technically be required from the property owners in the 500-foot development zone north of the proposed Wisconsin Avenue extension, such easements should be routinely granted at no cost to the detention basin project during the development approval process.

The dike would have side slopes of one vertical on three horizontal, a 10-foot top width, and a crest elevation of 833 feet above NGVD29, providing three feet of freeboard during the 100-year flood. Because of the potentially unsuitable peat and muck soils located along the proposed dike alignment and throughout the area proposed for the detention basin, it was assumed that the dike foundation would be excavated to sound soil and the trench would be backfilled with structural fill. The dike would be

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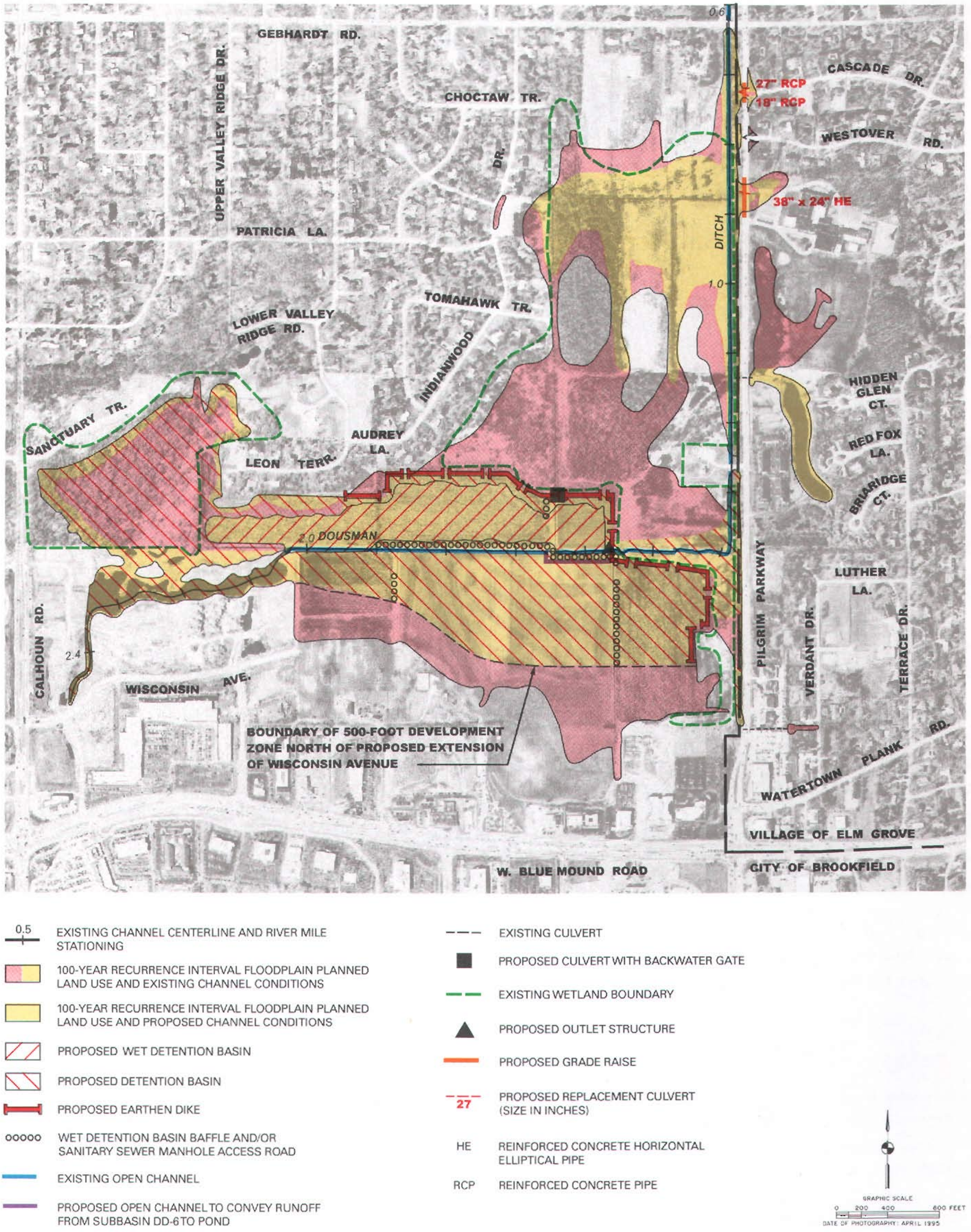
[24] *Annual operation and maintenance costs are assigned to the water quality control element of the stormwater plan.*

Map 21

ALTERNATIVE PLAN NO. 4
DETENTION STORAGE WITH EXCAVATION MINIMIZED, AND NO WETLAND DISTURBANCE



Source: SEWRPC.

located completely outside the wetlands in the vicinity of the project, as shown on Map 21. A culvert with a backwater gate would be installed in the north-south ditch that conveys runoff from a portion of the residential area located north of the detention basin.

Approximately 2,800 lineal feet of sanitary sewer access roads and/or wet detention basin flow baffles would be provided, as shown on Map 21. Those roads/baffles would have the same cross-section as the dike, but subsurface excavation and backfilling to stabilize the foundation would not be required since the roads/baffles would not be water-retaining structures and they would be used relatively infrequently. Sanitary sewer manholes for the Underwood trunk sewer and affected tributary sewers would be raised to the access road height of elevation 833 feet above NGVD29.

The detention basin would have a v-notch weir outlet with an 18-inch-diameter RCP discharge pipe. A concrete- or riprap-lined emergency spillway would be constructed to convey flows during floods with recurrence intervals greater than 100 years.

This alternative plan calls for raising about 310 feet of Pilgrim Parkway south of Gebhardt Road an average of about 0.9 foot to avoid inundation of the roadway during a 100-year flood. The grade raises would be located near the intersection with Cascade Drive and at the north entrance drive to Pilgrim Park Middle School. In order to provide adequate major system hydraulic capacity, the existing northern 24-inch-diameter CMP culvert under Pilgrim Parkway at Cascade Drive would be replaced with a 50-foot-long, 27-inch-diameter RCP culvert and the southern CMP culvert would be replaced with a 53-foot-long, 18-inch-diameter RCP culvert. The existing 27-inch-high by 43-inch-wide CMPA culvert under Pilgrim Parkway at the northern entrance to Pilgrim Park Middle School would be replaced with a 60-foot-long, 24-inch-high by 38-inch-wide reinforced concrete HE pipe culvert.

The plan also calls for the floodproofing of five single-family residential buildings in Brookfield and 11 in Elm Grove, the elevation of two single-family residential buildings in Brookfield and one in Elm Grove, the floodproofing of four apartment buildings in Elm Grove, the floodproofing of one commercial building in Brookfield and 14 in Elm Grove, and the acquisition and removal of one single-family residence in Brookfield.

As described in detail in Appendix D, under this alternative plan, the frequency and duration of flooding of the proposed Bluemound Road Golf Range site would be increased in comparison with existing conditions. Interruptions in the use of the range due to flooding above elevation 727.6 feet above NGVD29 for a duration of one day or more could be expected about once every 20 months.

Full implementation of this alternative plan would serve to eliminate structure flood damages due to direct overland flooding along Underwood Creek for floods up to and including the 100-year recurrence interval flood event under planned land use and channel conditions. Damages due to street flooding would be reduced, but not eliminated by implementation of this plan in the absence of other measures directed toward reduction of infiltration and inflow to sanitary sewers.

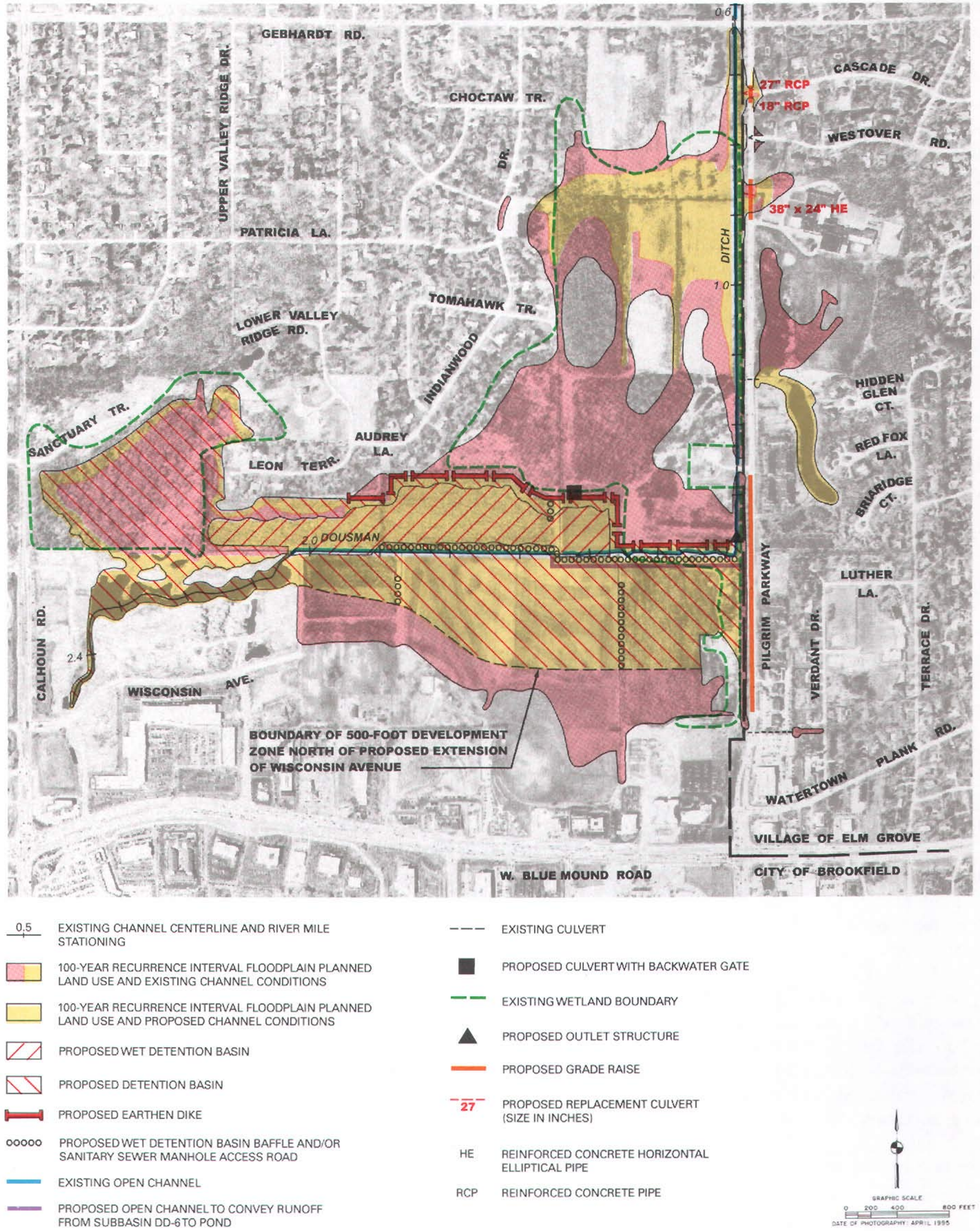
As set forth in Table 24, the total capital cost of the water quantity control portion of the minimal excavation detention storage alternative is estimated to be $7,030,000. This cost includes $2,720,000 for construction of the dike and spillway; $1,920,000 for construction of the water quantity control portion of the detention basin; $230,000 for access roads/baffles; $350,000 for land acquisition, $100,000 for easements; $1,660,000 for structure floodproofing, elevation, and removal; and $50,000 for raising the grade of Pilgrim Parkway and installing larger culverts under the roadway. Assuming an annual interest rate of 6 percent and a project life and amortization period of 50 years, the average annual cost of the alternative plan, including $10,000 in annual operation and maintenance costs is $456,000. The average annual flood damage abatement benefit is estimated to be $135,000, yielding a benefit-cost ratio of 0.30.

Alternative Floodland Management Plan No. 5—Expanded Detention Storage with Excavation Minimized and Structure Floodproofing, Elevation, and Removal

Similar to Alternative Plan Nos. 3 and 4, this alternative calls for the provision of approximately 60 acre-feet of excavation along Dousman Ditch above the permanent pond of the wet detention basin. As shown on Map 22, additional storage would be provided within the 100-year floodplain outside of the proposed 500-foot Wisconsin Avenue development zone. That storage would be attained through the construction of a dike with a length of about 3,700 feet. Unlike Alternative Plan No. 4, the eastern 1,000

Map 22

ALTERNATIVE PLAN NO. 5
EXPANDED DETENTION STORAGE WITH EXCAVATION MINIMIZED



Source: SEWRPC.

feet of this dike would be located in the wetland at the extreme eastern end of the detention basin near Pilgrim Parkway. Extension of the dike to that location would enable runoff from a larger area to be stored, providing a greater level of control of both nonpoint source pollution and floods. The total amount of storage provided during a 100-year flood would be about 340 acre-feet. The net increase in storage relative to existing conditions would be about 145 acre-feet, which would be sufficient to offset lost storage due to development within the 500-foot zone and also to provide reductions in downstream flood flows, stages, and damages.

The 100-year recurrence interval flood stage upstream of the detention basin outlet would be at approximate elevation 830.2 feet above NGVD29. That stage elevation represents an increase of from 0.0 to 2.8 feet in the flood stage compared to the existing 100-year flood stage. As under Alternative Plan No. 4, easements for the flood stage increases would be required from affected property owners in the Clearwater Lakes condominium development and at five lots in the Sanctuary Subdivision, but easements would not be required at the lots along the south side of Leon Terrace and easements should be routinely granted at no cost to the detention basin project in the 500-foot development zone north of the proposed Wisconsin Avenue extension. Additionally, easements might be required at several properties in Elm Grove near Verdant Drive on the east side of Pilgrim Parkway; however, the stormwater drainage element of this plan provides for the implementation of a plan to alleviate drainage and flooding problems in that location. That plan would necessarily be implemented along with the Dousman Ditch detention basin. The detention basin project would also include acquisition of about 115 acres of land.

The dike would be similar to that called for under Alternative Plan No. 4, with side slopes of one vertical on three horizontal, a 10-foot top width, and a crest elevation of 833.2 feet above NGVD29, providing three feet of freeboard during the 100-year flood. Again, it was assumed that the dike foundation would be excavated to sound soil and the trench would be backfilled with structural fill. As shown on Map 22, a culvert with a backwater gate would be installed in the north-south ditch that conveys runoff from a portion of the residential area located north of the detention basin.

Approximately 3,800 lineal feet of sanitary sewer access roads and/or wet detention basin flow baffles would be provided, as shown on Map 22. Those roads/baffles would have the same cross-section as the dike, but subsurface excavation and backfilling to stabilize the foundation would not be required. Sanitary sewer manholes for the Underwood trunk sewer and affected tributary sewers would be raised to the access road height of elevation 833.2 feet above NGVD29.

The detention basin would have a v-notch weir outlet with an 18-inch-diameter RCP discharge pipe. A concrete- or riprap-lined emergency spillway would be constructed to convey flows during floods with recurrence intervals greater than 100 years.

The eastern boundary of the detention basin could be constructed in two ways. Either a dike could be constructed on the west side of Pilgrim Parkway with the roadway ditch relocated farther west or an 1,800-foot-long stretch of Pilgrim Parkway could be raised from 0.0 to 3.2 feet, with the average raise being 1.8 feet. The project cost was estimated assuming that the grade of Pilgrim Parkway would be raised, as shown on Map 22.

This alternative plan calls for raising about 280 feet of Pilgrim Parkway south of Gebhardt Road an average of about 0.8 foot to avoid inundation of the roadway during a 100-year flood. The grade raises would be located near the intersection with Cascade Drive and at the north entrance drive to Pilgrim Park Middle School. In order to provide adequate major system hydraulic capacity, the existing northern 24-inch-diameter CMP culvert under Pilgrim Parkway at Cascade Drive would be replaced with a 50-foot-long, 27-inch-diameter RCP culvert and the southern CMP culvert would be replaced with a 53-foot-long, 18-inch-diameter RCP culvert. The existing 27-inch-high by 43-inch-wide CMPA culvert under Pilgrim Parkway at the northern entrance to Pilgrim Park Middle School would be replaced with a 60-foot-long, 24-inch-high by 38-inch-wide reinforced concrete HE pipe culvert.

The plan also calls for the floodproofing of five single-family residential buildings in Brookfield and 11 in Elm Grove, the elevation of two single-family residential buildings in Brookfield and one in Elm Grove, the floodproofing of four apartment buildings in Elm Grove, the floodproofing of one commercial building in Brookfield and 13 in Elm Grove, and the acquisition and removal of one single-family residence in Brookfield.

As described in detail in Appendix D, under this alternative plan, the frequency and duration of flooding of the proposed Bluemound Road Golf Range site would be increased in comparison with existing conditions. Interruptions in the use of the range due to flooding above elevation 727.6 feet above NGVD29 for a duration of one day or more could be expected about once a year.

Full implementation of this alternative plan would serve to eliminate structure flood damages due to direct overland flooding along Underwood Creek for floods up to and including the 100-year recurrence interval flood event under planned land use and channel conditions. Damages due to street flooding would be reduced, but not eliminated by implementation of this plan in the absence of other measures directed toward reduction of infiltration and inflow to sanitary sewers.

As set forth in Table 24, the total capital cost of the water quantity control portion of the minimal excavation detention storage alternative is estimated to be $7,140,000. This cost includes $2,480,000 for construction of the dike and spillway, $2,000,000 for construction of the water quantity control portion of the detention basin, $340,000 for access roads/baffles, $270,000 for raising Pilgrim Parkway and installing larger culverts under the roadway, $350,000 for land acquisition, $100,000 for easements, and $1,600,000 for structure floodproofing, elevation, and removal. Assuming an annual interest rate of 6 percent and a project life and amortization period of 50 years, the average annual cost of the alternative plan, including $11,000 in annual operation and maintenance costs is $464,000. The average annual flood damage abatement benefit is estimated to be $135,000, yielding a benefit-cost ratio of 0.29.

Alternative Floodland Management Plan No. 6—Expanded Detention Storage with Excavation Maximized and Structure Floodproofing, Elevation, and Removal

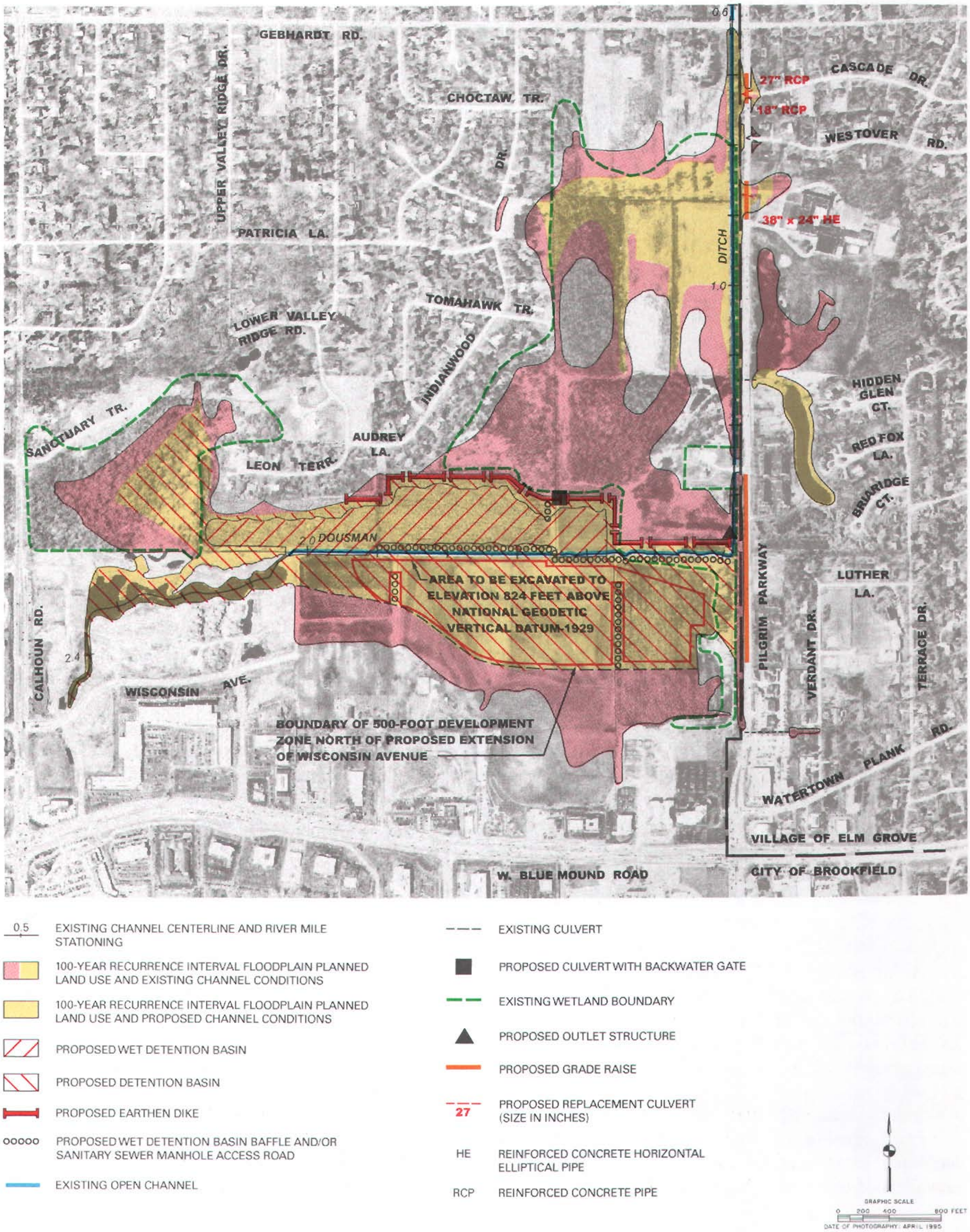
This alternative plan would have the same dike alignment as Alternative Plan No. 5 and it would be similar to Alternative Plan Nos. 3 through 5 in that it calls for the provision of approximately 60 acre-feet of excavation along Dousman Ditch above the permanent pond of the wet detention basin. However, this alternative provides for a substantial amount of detention storage to be created through excavation in the area shown on Map 23. As under Alternative Plan No. 5, the eastern 1,000 feet of a 3,700-foot-long dike would be located in the wetland at the extreme eastern end of the detention basin near Pilgrim Parkway. Extension of the dike to that location would enable runoff from a larger area to be stored, providing a greater level of control of both nonpoint source pollution and floods. The total amount of storage provided during a 100-year flood would be about 380 acre-feet. The net increase in storage relative to existing conditions would be about 185 acre-feet, which would be sufficient to offset lost storage due to development within the 500-foot zone and also to provide reductions in downstream flood flows, stages, and damages.

The 100-year recurrence interval flood stage upstream of the detention basin outlet would be at approximate elevation 829.2 feet above NGVD29. That stage elevation represents an increase of from 0.0 to 1.8 feet in the flood stage compared to the existing 100-year flood stage. Flood stage increases would not occur in the Clearwater Lakes condominium development or at the five lots in the Sanctuary Subdivision, thus, easements would not be required from those property owners. As under Alternative Plan Nos. 4 and 5, easements would not be required at the lots along the south side of Leon Terrace and easements should be routinely granted at no cost to the detention basin project in the 500-foot development zone north of the proposed Wisconsin Avenue extension. Easements might be required at several properties in Elm Grove near Verdant Drive on the east side of Pilgrim Parkway; however, the stormwater drainage element of this plan provides for the implementation of a plan to alleviate drainage and flooding problems in that location. That plan would necessarily be implemented along with the Dousman Ditch detention basin. In addition, the project would include acquisition of about 115 acres of land.

The dike would be similar to that called for under Alternative Plan No. 5, with side slopes of one vertical on three horizontal, a 10-foot top width, and a crest elevation of 832.2 feet above NGVD29, providing three feet of freeboard during the 100-year flood. Again, it was assumed that the dike foundation would be excavated to sound soil and the trench would be backfilled with structural fill. As shown on Map 23, a culvert with a backwater gate would be installed in the north-south ditch that conveys runoff

Map 23

ALTERNATIVE PLAN NO. 6
EXPANDED DETENTION STORAGE WITH EXCAVATION MAXIMIZED



Source: SEWRPC.

from a portion of the residential area located north of the detention basin.

Approximately 3,800 lineal feet of sanitary sewer access roads and/or wet detention basin flow baffles would be provided, as shown on Map 23. Those roads/baffles would have the same cross-section as the dike, but subsurface excavation and backfilling to stabilize the foundation would not be required. Sanitary sewer manholes for the Underwood trunk sewer and affected tributary sewers would be raised to the access road height of elevation 832.2 feet above NGVD29.

The detention basin would have a v-notch weir outlet with an 18-inch-diameter RCP discharge pipe. A concrete- or riprap-lined emergency spillway would be constructed to convey flows during floods with recurrence intervals greater than 100 years.

Similar to Alternative Plan No. 5, the eastern boundary of the detention basin could be constructed in two ways, using either a dike or by raising the grade of Pilgrim Parkway. The project cost was estimated assuming that the grade of Pilgrim Parkway would be raised from 0.0 to 2.2 feet, with the average raise being 1.4 feet, along a 1,400-foot-long stretch of the road. The extent of the road grade raise is shown on Map 23.

This alternative plan calls for raising about 280 feet of Pilgrim Parkway south of Gebhardt Road an average of about 0.8 foot to avoid inundation of the roadway during a 100-year flood. The grade raises would be located near the intersection with Cascade Drive and at the north entrance drive to Pilgrim Park Middle School. In order to provide adequate major system hydraulic capacity, the existing northern 24-inch-diameter CMP culvert under Pilgrim Parkway at Cascade Drive would be replaced with a 50-foot-long, 27-inch-diameter RCP culvert and the southern CMP culvert would be replaced with a 53-foot-long, 18-inch-diameter RCP culvert. The existing 27-inch-high by 43-inch-wide CMPA culvert under Pilgrim Parkway at the northern entrance to Pilgrim Park Middle School would be replaced with a 60-foot-long, 24-inch-high by 38-inch-wide reinforced concrete HE pipe culvert.

As under Alternative Plan No. 5, this plan calls for the floodproofing of five single-family residential buildings in Brookfield and 11 in Elm Grove, the elevation of two single-family residential buildings in Brookfield and one in Elm Grove, the floodproofing of four apartment buildings in Elm Grove, the floodproofing of one commercial building in Brookfield and 13 in Elm Grove, and the acquisition and removal of one single-family residence in Brookfield.

As described in detail in Appendix D, under this alternative plan, the proposed Bluemound Road Golf Range could not be developed as intended because the site would be purchased and excavated to elevation 824 feet above NGVD29 to provide additional flood storage capacity. Frequent flooding of the excavated area would be expected.

Full implementation of this alternative plan would serve to eliminate structure flood damages due to direct overland flooding along Underwood Creek for floods up to and including the 100-year recurrence interval flood event under planned land use and channel conditions. Damages due to street flooding would be reduced, but not eliminated by implementation of this plan in the absence of other measures directed toward reduction of infiltration and inflow to sanitary sewers.

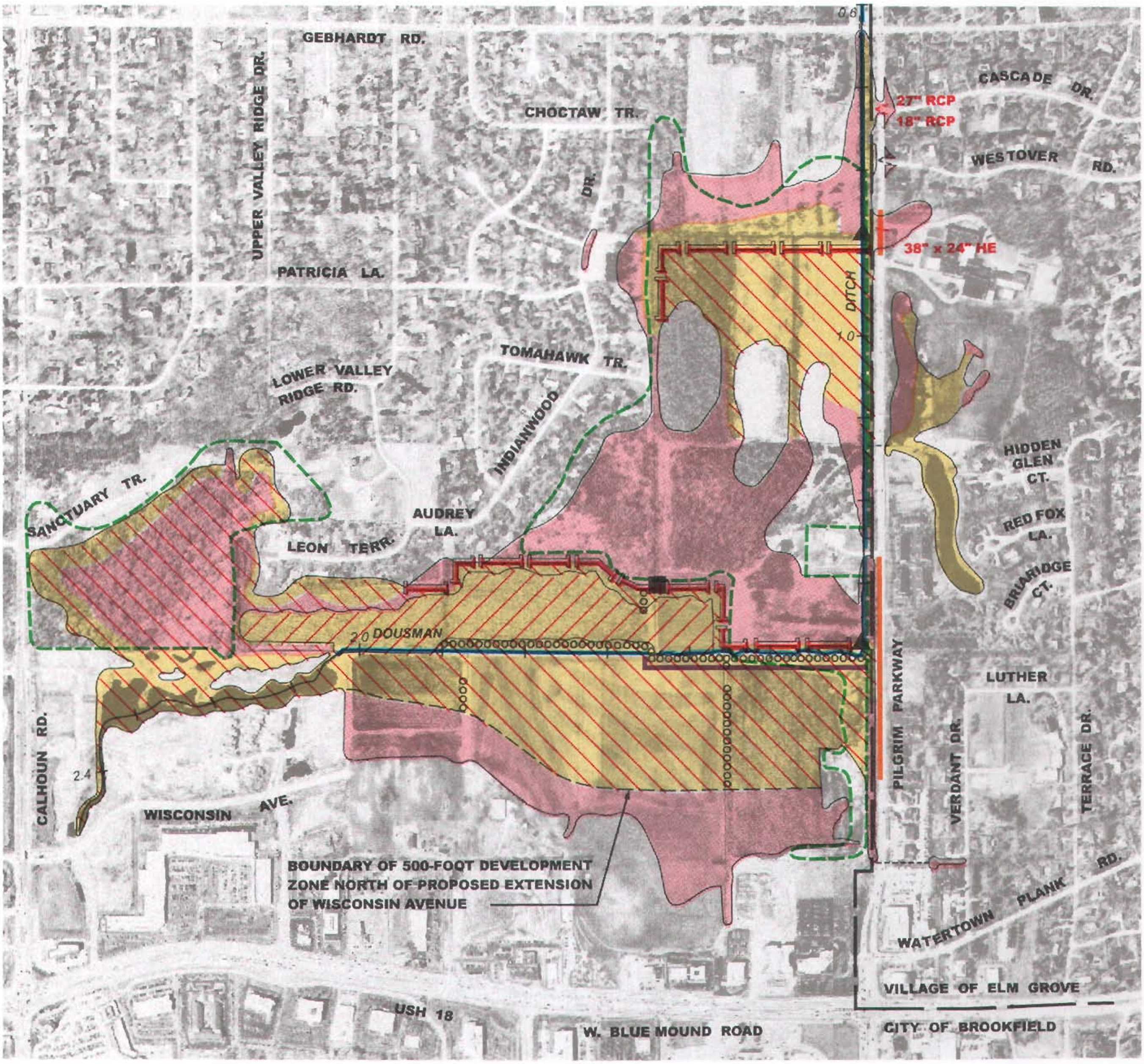
As set forth in Table 24, the total capital cost of the water quantity control portion of the minimal excavation detention storage alternative is estimated to be $8,710,000. This cost includes $2,130,000 for construction of the dike and spillway, $4,180,000 for construction of the water quantity control portion of the detention basin, $250,000 for access roads/baffles, $200,000 for raising Pilgrim Parkway and installing larger culverts under the roadway, $350,000 for land acquisition, and $1,600,000 for structure floodproofing, elevation, and removal. Assuming an annual interest rate of 6 percent and a project life and amortization period of 50 years, the average annual cost of the alternative plan, including $10,000 in annual operation and maintenance costs is $563,000. The average annual flood damage abatement benefit is estimated to be $135,000, yielding a benefit-cost ratio of 0.24.

Alternative Floodland Management Plan No. 7— Expanded Two-Basin Detention Storage with Excavation Minimized and Structure Floodproofing, Elevation, and Removal

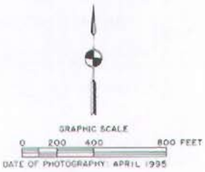
This alternative is essentially the same as Alternative Plan No. 5, except that it includes an additional detention basin located south of Gebhardt Road, as shown on Map 24. That detention basin, designated the north basin, would function in series with the

Map 24

ALTERNATIVE PLAN NO. 7
EXPANDED TWO-BASIN DETENTION STORAGE WITH EXCAVATION MINIMIZED



0.5	EXISTING CHANNEL CENTERLINE AND RIVER MILE STATIONING
🟥🟨	100-YEAR RECURRENCE INTERVAL FLOODPLAIN PLANNED LAND USE AND EXISTING CHANNEL CONDITIONS
🟨	100-YEAR RECURRENCE INTERVAL FLOODPLAIN PLANNED LAND USE AND PROPOSED CHANNEL CONDITIONS
▨	PROPOSED WET DETENTION BASIN
▧	PROPOSED DETENTION BASIN
┣━┫	PROPOSED EARTHEN DIKE
ooooo	PROPOSED WET DETENTION BASIN BAFFLE AND/OR SANITARY SEWER MANHOLE ACCESS ROAD
━	EXISTING OPEN CHANNEL
━	PROPOSED OPEN CHANNEL TO CONVEY RUNOFF FROM SUBBASIN DD-6 TO POND
- - -	EXISTING CULVERT
■	PROPOSED CULVERT WITH BACKWATER GATE
- -	EXISTING WETLAND BOUNDARY
▲	PROPOSED OUTLET STRUCTURE
━	PROPOSED GRADE RAISE
27	PROPOSED REPLACEMENT CULVERT (SIZE IN INCHES)
HE	REINFORCED CONCRETE HORIZONTAL ELLIPTICAL PIPE
RCP	REINFORCED CONCRETE PIPE



Source: SEWRPC.

larger south, or upstream, basin, providing a somewhat greater degree of reduction of flood flows than would Alternative Plan No. 5. The amount of storage provided in the north detention basin during a 100-year flood would be about 40 acre-feet and the amount provided in the south basin would be 340 acre-feet, for a total of about 380 acre-feet. The net increase in storage relative to existing conditions would be about 185 acre-feet. That amount of storage would be sufficient to offset lost storage due to development within the 500-foot zone adjacent to the south basin and also to provide reductions in downstream flood flows, stages, and damages.

The 100-year recurrence interval flood stage in the level pool upstream of the north detention basin outlet would be limited to elevation 825.9 feet above National Geodetic Vertical Datum (NGVD), which is less than or equal to the 100-year stage under planned land use and existing channel conditions. As under Alternative Plan No. 5, the 100-year flood stage in the south detention basin would be at approximate elevation 830.2 feet above NGVD29. That stage elevation represents an increase of from 0.0 to 2.8 feet in the flood stage compared to the existing 100-year flood stage. Easements for the flood stage increases in the south detention basin would be required from affected property owners in the Clearwater Lakes condominium development and at five lots in the Sanctuary Subdivision, but easements would not be required at the lots along the south side of Leon Terrace and easements should be routinely granted at no cost to the detention basin project in the 500-foot development zone north of the proposed Wisconsin Avenue extension. Additionally, easements might be required at several properties in Elm Grove near Verdant Drive on the east side of Pilgrim Parkway; however, the stormwater drainage element of this plan provides for the implementation of a plan to alleviate drainage and flooding problems in that location. That plan would necessarily be implemented along with the Dousman Ditch detention basin. The detention basin project would also include acquisition of about 155 acres of land.

For the south detention basin, the dike, sanitary sewer access roads and/or wet detention basin flow baffles, detention basin outlet, emergency spillway, and southern Pilgrim Parkway road grade raise or parallel dike would be the same as under Alternative Plan No. 5. As shown on Map 24, a culvert with a backwater gate would be installed in the north-south ditch that conveys runoff from a portion of the residential area located north of the detention basin.

The 1,800-foot-long dike for the north detention basin would have side slopes of one vertical on three horizontal, a 10-foot top width, and a crest elevation of 828.9 feet above NGVD29, providing three feet of freeboard during the 100-year flood. It was assumed that the dike foundation would be excavated to sound soil and the trench would be backfilled with structural fill. The dike would be located in a wetland. That location was chosen for this alternative because it would avoid ponding of runoff at the outlet of the storm sewers discharging to the wetland at Onondoga Circle and Indianwood Drive and from the Starbridge Subdivision and at the outlets of the culverts discharging to Dousman Ditch at Cascade Drive, Westover Road, and the entrance drive to Pilgrim Park Middle School.

The north detention basin would have a 15-inch-diameter RCP discharge pipe and an adjacent drop inlet weir with a 10-foot-long crest at approximate elevation 825.1 feet above NGVD29. That weir would be provided with an outlet pipe large enough to convey flow occurring over the weir without submerging the weir crest. A concrete- or riprap-lined emergency spillway would be constructed to convey flows during floods with recurrence intervals greater than 100 years.

One property would have to be acquired for construction of the north detention basin.

This alternative plan calls for raising about 110 feet of Pilgrim Parkway south of Gebhardt Road an average of about 0.5 foot to avoid inundation of the roadway during a 100-year flood. The grade raise would be located near the north entrance drive to Pilgrim Park Middle School. In order to provide adequate major system hydraulic capacity, the existing 27-inch-high by 43-inch-wide CMPA culvert under Pilgrim Parkway at the northern entrance to the Middle School would be replaced with a 60-foot-long, 24-inch-high by 38-inch-wide reinforced concrete HE pipe culvert.

The plan also calls for the floodproofing of four single-family residential buildings in Brookfield and 11 in Elm Grove, the elevation of two single-family residential buildings in Brookfield and one in Elm Grove, the floodproofing of four apartment buildings in Elm Grove, the floodproofing of one commercial building in Brookfield and 13 in Elm Grove, and the acquisition and removal of one single-family residence in Brookfield.

As described in detail in Appendix D, under this alternative plan, the frequency and duration of flooding of the proposed Bluemound Road Golf Range site would be increased in comparison with existing conditions. Interruptions in the use of the range due to flooding above elevation 727.6 feet above NGVD29 for a duration of one day or more could be expected about once a year.

Full implementation of this alternative plan would serve to eliminate structure flood damages due to direct overland flooding along Underwood Creek for floods up to and including the 100-year recurrence interval flood event under planned land use and channel conditions. Damages due to street flooding would be reduced, but not eliminated by implementation of this plan in the absence of other measures directed toward reduction of infiltration and inflow to sanitary sewers.

As set forth in Table 24, the total capital cost of the water quantity control portion of the expanded two-basin detention storage with excavation minimized alternative is estimated to be $8,310,000. This cost includes the following items related to the south detention basin: 1) $2,480,000 for construction of the dike and spillway, 2) $2,000,000 for construction of the water quantity control portion of the basin, 3) $340,000 for access roads/baffles, 4) $230,000 for raising Pilgrim Parkway, 5) $350,000 for land acquisition, and 6) $100,000 for easements. The cost also includes the following items related to the north detention basin: 1) $1,170,000 for construction of the dike and spillway, 2) $30,000 for land acquisition, and 3) $20,000 for raising Pilgrim Parkway and installing a larger culvert under the roadway. Finally, the total cost includes $1,590,000 for structure floodproofing, elevation, and removal. Assuming an annual interest rate of 6 percent and a project life and amortization period of 50 years, the average annual cost of the alternative plan, including $14,000 in annual operation and maintenance costs is $542,000. The average annual flood damage abatement benefit is estimated to be $135,000, yielding a benefit-cost ratio of 0.25.

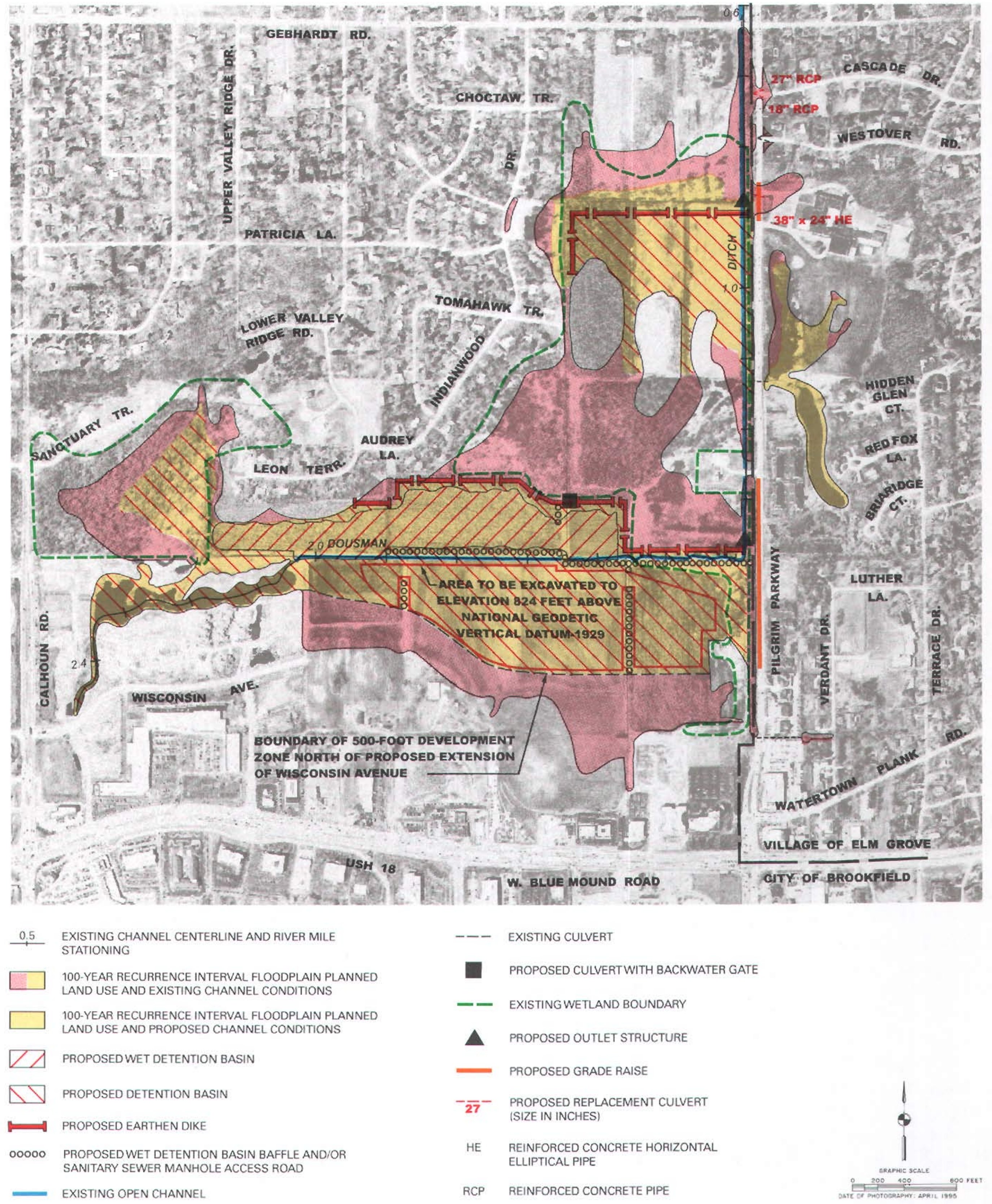
Alternative Floodland Management Plan No. 8—Expanded Two-Basin Detention Storage with Excavation Maximized and Structure Floodproofing, Elevation, and Removal

This alternative is the same as Alternative Plan No. 6, except that it includes an additional detention basin located south of Gebhardt Road, as shown on Map 25. That detention basin, designated the north basin, would function in series with the larger south, or upstream, basin, providing a somewhat greater degree of reduction of flood flows than would Alternative Plan No. 6. The amount of storage provided in the north detention basin during a 100-year flood would be about 40 acre-feet and the amount provided in the south basin would be 380 acre-feet, for a total of 420 acre-feet. The net increase in storage relative to existing conditions would be about 225 acre-feet. That amount of storage would be sufficient to offset lost storage due to development within the 500-foot zone adjacent to the south basin and also to provide reductions in downstream flood flows, stages, and damages.

The 100-year recurrence interval flood stage in the level pool upstream of the north detention basin outlet would be limited to elevation 825.9 feet above NGVD, which is less than or equal to the 100-year stage under planned land use and existing channel conditions. As under Alternative Plan No. 6, the 100-year recurrence interval flood stage upstream of the detention basin outlet would be at approximate elevation 829.2 feet above NGVD29. That stage elevation represents an increase of from 0.0 to 1.8 feet in the flood stage compared to the existing 100-year flood stage. Flood stage increases would not occur in the Clearwater Lakes condominium development or at the five lots in the Sanctuary Subdivision, thus, easements would not be required from those property owners. As under Alternative Plan No. 5, easements would not be required at the lots along the south side of Leon Terrace, easements should be routinely granted at no cost to the detention basin project in the 500-foot development zone north of the proposed Wisconsin Avenue extension. Easements might be required at several properties in Elm Grove near Verdant Drive on the east side of Pilgrim Parkway; however, the stormwater drainage element of this plan provides for the implementation of a plan to alleviate drainage and flooding problems in that location. That plan would necessarily be implemented along with the Dousman Ditch detention basin. In addition, the project would include acquisition of about 155 acres of land.

Map 25

ALTERNATIVE PLAN NO. 8
EXPANDED TWO-BASIN DETENTION STORAGE WITH EXCAVATION MAXIMIZED



Source: SEWRPC.

For the south detention basin, the dike, detention basin excavation, sanitary sewer access roads and/or wet detention basin flow baffles, detention basin outlet, emergency spillway, and Pilgrim Parkway road grade raise or parallel dike would be the same as under Alternative Plan No. 6. As shown on Map 25, a culvert with a backwater gate would be installed in the north-south ditch that conveys runoff from a portion of the residential area located north of the detention basin.

As under Alternative Plan No. 7, the 1,800-foot-long dike for the north detention basin would have side slopes of one vertical on three horizontal, a 10-foot top width, and a crest elevation of 828.9 feet above NGVD29, providing three feet of freeboard during the 100-year flood. It was assumed that the dike foundation would be excavated to sound soil and the trench would be backfilled with structural fill. The dike would be located in a wetland. That location was chosen for this alternative because it would avoid ponding of runoff at the outlet of the storm sewers discharging to the wetland at Onondoga Circle and Indianwood Drive and from the Starbridge Subdivision and at the outlets of the culverts discharging to Dousman Ditch at Cascade Drive, Westover Road, and the entrance drive to Pilgrim Park Middle School.

The north detention basin would have a 15-inch-diameter RCP discharge pipe and an adjacent drop inlet weir with a 10-foot-long crest at approximate elevation 825.1 feet above NGVD29. That weir would be provided with an outlet pipe large enough to convey flow occurring over the weir without submerging the weir crest. A concrete- or riprap-lined emergency spillway would be constructed to convey flows during floods with recurrence intervals greater than 100 years.

One property would have to be acquired for construction of the detention basin.

This alternative plan calls for raising about 110 feet of Pilgrim Parkway south of Gebhardt Road an average of about 0.5 foot to avoid inundation of the roadway during a 100-year flood. The grade raise would be located near the north entrance drive to Pilgrim Park Middle School. In order to provide adequate major system hydraulic capacity, the existing 27-inch-high by 43-inch-wide CMPA culvert under Pilgrim Parkway at the northern entrance to the Middle School would be replaced with a 60-foot-long, 24-inch-high by 38-inch-wide reinforced concrete HE pipe culvert.

The plan also calls for the floodproofing of four single-family residential buildings in Brookfield and 11 in Elm Grove, the elevation of two single-family residential buildings in Brookfield and one in Elm Grove, the floodproofing of four apartment buildings in Elm Grove, the floodproofing of one commercial building in Brookfield and 13 in Elm Grove, and the acquisition and removal of one single-family residence in Brookfield.

As described in detail in Appendix D, under this alternative plan, the proposed Bluemound Road Golf Range could not be developed as intended because the site would be purchased and excavated to elevation 824 feet above NGVD29 to provide additional flood storage capacity. Frequent flooding of the excavated area would be expected.

Full implementation of this alternative plan would serve to eliminate structure flood damages due to direct overland flooding along Underwood Creek for floods up to and including the 100-year recurrence interval flood event under planned land use and channel conditions. Damages due to street flooding would be reduced, but not eliminated by implementation of this plan in the absence of other measures directed toward reduction of infiltration and inflow to sanitary sewers.

As set forth in Table 24, the total capital cost of the water quantity control portion of the expanded two-basin detention storage with excavation minimized alternative is estimated to be $9,870,000. This cost includes the following items related to the south detention basin: 1) $2,130,000 for construction of the dike and spillway, 2) $4,180,000 for construction of the water quantity control portion of the basin, 3) $240,000 for access roads/baffles, 4) $160,000 for raising Pilgrim Parkway, and 5) $350,000 for land acquisition. The cost also includes the following items related to the north detention basin: 1) $1,170,000 for construction of the dike and spillway, 2) $30,000 for land acquisition, and 3) $20,000 for raising Pilgrim Parkway and installing a larger culvert under the roadway. Finally, the total cost includes $1,590,000 for structure floodproofing, elevation, and removal. Assuming an annual interest rate of 6 percent and a project life and amortization period of 50 years, the average annual cost of the alternative plan, including $13,000 in annual operation and maintenance costs is $640,000. The average annual flood damage abatement benefit is estimated to be $135,000, yielding a benefit-cost ratio of 0.21.

Alternative Floodland Management Plan No. 9—Two-Basin Detention Storage with Excavation Minimized, No Wetland Disturbance, and Structure Floodproofing and Elevation

This alternative is the same as Alternative Plan No. 4, except that it includes an additional detention basin located south of Gebhardt Road, as shown on Map 26 and it does not include structure acquisition and removal. The additional detention basin, designated the north basin, would function in series with the larger south, or upstream, basin, providing a somewhat greater degree of reduction of flood flows than would Alternative Plan No. 4. The amount of storage provided in the north detention basin during a 100-year flood would be about 70 acre-feet and the amount provided in the south basin would be 310 acre-feet, for a total of about 380 acre-feet. The net increase in storage relative to existing conditions would be about 185 acre-feet. That amount of storage would be sufficient to offset lost storage due to development within the 500-foot zone adjacent to the south basin and also to provide reductions in downstream flood flows, stages, and damages.

The 100-year recurrence interval flood stage in the level pool upstream of the north detention basin outlet would be limited to elevation 825.6 feet above NGVD, which is less than or equal to the 100-year stage under planned land use and existing channel conditions. As under Alternative Plan No. 4, the 100-year flood stage in the south detention basin would be at approximate elevation 830.0 feet above NGVD29. That stage elevation represents an increase of from 0.0 to 2.4 feet in the flood stage compared to the existing 100-year flood stage. Easements for the flood stage increases would be required from affected property owners in the Clearwater Lakes condominium development and at five lots in the Sanctuary Subdivision. In addition, the project would include acquisition of about 170 acres of land. Easements would not be required at the lots along the south side of Leon Terrace in the north central portion of the detention basin because a low dike would be constructed in that area outside of the lots. While easements might technically be required from the property owners in the 500-foot development zone north of the proposed Wisconsin Avenue extension, such easements should be routinely granted at no cost to the detention basin project during the development approval process.

For the south detention basin, the dike, sanitary sewer access roads and/or wet detention basin flow baffles, detention basin outlet, and emergency spillway would be the same as under Alternative Plan No. 4. As shown on Map 26, a culvert with a backwater gate would be installed in the north-south ditch that conveys runoff from a portion of the residential area located north of the detention basin.

The 260-foot-long dike for the north detention basin would have side slopes of one vertical on three horizontal, a 10-foot top width, and a crest elevation of 828.6 feet above NGVD29, providing three feet of freeboard during the 100-year flood. It was assumed that the dike foundation would be excavated to sound soil and the trench would be backfilled with structural fill. The dike would be located outside of wetlands. In that location runoff would be ponded at the outlet of the storm sewer discharging to the wetland at Onondoga Circle and Indianwood Drive and at the outlets of the culverts discharging to Dousman Ditch at Cascade Drive, Westover Road, and the entrance drive to Pilgrim Park Middle School. That ponding could possibly restrict outflow through the storm sewer and culverts, but the degree of restriction during large floods would be no greater than under existing channel conditions.

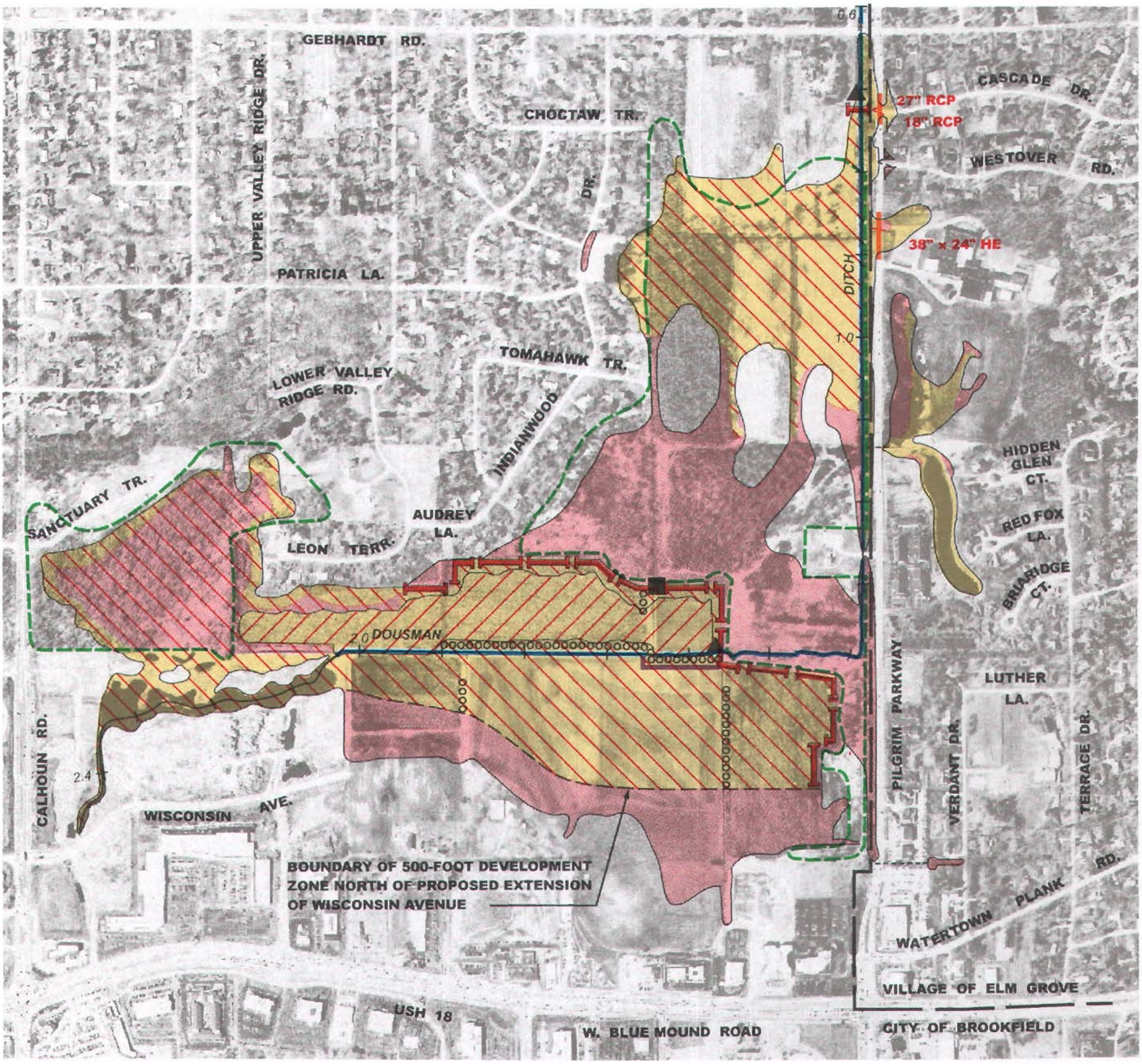
The north detention basin would have two 30-inch-diameter RCP discharge pipes, each with a different upstream invert elevation to enable achievement of the desired level of control of the basin outflow. A concrete- or riprap-lined emergency spillway would be constructed to convey flows during floods with recurrence intervals greater than 100 years.

Part of one property and all of another would have to be acquired for construction of the detention basin. In addition, easements would be required at 18 properties. Those easements would not be necessary because of an increase in the 100-year flood stage as a result of construction of the detention basin. They would be required to enable municipal control of the lands associated with the basin.

This alternative plan calls for raising about 400 feet of Pilgrim Parkway south of Gebhardt Road an average of about 1.3 feet to avoid inundation of the roadway during a 100-year flood. The grade raises would be located near the intersection with Cascade Drive and at the north entrance drive to Pilgrim Park Middle School. In order to provide adequate major system hydraulic capacity, the existing northern 24-inch-diameter CMP culvert under Pilgrim Parkway at Cascade Drive would be replaced with a 50-foot-long, 27-inch-diameter RCP culvert and the southern CMP

Map 26

ALTERNATIVE PLAN NO. 9
TWO-BASIN DETENTION STORAGE WITH EXCAVATION MINIMIZED AND NO WETLAND DISTURBANCE



0.5 EXISTING CHANNEL CENTERLINE AND RIVER MILE STATIONING

🟥🟨 100-YEAR RECURRENCE INTERVAL FLOODPLAIN PLANNED LAND USE AND EXISTING CHANNEL CONDITIONS

🟨 100-YEAR RECURRENCE INTERVAL FLOODPLAIN PLANNED LAND USE AND PROPOSED CHANNEL CONDITIONS

▨ PROPOSED WET DETENTION BASIN

▧ PROPOSED DETENTION BASIN

━ PROPOSED EARTHEN DIKE

ooooo PROPOSED WET DETENTION BASIN BAFFLE AND/OR SANITARY SEWER MANHOLE ACCESS ROAD

━ EXISTING OPEN CHANNEL

━ PROPOSED OPEN CHANNEL TO CONVEY RUNOFF FROM SUBBASIN DD-6 TO POND

– – – EXISTING CULVERT

■ PROPOSED CULVERT WITH BACKWATER GATE

– – EXISTING WETLAND BOUNDARY

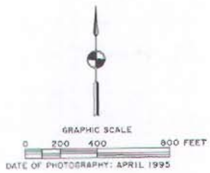
▲ PROPOSED OUTLET STRUCTURE

━ PROPOSED GRADE RAISE

27 PROPOSED REPLACEMENT CULVERT (SIZE IN INCHES)

HE REINFORCED CONCRETE HORIZONTAL ELLIPTICAL PIPE

RCP REINFORCED CONCRETE PIPE



Source: SEWRPC.

culvert would be replaced with a 53-foot-long, 18-inch-diameter RCP culvert. The existing 27-inch-high by 43-inch-wide CMPA culvert under Pilgrim Parkway at the northern entrance to the Middle School would be replaced with a 60-foot-long, 24-inch-high by 38-inch-wide reinforced concrete HE pipe culvert.

The plan also calls for the floodproofing of one single-family residential buildings in Brookfield and 11 in Elm Grove, the elevation of two single-family residential buildings in Brookfield and one in Elm Grove, the floodproofing of four apartment buildings in Elm Grove, and the floodproofing of one commercial building in Brookfield and 13 in Elm Grove.

As set forth in detail in Appendix D, under this alternative plan, the frequency and duration of flooding of the proposed Bluemound Road Golf Range site would be increased in comparison with existing conditions. Interruptions in the use of the range due to flooding above elevation 727.6 feet above NGVD29 for a duration of one day or more could be expected about once every 20 months.

Full implementation of this alternative plan would serve to eliminate structure flood damages due to direct overland flooding along Underwood Creek for floods up to and including the 100-year recurrence interval flood event under planned land use and channel conditions. Damages due to street flooding would be reduced, but not eliminated by implementation of this plan in the absence of other measures directed toward reduction of infiltration and inflow to sanitary sewers.

As set forth in Table 24, the total capital cost of the water quantity control portion of the two-basin detention storage with excavation minimized and no wetland disturbance alternative is estimated to be $7,055,000. This cost includes the following items related to the south detention basin: 1) $2,770,000 for construction of the dike and spillway, 2) $1,920,000 for construction of the water quantity control portion of the basin, 3) $230,000 for access roads/baffles, 4) $350,000 for land acquisition, and 5) $100,000 for easements. The cost also includes the following items related to the north detention basin: 1) $130,000 for construction of the dike and spillway, 2) $100,000 for land acquisition, 3) $90,000 for easements, and 4) $55,000 for raising Pilgrim Parkway and installing larger culverts under the roadway. Finally, the total cost includes $1,310,000 for structure floodproofing and elevation. Assuming an annual interest rate of 6 percent and a project life and amortization period of 50 years, the average annual cost of the alternative plan, including $11,000 in annual operation and maintenance costs is $459,000. The average annual flood damage abatement benefit is estimated to be $135,000, yielding a benefit-cost ratio of 0.29.

Alternative Floodland Management Plan No. 10—Limited Dousman Ditch Detention Storage, Maximum On-Line Storage, Bridge and Culvert Modification, and Structure Floodproofing, Elevation, and Removal

This alternative was developed as an extension of Alternative Plan No. 3. As shown on Maps 20 and 27, under this alternative, the Alternative Plan No. 3 detention basin would be constructed along Dousman Ditch west of Pilgrim Parkway and selected bridges and culverts would be modified along Underwood Creek in the Village of Elm Grove. Thus, under this alternative, the floodland management measures called for along Dousman Ditch and in the City of Brookfield would be identical to those for Alternative Plan No. 3. They would include 1) constructing a detention basin for water quality and quantity control with a net total of approximately 23 acre-feet of flood storage along Dousman Ditch; 2) acquiring about 115 acres of land in the vicinity of the detention basin; 3) raising about 360 feet of Pilgrim Parkway south of Gebhardt Road an average of about 0.9 foot to avoid inundation of the roadway during a 100-year flood; 4) replacing the existing northern 24-inch-diameter CMP culvert under Pilgrim Parkway at Cascade Drive with a 50-foot-long, 27-inch-diameter RCP culvert, replacing the southern CMP culvert with a 53-foot-long, 18-inch-diameter RCP culvert, and replacing the existing 27-inch-high by 43-inch-wide CMPA culvert under Pilgrim Parkway at the northern entrance to Pilgrim Park Middle School with a 60-foot-long, 24-inch-high by 38-inch-wide reinforced concrete HE pipe culvert; 5) floodproofing five single-family residences and one commercial structure in Brookfield; 6) elevating two single-family residential buildings in Brookfield; and 7) removing one single-family residence in the City of Brookfield. As described in Appendix D, under this alternative plan, the frequency and duration of flooding of the proposed Bluemound Road Golf Range site would be reduced in comparison with both existing conditions and conditions under the other alternative plans. Interruptions in the use of the range due to flooding would be infrequent.

In the Village of Elm Grove, the six bridges that have the most significant effect on flood stages would be

Map 27

ALTERNATIVE FLOODLAND MANAGEMENT PLAN NO. 10
LIMITED DOUSMAN DITCH DETENTION STORAGE, MAXIMUM ON-LINE STORAGE, BRIDGE AND CULVERT MODIFICATION, AND STRUCTURE FLOODPROOFING, ELEVATION, AND REMOVAL

0.5	EXISTING CHANNEL CENTERLINE AND RIVER MILE STATIONING
🟥	100-YEAR RECURRENCE INTERVAL FLOODPLAIN—PLANNED LAND USE AND EXISTING CHANNEL CONDITIONS
🟨	100-YEAR RECURRENCE INTERVAL FLOODPLAIN—PLANNED LAND USE AND PROPOSED CHANNEL CONDITIONS
- - -	EXISTING WETLAND BOUNDARY
607a	BUILDING DESIGNATION
●	BUILDING PROPOSED TO BE FLOODPROOFED
●	BUILDING PROPOSED TO BE ELEVATED
●	BUILDING PROPOSED TO BE REMOVED
●	BUILDING NO LONGER IN FLOODPLAIN DUE TO IMPLEMENTATION OF RECOMMENDED FLOOD CONTROL MEASURES
●	BUILDING NEAR EDGE OF FLOODPLAIN, FLOODPROOFING MAY NOT BE REQUIRED
- - -	EXISTING CULVERT
—	PROPOSED BOX CULVERT (SIZE IN FEET)
▬	BRIDGE PROPOSED TO BE REMOVED
▬	BRIDGE PROPOSED TO BE REPLACED AND SIZE
▨	PROPOSED COMPENSATING STORAGE AREA

GRAPHIC SCALE
0 200 400 800 FEET
DATE OF PHOTOGRAPHY: APRIL 1995

Source: SEWRPC.

modified, expanded, or removed, as shown on Map 27. From downstream to upstream, 1) the first private bridge downstream from Wall Street would be removed, 2) the 28-foot-wide Wall Street bridge would be replaced with a 40-foot-wide bridge, 3) a six-foot-high by 20-foot-wide, 570-foot-long reinforced concrete box culvert would be added parallel to the existing Park and Shop enclosure of similar size south of Watertown Plank Road, 4) a nine-foot-high by 20-foot-wide, reinforced concrete box culvert would be added parallel to the existing culvert of similar size under Watertown Plank Road, 5) an eight-foot-high by 22-foot-wide, reinforced concrete box culvert would be added parallel to the existing private culvert of similar size immediately upstream from Watertown Plank Road, and 6) the 26-foot-wide Canadian Pacific Railway bridge between Watertown Plank Road and Juneau Boulevard would be replaced with a 40-foot-wide bridge.

The provision of increased hydraulic capacity at the six bridge/culvert locations would reduce the 100-year flood stage from 0.7 to five feet in the reach extending from the upstream end of the Park and Shop enclosure to the northern limit of the Village Park. However, that reduction in flood stage would correspond to a reduction in floodwater storage volume and a corresponding increase in downstream flood flows and stages unless additional floodplain storage volume were provided. Thus, under this alternative, approximately 16 acre-feet of excavated floodplain storage volume would be provided in the Village Park and an additional eight acre-feet of volume would be provided along the Milwaukee County Underwood Creek Parkway in the City of Wauwatosa. The provision of such storage would eliminate 100-year flood flow and stage increases downstream of the Village of Elm Grove. Even with the provision of the maximum amount of storage volume reasonably possible in the Village Park, there would still be small 100-year flood stage increases of from 0.05 to 0.16 foot in Elm Grove downstream of Wall Street. The Village floodplain zoning ordinance requires that legal agreements be obtained from all property owners affected by increases of 0.01 foot or more in the 100-year flood stage.

The 100-year flood stage along Dousman Ditch upstream of the detention basin outlet structure would be reduced from 0.4 to 1.9 feet compared to the existing 100-year flood stage. Along Dousman Ditch between the basin outlet and Gebhardt Road, the 100-year flood stage would be decreased by about 0.1 foot. That reduction would marginally improve drainage of adjacent developed lands in the City of Brookfield and the Village of Elm Grove, including the Indianwood and Onondaga area where significant stormwater drainage problems exist.

The number of buildings located in the 100-year floodplain of Underwood Creek would be reduced from 51 to 33 if this alternative plan were implemented.

In addition to the structures to be floodproofed and elevated in Brookfield as listed above, this plan also calls for the floodproofing of nine single-family residences in Elm Grove, the floodproofing of four apartment buildings in Elm Grove, and the floodproofing of 10 commercial buildings in Elm Grove.

Full implementation of this alternative plan would serve to eliminate structure flood damages due to direct overland flooding along Underwood Creek for floods up to and including the 100-year recurrence interval flood event under planned land use and channel conditions. Damages due to street flooding would be reduced, but not eliminated by implementation of this plan in the absence of other measures directed toward reduction of infiltration and inflow to sanitary sewers.

As set forth in Table 24, the total capital cost of the water quantity control portion of the limited detention storage alternative is estimated to be $9,900,000. This cost includes $1,870,000 for construction of the water quantity control portion of the detention basin; $350,000 for land acquisition; $50,000 for raising the grade of Pilgrim Parkway and installing larger culverts under the roadway; $2,665,000 for bridge and culvert modification or removal; $3,595,000 for the provision of floodwater storage volume in the Elm Grove Village Park; $185,000 for the provision of floodwater storage volume along the Underwood Creek Parkway in the City of Wauwatosa; and $1,185,000 for floodproofing, elevation or removal of structures. Assuming an annual interest rate of 6 percent, a project life and amortization period of 50 years, and annual operation and maintenance costs of $2,000 per year, the average annual cost of the alternative plan is $631,000. The average annual flood damage abatement benefit is estimated to be $135,000, yielding a benefit-cost ratio of 0.21.

Alternative Floodland Management Plan No. 11—Limited Dousman Ditch Detention Storage, Underwood Creek Overflow Channel and Diversion, and Compensating Storage, with Structure Floodproofing and Removal

This alternative was conceptually proposed by the Village of Elm Grove subcommittee of the Underwood Creek Task Force at the subcommittee's meeting on January 28, 1999. The subcommittee directed Ruekert & Mielke, Inc., the Village engineer, to evaluate the concept and Ruekert & Mielke, Inc. issued a report on their evaluation, including approximate costs on February 25, 1999. That report called for a 2.3-mile-long reinforced concrete box culvert diversion. The February report was considered by the Elm Grove subcommittee at their March 2, 1999 meeting. At that meeting, the subcommittee and the Village staff decided to pursue the alternative plan further and they requested 1) that Ruekert & Mielke examine possible utility conflicts along the proposed route and 2) that the Regional Planning Commission staff develop a detailed alternative, including the provision of compensating floodwater storage, following completion of Ruekert & Mielke's utility conflict analysis. On April 8, 1999, Ruekert & Mielke issued a report on their findings regarding utility conflicts and the diversion alignment. That report, which was presented to the Elm Grove subcommittee at their April 9, 1999 meeting, refined the original proposal and called for an 0.8-mile-long overflow channel, located approximately parallel to Underwood Creek, from the intersection of Mt. Kisco Drive and Underwood River Parkway to Juneau Boulevard and a one-mile-long, double six-foot-high by seven-foot-wide reinforced concrete box culvert diversion from Juneau Boulevard through the Village to a location about 450 feet east of the Milwaukee-Waukesha County line. The issues involved in the analysis of the overflow channel and diversion with compensating storage alternative were reviewed at the April 21, 1999 full Underwood Creek Task Force meeting and the analyses of the alternative plan in the context of the overall stormwater and floodland management plan for Dousman Ditch and Underwood Creek were performed by the Commission staff following that meeting.

This alternative plan was developed as an extension of Alternative Plan No. 3. As shown on Maps 20 and 28, under this alternative, 1) the Alternative Plan No. 3 detention basin and associated measures would be constructed along Dousman Ditch west of Pilgrim Parkway; 2) about 14 acre-feet of floodwater storage volume would be provided in the east overbank of Underwood Creek in the City of Brookfield immediately northwest of the intersection of W. North Avenue and Lilly Road; 3) six houses and lots located east of Underwood Creek in the City of Brookfield would be purchased to enable construction of the detention storage area described under Item 2;[25] 4) about 35 acre-feet of floodwater storage volume would be provided in the northern portion of the Village Park; 5) a 4,100-foot-long overflow channel would be constructed along the west overbank of Underwood Creek from near the intersection of Mt. Kisco Drive and Underwood River Parkway to Juneau Boulevard;[26] 6) three parallel 31-foot-long, four-foot-high by 10-foot-wide reinforced concrete box culverts would be provided at the Marcella Avenue crossing of the overflow channel; 7) two parallel 28-foot-long, five-foot-high by 10-foot-wide reinforced con-crete box culverts would be provided at the Village Hall Drive crossing of the overflow channel; and 8) a 5,400-foot long double six-foot-high by seven-foot-wide reinforced concrete box culvert diversion would be constructed from Juneau Boulevard through the downtown portion of the Village of Elm Grove to a location about 450 feet east of the Milwaukee-Waukesha County line.

Under this alternative, the floodland management measures called for along Dousman Ditch would be identical to those for Alternative Plan No. 3. They would include 1) constructing a detention basin for water quality and quantity control with a net total of approximately 23 acre-feet of flood storage along

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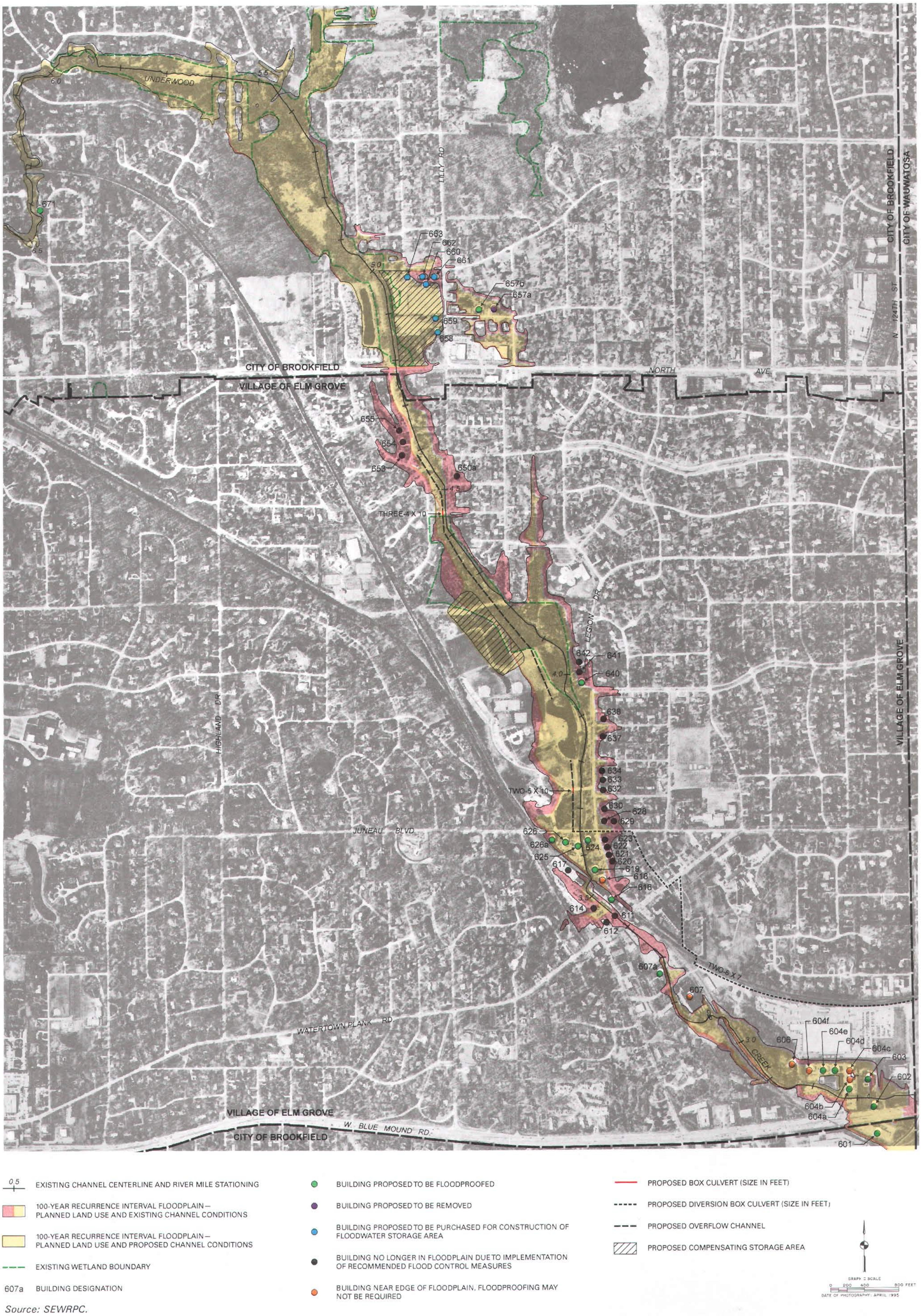
[25] *The City of Brookfield subcommittee of the Underwood Creek Task Force originally endorsed considering the purchase of houses and the development of floodwater storage along Underwood Creek upstream of W. North Avenue. That approach was supported by the task force as a whole at its March 24, 1999, meeting. Four of those six houses are located in the 100-year floodplain of Underwood Creek and the other two would be "floodplain islands" surrounded by water during a 100-year flood.*

[26] *In general the overflow channel would be from two to 4.5 feet deep, with a 40- to 300-foot-wide bottom and 70- to 330-foot-wide top. Channel side slopes would be one vertical on three horizontal, or flatter. The channel would flow into, and out of, the existing pond in the Village Park.*

Map 28

ALTERNATIVE FLOODLAND MANAGEMENT PLAN NO. 11
LIMITED DOUSMAN DITCH DETENTION STORAGE, UNDERWOOD CREEK OVERFLOW CHANNEL AND DIVERSION, AND COMPENSATING STORAGE WITH STRUCTURE FLOODPROOFING AND REMOVAL



Source: SEWRPC.

Dousman Ditch; 2) acquiring about 115 acres of land in the vicinity of the detention basin; 3) raising about 360 feet of Pilgrim Parkway south of Gebhardt Road an average of about 0.9 foot to avoid inundation of the roadway during a 100-year flood; and 4) replacing the existing northern 24-inch-diameter CMP culvert under Pilgrim Parkway at Cascade Drive with a 50-foot-long, 27-inch-diameter RCP culvert, replacing the southern CMP culvert with a 53-foot-long, 18-inch-diameter RCP culvert, and replacing the existing 27-inch-high by 43-inch-wide CMPA culvert under Pilgrim Parkway at the northern entrance to Pilgrim Park Middle School with a 60-foot-long, 24-inch-high by 38-inch-wide reinforced concrete HE pipe culvert.

As described in Appendix D, under this alternative plan, the frequency and duration of flooding of the proposed Bluemound Road Golf Range site would be reduced in comparison with both existing conditions and conditions under the other alternative plans. Interruptions in the use of the range due to flooding would be infrequent.

The 100-year flood stage along Dousman Ditch upstream of the detention basin outlet structure would be reduced from 0.4 to 1.9 feet compared to the existing 100-year flood stage. Along Dousman Ditch between the basin outlet and Gebhardt Road, the 100-year flood stage would be decreased by about 0.1 foot. That reduction would marginally improve drainage of adjacent developed lands in the City of Brookfield and the Village of Elm Grove, including the Indianwood and Onondaga area where significant stormwater drainage problems exist.

The provision of the overflow channel, diversion, and compensating storage would reduce the 100-year flood stage from 0.7 to 3.5 feet in the reach extending from the Milwaukee-Waukesha County line to W. North Avenue and from 0.2 to 0.3 feet in the 0.5-mile-long reach upstream from W. North Avenue. The provision of floodwater storage volume as described above would avoid flood flow and stage increases in the City of Wauwatosa downstream of the Village of Elm Grove during floods with recurrence intervals ranging from two through 100 years.

In comparison to the other 10 floodland management alternative plans, the number of buildings located in the 100-year floodplain of Underwood Creek would be reduced from 51 to 22 if this alternative plan were implemented.[27] This plan calls for the purchase and removal of one house in Brookfield, the floodproofing of two single-family residences in Brookfield and two in Elm Grove, the floodproofing of three apartment buildings in Elm Grove, and the floodproofing of one commercial building in Brookfield and eight in Elm Grove.[28]

This alternative plan was developed to minimize the number of buildings in the 100-year floodplain and to avoid disturbance and modification of the existing Underwood Creek stream channel. The upstream 2,900-foot-long reach of the overflow channel from Marcella Street to the north end of the pond in the Village Park would be located in a wetland. In general, it would not be possible to construct the overflow channel without some wetland disturbance; however, it may be possible to minimize the disturbance by refining the channel alignment during the final design stage. Construction of the proposed floodwater storage areas upstream of W. North Avenue and in the Elm Grove Village Park and the downstream portion of the diversion culvert might also involve some wetland disturbance, but, once

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[27] *When the hydrologic and hydraulic analyses of Alternative Plan No. 11 were conducted, the continuous simulation hydrologic model used for Alternative Plan Nos. 1 through 10 was revised to simulate the additional period of streamflow from 1940 through 1997, as opposed to 1940 through 1988 for the other alternatives. As a result, the flood frequency relationship was revised and the peak 100-year recurrence interval flood flow under planned land use and existing channel conditions was increased slightly in areas of potential flood damage. Thus, the total number of buildings identified as potentially being within the 100-year floodplain was revised from 51 to 58. For a consistent comparison with the other 10 alternatives, the total of 51 is used here. The seven additional buildings included based on the revised 100-year flood flow would no longer be in the floodplain if Alternative Plan No. 11 were implemented.*

[28] *Three additional commercial buildings and three apartment buildings in the Village of Elm Grove would be on the edge of the floodplain, but not flooded to the extent that floodproofing would be required.*

again, the degree of disturbance could be minimized during the final design of the project. The final overflow channel alignment and floodwater storage area configurations would involve consideration of 1) the concerns of property owners along the route of the channel in the area north of the Village park, 2) the impacts to the recreational features of the Village Park, 3) the degree of disturbance of wetlands, and 4) the monetary costs of alternative alignments and configurations.

Full implementation of this alternative plan would serve to eliminate structure flood damages due to direct overland flooding along Underwood Creek for floods up to and including the 100-year recurrence interval flood event under planned land use and channel conditions. Damages due to street flooding would be reduced, but not eliminated by implementation of this plan in the absence of other measures directed toward reduction of infiltration and inflow to sanitary sewers.

As set forth in Table 24, the total capital cost of the water quantity control portion of the limited detention storage alternative is estimated to be $16,940,000. This cost includes $1,870,000 for construction of the water quantity control portion of the detention basin; $350,000 for land acquisition; $50,000 for raising the grade of Pilgrim Parkway and installing larger culverts under the roadway; $1,625,000 for construction of the overflow channel and associated culverts; $9,400,000 for construction of the diversion box culvert and associated easements; $1,540,000 for the provision of floodwater storage volume along Underwood Creek upstream of W. North Avenue, including the purchase of buildings and lots; $1,500,000 for the provision of floodwater storage volume in the Elm Grove Village Park; and $605,000 for floodproofing or removal of structures. Assuming an annual interest rate of 6 percent, a project life and amortization period of 50 years, and annual operation and maintenance costs of $36,000 per year, the average annual cost of the alternative plan is $1,112,000. The average annual flood damage abatement benefit is estimated to be $135,000, yielding a benefit-cost ratio of 0.12.

Additional Alternative Floodland Management Plans Evaluated by the Village of Elm Grove

At the request of the Elm Grove subcommittee of the Underwood Creek Task Force, Ruekert & Mielke, Inc., the Village engineer, investigated two plans that would pump runoff from Dousman Ditch during a 100-year flood and divert it about two miles to the east, discharging it to Underwood Creek at the Milwaukee-Waukesha County line. The preliminary evaluation of two alternative plans to divert runoff from Dousman Ditch was presented in a February 25, 1999 letter report from Ruekert & Mielke to the Village. This approach to flood control was eliminated from further consideration because 1) it would be ineffective in providing flood relief to potential downstream damage areas in Brookfield and Elm Grove and 2) the capital and annual operation and maintenance costs would be high.

Wet Detention Basin for the Control of Nonpoint Source Pollution

As noted above, the proposed wet detention basin along Dousman Ditch would be located, as shown on Maps 20 through 26. That basin would have a permanent pond elevation of about 824 feet above NGVD29,[29] an area of about 19 acres, and a normal pond volume of about 87 acre-feet. The basin would be excavated adjacent to Dousman Ditch and no dikes would be required for the water quality portion of the basin. Outflow from the detention basin would be controlled by a v-notch weir to produce longer residence times for settling of nonpoint source pollutants during relatively low flow conditions. Although the pond would be the same under Alternative Plan Nos. 3 through 11 as described above, certain appurtenances would differ between alternatives.

The level of control of nonpoint source pollution would vary between the alternatives because some would enable the treatment of more runoff than would others. The areas tributary to the wet detention basin under the various configurations considered are shown on Map 18. The tributary area would range from 1.9 square miles under Alternative Plan Nos. 3, 4, 9, 10, and 11 to 2.3 square miles under Alternative Plan Nos. 5 through 8.

The area tributary to the wet detention basin is one of the most densely developed portions of the Dousman

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[29] *The permanent pond elevation was estimated using data from the large-scale topographic map compiled for the area in 1986 at a scale of one inch equals 200 feet and a contour interval of two feet and also based on observations of the average groundwater table elevation by property owners along the subject reach of Dousman Ditch. The normal pond elevation would be equal to the approximate normal groundwater elevation.*

Ditch and Underwood Creek subwatersheds within the study area. The tributary area includes one of the highest concentrations of critical land uses targeted for management of nonpoint source pollution under the Menomonee River Priority Watershed Study. Critical land uses in the tributary area include commercial and governmental and institutional uses. Under existing 1990 land use conditions, land uses in the area are 24 percent commercial; 1 percent governmental and institutional; 38 percent medium- and low density residential; and 37 percent open spaces, including primary environmental corridor and recreational. Under planned buildout land use conditions, land uses in the area are anticipated to be 29 percent commercial; 1 percent governmental and institutional; 46 percent medium- and low-density residential; and 24 percent open spaces, including primary environmental corridor and recreational.

In addition to calling for controls on nonpoint source pollution in runoff from areas of critical existing land uses, the priority watershed study also calls for controls in areas of planned development. With any of Alternative Plan Nos. 3 through 11 implemented, the approximate areas of incremental planned development occurring between 1990 and the achievement of buildout conditions which would be treated by the detention basin include 78 acres in commercial uses, two acres in governmental and institutional uses, and 113 acres in medium- and low-density residential uses.

The levels of control of particulate and total solids, and total phosphorus, copper, lead, and zinc under each of the alternative plans are summarized in Tables 25 through 27. The table compares annual loads under existing 1990 and planned buildout land use conditions with existing controls to loads under those conditions with the detention basin in place.[30] In general, a high level of control of nonpoint source pollution would be provided by the detention basin. Alternative Plan Nos. 5 through 8 would provide the highest level of control and they would treat the largest land area. Alternative Plan Nos. 4 and 9 would provide the next highest level of control. The reduced level of control under those alternatives is primarily because they were designed to treat a smaller land area in order to avoid disturbance of wetlands. Alternative Plan Nos. 3, 10, and 11 would provide the lowest level of control, although their implementation would still result in significant reductions in the amounts of nonpoint source pollutants discharged from the area tributary to the detention basin. Alternative Plan Nos. 3, 10, and 11 would treat the same land area as Alternative Plan Nos. 4 and 9, but they would provide a lower level of detention of runoff because they would not use dikes to impound runoff.

The following section provides a description of the appurtenant facilities associated with each different wet detention basin system considered under the alternatives analysis.

Wet Detention Basin for Alternative Plan Nos. 3, 10, and 11 [31]

Under this alternative, runoff from approximately 1,240 acres of land would be controlled. Appurtenant facilities required for the proper functioning of the wet detention basin under this alternative include about 1,900 lineal feet of access roads/baffles and an 1,800-foot-long open channel along the south side of the access road, as shown on Map 20.

The access road/baffle would provide access to the Underwood trunk sewer manholes which would be located within the permanent pond, would divert runoff from Subbasin DD-6 into the wet basin, and would provide an adequate travel distance for that runoff. The provision of that travel distance would maximize the settling time for removal of particulate pollutants. Subbasin DD-6 includes significant areas

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[30] *As already noted, different land areas are treated by the wet detention basin under different alternative plans; however, to provide a consistent basis for comparison, the loads set forth in Tables 25 through 27 are determined for the same total 2.3-square-mile area for each alternative. That area represents the largest area tributary to the detention basin under any of the alternative plans.*

[31] *Alternative Plan No. 3—Limited Detention Storage with Structure Floodproofing, Elevation, and Removal. Alternative Plan No. 10—Limited Dousman Ditch Detention Storage, Maximum On-Line Storage, Bridge and Culvert Modification, and Structure Floodproofing, Elevation, and Removal. Alternative Plan No. 11—Limited Dousman Ditch Detention Storage, Underwood Creek Overflow Channel and Diversion, and Compensating Storage with Structure Floodproofing and Removal.*

Table 25

REDUCTIONS IN NONPOINT SOURCE POLLUTION LOADS DUE TO IMPLEMENTATION OF ALTERNATIVE PLAN NOS. 3, 10, AND 11

Pollutant	Loads for Existing 1990 Land Use with Existing Controls[a] (pounds)	Loads for Planned Buildout Land Use with Existing Controls[a] (pounds)	Loads for Planned Buildout Land Use with Existing Controls and Proposed DD Detention Basin (runoff from DD-1 through 4, 6, and 7.01) (pounds)	Percent Reduction in Load Relative to Load for Existing 1990 Land Use with Existing Controls[a]	Percent Reduction in Load Relative to Load for Planned Buildout Land Use with Existing Controls[a]
Particulate Solids	642,900	693,200	155,600	76	78
Total Solids	1,863,500	1,967,400	1,429,800	23	27
Total Phosphorus	1,480	1,800	910	39	49
Total Copper	2,090	1,810	440	79	76
Total Lead	1,150	1,380	300	74	78
Total Zinc	1,200	1,440	760	37	47

[a] *The loads and load reductions are applicable to Subbasins DD-1 through 6 and DD-7.01 only.*

Source: SEWRPC.

Table 26

REDUCTIONS IN NONPOINT SOURCE POLLUTION LOADS DUE TO IMPLEMENTATION OF ALTERNATIVE PLAN NOS. 4 AND 9

Pollutant	Loads for Existing 1990 Land Use with Existing Controls[a] (pounds)	Loads for Planned Buildout Land Use with Existing Controls[a] (pounds)	Loads for Planned Buildout Land Use with Existing Controls and Proposed DD Detention Basin (runoff from DD-1 through 4, DD-6 and 7.01) (pounds)	Percent Reduction in Load Relative to Load for Existing 1990 Land Use with Existing Controls[a]	Percent Reduction in Load Relative to Load for Planned Buildout Land Use with Existing Controls[a]
Particulate Solids	642,900	693,230	133,000	79	81
Total Solids	1,863,500	1,967,400	1,407,100	24	28
Total Phosphorus	1,480	1,800	870	41	52
Total Copper	2,090	1,810	360	83	80
Total Lead	1,150	1,380	250	78	82
Total Zinc	1,200	1,440	730	39	49

[a] *The loads and load reductions are applicable to Subbasins DD-1 through 6 and DD-7.01only.*

Source: SEWRPC.

of commercial development, including Brookfield Square shopping center. Thus treatment of that runoff is important in achieving the highest practicable degree of control of nonpoint source pollution.

The open channel would convey runoff from Subbasin DD-6 to the permanent pond. Construction of the channel would require reversing the existing slope of a portion of Dousman Ditch to enable flow to occur from east to west along the baffle and into the permanent pond. The eastern 500 feet of the channel would be excavated beginning at the existing south to north channel that conveys runoff from Subbasin DD-6 and extending west to the existing Dousman Ditch channel. From that point, the streambed slope of Dousman Ditch would be reversed for a distance of 1,300 feet. The open channel would essentially be an extension of the pond. The channel would be from five to six feet deep and could be parabolic in shape, with a top width of 35 to 40 feet.

Table 27

REDUCTIONS IN NONPOINT SOURCE POLLUTION LOADS DUE TO IMPLEMENTATION OF ALTERNATIVE PLAN NOS. 5 THROUGH 8

Pollutant	Loads for Existing 1990 Land Use with Existing Controls[a] (pounds)	Loads for Planned Buildout Land Use with Existing Controls[a] (pounds)	Loads for Planned Buildout Land Use with Existing Controls and Proposed DD Detention Basin (runoff from DD-1 through 6 and 7.01) (pounds)	Percent Reduction in Load Relative to Load for Existing 1990 Land Use with Existing Controls[a]	Percent Reduction in Load Relative to Load for Planned Buildout Land Use with Existing Controls[a]
Particulate Solids	642,900	693,200	2,970	99	99
Total Solids	1,863,500	1,967,400	1,230,900	34	37
Total Phosphorus	1,480	1,800	550	63	69
Total Copper	2,090	1,810	20	99	99
Total Lead	1,150	1,380	20	98	99
Total Zinc	1,200	1,440	500	58	65

[a] *The loads and load reductions are applicable to Subbasins DD-1 through 6 and DD-7.01 only.*

Source: SEWRPC.

A sediment forebay would be provided in the wet detention basin to trap the coarser particulates in a localized area, reducing sediment removal costs.

As set forth in Table 24, the total capital cost of the water quality control portions of Alternative Plan No. 3—Limited Detention Storage with Structure Floodproofing, Elevation, and Removal and Alternative Plan No. 10—Limited Dousman Ditch Detention Storage, Maximum On-Line Storage, Bridge and Culvert Modification, and Structure Floodproofing, Elevation, and Removal, is estimated to be $2,130,000. This cost includes $1,910,000 for construction of the permanent pond, $120,000 for access roads/baffles, $100,000 for the open channel to convey runoff to the pond. Assuming an annual interest rate of 6 percent and a project life and amortization period of 50 years, the average annual cost of the water quality control portion of these alternative plans, including $9,000 in annual operation and maintenance costs is $144,000.

Wet Detention Basin for Alternative Plan Nos. 4 and 9 [32]

Under these alternatives, runoff from approximately 1,240 acres of land would be controlled. The proper functioning of the wet detention basin under these alternatives would require construction of an 1,800-foot-long open channel along the south side of the access road, as shown on Maps 21 and 26. That open channel would have the same characteristics and function as the channel called for under Alternative Plan Nos. 3, 10, and 11. Similar access roads/baffles would also be required; however, those would also be needed for the water quantity control portion of the

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[32] *Alternative Plan No. 4—Detention Storage with Excavation Minimized, No Wetland Disturbance, and Structure Floodproofing, Elevation, and Removal. Alternative Plan No. 9—Two-Basin Detention Storage with Excavation Minimized, No Wetland Disturbance, and Structure Floodproofing and Elevation.*

basin even if the permanent pond were not constructed. Thus, their cost was assigned to the water quantity control portion of the plan.

A sediment forebay would be provided in the wet detention basin to trap the coarser particulates in a localized area, reducing sediment removal costs.

As set forth in Table 24, the total capital cost of the water quality control portions of Alternative Plan No. 4—Detention Storage with Excavation Minimized, No Wetland Disturbance, and Structure Floodproofing, Elevation, and Removal, and Alternative Plan No. 9—Two-Basin Detention Storage with Excavation Minimized, No Wetland Disturbance, and Structure Floodproofing and Elevation, is estimated to be $2,010,000. This cost includes $1,910,000 for construction of the permanent pond and $100,000 for the open channel to convey runoff to the pond. Assuming an annual interest rate of 6 percent and a project life and amortization period of 50 years, the average annual cost of the water quality control portion of these alternative plans, including $9,000 in annual operation and maintenance costs is $137,000.

Wet Detention Basin for Alternative Plan Nos. 5 and 7[33]

Under these alternatives, runoff from approximately 1,480 acres of land would be controlled. Appurtenant facilities required for the proper functioning of the wet detention basin under these alternative plans include a 2,700-foot-long open channel along the south side of the access road, as shown on Maps 22 and 24. That open channel would have similar characteristics and functions as the channel called for under Alternative Plan Nos. 3, 4, 9, 10, and 11 but it would be extended to the east to Pilgrim Parkway to enable the conveyance of runoff from Subbasin DD-5 to the permanent pond. That subbasin is located east of Pilgrim Parkway/N. Moorland Road and north and south of W. Bluemound Road and it includes a mix of commercial and residential land uses. Access roads/baffles would be required; however, those would also be needed for the water quantity control portion of the basin even if the permanent pond were not constructed. Thus, their cost was assigned to the water quantity control portion of the plan.

The access road/baffle would provide an adequate travel distance for runoff from Subbasins DD-5 and DD-6, maximizing the settling time for removal of particulate pollutants.

The open channel would convey runoff from Subbasins DD-5 and DD-6 to the permanent pond. Construction of the channel would require reversing the existing slope of a portion of Dousman Ditch to enable flow to occur from east to west along the baffle and into the permanent pond. The eastern 1,400 feet of the channel would be excavated beginning just west of Pilgrim Parkway and extending west to the existing Dousman Ditch channel. From that point, the streambed slope of Dousman Ditch would be reversed for a distance of 1,300 feet.

A sediment forebay would be provided in the wet detention basin to trap the coarser particulates in a localized area, reducing sediment removal costs.

As set forth in Table 24, the total capital cost of the water quality control portions of Alternative Plan No. 5—Expanded Detention Storage with Excavation Minimized and Structure Floodproofing, Elevation, and Removal, and Alternative Plan No. 7—Two-Basin Detention Storage with Excavation Minimized and Structure Floodproofing, Elevation, and Removal, is estimated to be $2,060,000. This cost includes $1,910,000 for construction of the permanent pond and $150,000 for the open channel to convey runoff to the pond. Assuming an annual interest rate of 6 percent and a project life and amortization period of 50 years, the average annual cost of the water quality control portion of these alternative plans, including $9,000 in annual operation and maintenance costs is $140,000.

Wet Detention Basin for Alternative Plan Nos. 6 and 8

Under these alternatives, runoff from approximately 1,480 acres of land would be controlled. These alternative plans call for excavation of the area south of Dousman Ditch, as shown on Maps 23 and 25. Thus, construction of an open channel to convey runoff to the permanent pond is not necessary. Access roads/baffles would be required; however, those would also be needed for the water quantity control

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[33] *Alternative Plan No. 5—Expanded Detention Storage with Excavation Minimized and Structure Floodproofing, Elevation, and Removal. Alternative Plan No. 7—Two-Basin Detention Storage with Excavation Minimized and Structure Floodproofing, Elevation, and Removal.*

portion of the basin even if the permanent pond were not constructed. Thus, their cost was assigned to the water quantity control portion of the plan.

The access road/baffle would provide an adequate travel distance for runoff from Subbasins DD-5 and DD-6, maximizing the settling time for removal of particulate pollutants. A sediment forebay would be provided in the wet detention basin to trap the coarser particulates in a localized area, reducing sediment removal costs.

As set forth in Table 24, the total capital cost of the water quality control portions of Alternative Plan No. 6—Expanded Detention Storage with Excavation Maximized and Structure Floodproofing, Elevation, and Removal, and Alternative Plan No. 8—Expanded Two-Basin Detention Storage with Excavation Maximized and Structure Floodproofing, Elevation, and Removal, is estimated to be $1,910,000 for construction of the permanent pond. Assuming an annual interest rate of 6 percent and a project life and amortization period of 50 years, the average annual cost of the water quality control portion of these alternative plans, including $9,000 in annual operation and maintenance costs is $130,000.

Stormwater Management Issues Related to the Alternative Plans that Call for Detention Basins
The alternative detention basin configurations must be evaluated in the context of the tributary minor and major stormwater drainage systems in order to ensure the proper functioning of the overall system. Ideally, the detention basin would not restrict the hydraulic capacities of the culverts, storm sewers, and open channels tributary to the basin. The impacts of the alternative detention basin configurations were evaluated at the following locations in Elm Grove: 1) the area along Verdant Drive and 2) the areas tributary to the culverts under Pilgrim Parkway at Cascade Drive, Westover Road, and Pilgrim Park Middle School and the following locations in Brookfield: 3) the areas tributary to an open channel that conveys runoff from the Brookfield Square shopping center and adjacent commercial lands, 4) the areas tributary to the storm sewer outfall at Onondoga Circle and Indianwood Drive, and 5) the Starbridge Subdivision.

Alternative Plan Nos. 1 and 2 do not call for the construction of a detention basin; therefore, they create no restriction on tributary hydraulic capacities.

Under Alternative Plan Nos. 3, 10, and 11 the 10- and 100-year recurrence interval flood stages would be reduced in the south detention basin area and along Dousman Ditch south of Gebhardt Road in comparison to existing channel conditions, but those flood stages would remain about the same at the culverts under Pilgrim Parkway east of Verdant Drive. Thus, the implementation of Alternative Plan Nos. 3, 10, and 11 would serve to improve the drainage of runoff from the tributary lands enumerated under Items 2 through 5 above and it would maintain the existing stages at the culverts draining the area along Verdant Drive.

The implementation of Alternative Plan No. 4 would increase the 10- and 100-year flood stages in the south detention basin area, would maintain the existing flood stages at the culverts draining the area along Verdant Drive, and would decrease flood stages in the reach of Dousman Ditch south of Gebhardt Road. Thus, that alternative would cause no change in the Verdant Drive area, would further restrict the drainage of runoff from the tributary lands enumerated under Item 3 above and would improve drainage from the lands listed under Items 2, 4, and 5.

The implementation of Alternative Plan Nos. 5 through 8 would increase the 10- and 100-year recurrence interval flood stages in the south detention basin area and at the culverts under Pilgrim Parkway east of Verdant Drive in comparison to existing channel conditions, but it would decrease stages along Dousman Ditch south of Gebhardt Road. Thus, those alternatives would serve to restrict the drainage of runoff from the tributary lands listed under Items 1 and 3 above, but would improve drainage from the lands listed under Items 2, 4, and 5.

In comparison to existing channel conditions, Alternative Plan No. 9 would increase the 10- and 100-year recurrence interval flood stages in the south detention basin area and would maintain the existing flood stages both at the culverts draining the area along Verdant Drive and in the vicinity of the proposed north detention basin located south of Gebhardt Road. Thus, this alternative would cause no change in the areas listed under Items 1, 2, 4, and 5 and would further restrict the drainage of runoff from the tributary lands enumerated under Item 3 above.

In those instances where a given detention basin alternative would restrict hydraulic capacities of the tributary stormwater drainage system, additional remedial measures for the drainage system could be necessary. In general, those measures could include runoff storage, runoff conveyance, or stormwater pumping measures designed to offset the effects of increased flood stages along the receiving stream. The need for such additional measures is greatest in the area of Elm Grove near Verdant Drive. Such measures would increase the cost of the overall stormwater management and floodland management system. Alternative Plan Nos. 3, 4, 9, 10, and 11 would be the most compatible with providing a reliable solution to the Verdant area problems at the lowest cost.

Regulatory Issues Related to the Alternative Plans that Call for Detention Basins

Dam Safety

It is likely that the proposed dikes and associated spillways attendant to the construction of each of the detention basins called for under Alternative Plan Nos. 4 through 9 would be regulated as dams under Chapter NR 333 of the *Wisconsin Administrative Code*, "Dam Design and Construction Standards." Chapter NR 333 generally applies to dams with a structural height greater than six feet and a maximum storage capacity of 50 acre-feet or more. In Chapter NR 333, the structural height of a dam is defined as "the difference in elevation in feet between the lowest elevation on the top of the dike and the lowest elevation of the natural streambed at the downstream toe of the dam" and the maximum storage capacity of a dam is defined as "the volume of water in acre-feet capable of being stored behind a dam at the maximum water surface elevation before overtopping would occur."

In addition, Chapter NR 333 defines a minor dam as one "with less than 15 feet of structural height and less than 300 acre-feet of maximum storage capacity" and a major dam as one "with 15 feet or more of structural height, or 300 acre-feet or more of maximum storage capacity."

For each of the alternative south detention basin configurations, the dikes would have structural heights greater than six feet and maximum storage capacities greater than 300 acre-feet. Thus, they would be classified as major dams under Chapter NR 333. Each of the alternative north detention basin configurations would have dikes with structural heights greater than six feet and maximum storage capacities between 50 and 300 acre-feet. Therefore, they would be regulated under Chapter NR 333 and they would be classified as minor dams.[34]

The main consequences of regulation under Chapter NR 333 are the need to meet stringent structural and hydraulic design standards and a requirement to establish additional floodplain zoning districts for developed and undeveloped areas downstream of the dam.[35,36] Chapter NR 333 also requires that an emergency action plan be prepared for the area downstream of the dam which could be affected by a dam failure.

Permits for Activities in or Adjacent to Navigable Waters of the State of Wisconsin

It is likely that the implementation of Alternative Plan Nos. 3 through 11, each of which calls for the construction of detention basins, would require permits from the State of Wisconsin under Chapter 30, "Navigable Waters, Harbors, and Navigation" and/or Chapter 31, "Regulation of Dams and Bridges Affecting Navigable Waters," of the *Wisconsin Statutes*.

Wetlands

In cases where permits would be required under Chapters 30 or 31 of the *Wisconsin Statutes*, and

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[34] *While the peak volumes of water stored in the north detention basins during the 100-year flood are about 40 acre-feet under Alternative Plan Nos. 7 and 8, the maximum storage volumes would exceed 50 acre-feet during larger floods when the water surface in the basins would approach the top of the dike.*

[35] *It appears that the dams proposed under the alternative plans could be classified as high hazard dams according to the criteria of Chapter NR 333. Minor, high hazard dams must have a minimum total spillway discharge capacity equal to the 500-year recurrence interval flood flow and major, high hazard dams must have a minimum total spillway discharge capacity equal to the 1,000-year flood flow.*

[36] *Chapter NR 116, "Wisconsin's Floodplain Management Program," of the* Wisconsin Administrative Code *requires that "developed areas downstream of a safe dam be zoned and regulated assuming that the dam is in place during the regional (100-year recurrence interval) flood" and that "undeveloped areas downstream of a safe dam be zoned and regulated assuming that the dam does not exist."*

where activities are proposed in wetlands, the criteria and standards of Chapter NR 103 of the *Wisconsin Administrative Code,* "Water Quality Standards for Wetlands," would be used by the WDNR in the evaluation of the project. Chapter NR 103 generally prohibits activities which could significantly harm the functional values of wetlands.[37] Where such activities are proposed, a practicable alternatives analysis is required to explore actions which may accomplish the objectives of a project while minimizing or avoiding adverse impacts on wetlands. Approval by the WDNR of a project in a wetland is dependent on whether or not the project would cause significant adverse impacts to the wetland.

Alternative Plan Nos. 1 through 4, and 9 involve no direct disturbance of wetlands. Alternative Plan Nos. 5 through 8, 10, and 11 call for some wetland disturbance, through dike or open channel construction or through the provision of floodwater storage along Underwood Creek. Under Alternative Plan Nos. 5 through 8, the wetland disturbance is generally required to achieve a higher degree of control of nonpoint source pollution and flood flows. Under Alternative Plan Nos. 10 and 11, the wetland disturbance is required to achieve a higher degree of control of flood flows. All of the plans except Alternatives Plan Nos. 1 and 2 have the potential to result in a net increase in wetland area, depending on the final design. The relative merits of the alternative plans regarding wetland disturbance are evaluated in a subsequent section of this chapter.

COMPARISON AND EVALUATION OF FLOODLAND MANAGEMENT ALTERNATIVE PLANS 1 THROUGH 11

The alternative plans were compared with respect to cost, ability to be implemented; potential impacts on, and compatibility with, the stormwater management system; potential environmental impacts; potential impacts on public health and safety; and potential impacts on the downtown business and commercial area in the Village of Elm Grove. The costs of the alternative plans are provided in Table 24. A comparison of various decision criteria is provided in Table 28.

In order to facilitate the evaluation of alternative plans, the 11 alternatives were grouped relative to the general approach that they would employ in the solution of flooding problems. Alternative Plan No. 1-Structure Floodproofing, Elevation, and Removal and Alternative Plan No. 2—Acquisition and Removal of Floodprone Structures fall in the group of "nonstructural alternatives." Alternative Plan Nos. 3 through 9 each call a combination of some degree of new detention storage along the upper reach of Dousman Ditch along with varying degrees of structure floodproofing, elevation, and removal. Thus, those alternatives are classified as "storage/ nonstructural alternatives." Alternative Plan No. 10—Limited Dousman Ditch Detention Storage, Bridge and Culvert Modification, and Maximum On-Line Storage with Structure Floodproofing, Elevation, and Removal shares characteristics of the "storage/nonstructural alternatives" and of Alternative Plan No. 11—Limited Dousman Ditch Detention Storage, Underwood Creek Overflow Channel and Diversion, and Compensating Storage, with Structure Floodproofing and Removal. Alternative No. 10 is appropriately grouped with Alternative No. 11 as a "storage/conveyance" alternative because both alternatives expand on the storage/nonstructural alternatives by adding floodwater storage and conveyance features that are designed to reduce the number of buildings in the 100-year floodplain, and, thus, the number of buildings to be floodproofed, elevated, or removed. However, Alternative No. 10 can also be compared to the "storage/nonstructural alternatives" group because it calls for a degree of application of nonstructural measures similar to that of Alternative Nos. 4 through 9.

Where possible, the evaluation of alternatives was focused by selecting one alternative, or a combination of alternatives, from each group. As explained below, it is unlikely that a pure floodproofing and elevation alternative would be implemented. Therefore, the "nonstructural" alternatives (Nos. 1 and 2) were combined as described below. The "storage/ nonstructural alternatives" represented by Nos. 4 through 9 generally have similar capital and operation

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[37] *As set forth in Chapter NR 103, wetland functional values include: 1) stormwater and floodwater storage; 2) hydrologic functions, including groundwater discharge and recharge and maintenance of baseflow; 3) filtration or storage of sediments, nutrients, or toxic substances; 4) shoreline protection against erosion; 5) habitat for aquatic organisms; 6) habitat for wildlife species; and 7) recreational, cultural, educational, scientific, and natural aesthetic values and uses.*

Table 28

COMPARISON OF DECISION FACTORS IN THE EVALUATION ALTERNATIVE FLOODLAND MANAGEMENT AND ASSOCIATED NONPOINT SOURCE POLLUTION CONTROL PLANS FOR UNDERWOOD CREEK IN THE CITY OF BROOKFIELD AND THE VILLAGE OF ELM GROVE

Criterion	1	2	3	4	5	6	7	8	9	10
Alternative	Wetland Disturbance?	Flood Easement Required?[a]	Nonpoint Source Pollution Control Provided?	Change in 100-Year Flood Stage within South Detention Basin (feet)[b]	Does Alternative Permit Development of 500-Foot Zone North of Proposed Wisconsin Avenue Extension without the Provision of Compensatory Storage?	Does Alternative Call for the Construction of a Dam and Compliance with Chapter NR 333?	Number of Buildings in the 100-Year Floodplain that Are to Be Floodproofed[c]	Number of Buildings in the 100-Year Floodplain that Are to Be Elevated or Acquired and Removed[c,d]	Alternative Causes Increased Tailwater Elevation on Certain Tributary Culverts	Benefit-Cost Ratio of Flood Control Element
No. 1—Structure Floodproofing and Elevation	No	No	No	- -	No	No	40	6	No	1.08
No. 2—Acquisition and Removal of Floodprone Structures	No	No	No	- -	No	No	- -[e]	- -[e]	No	0.11
No. 3—Limited Detention Storage Primarily for Water Quality Control with Structure Floodproofing and Elevation	No	No	Yes	-0.4 to -1.9	Yes	No	35	6	No	0.52
No. 4—Detention Storage with Excavation Minimized, No Wetland Disturbance, and Structure Floodproofing and Elevation	No	Yes	Yes	0.0 to 2.4	Yes	Yes	35	4	Yes	0.30
No. 5—Expanded Detention Storage with Excavation Minimized and Structure Floodproofing and Elevation	Yes	Yes	Yes	0.0 to 2.8	Yes	Yes	34	4	Yes	0.29
No. 6—Expanded Detention Storage with Excavation Maximized and Structure Floodproofing and Elevation	Yes	Yes	Yes	0.0 to 1.8	Yes	Yes	34	4	Yes	0.24
No. 7—Expanded Two-Basin Detention Storage with Excavation Minimized and Structure Floodproofing and Elevation	Yes	Yes	Yes	0.0 to 2.8	Yes	Yes	33	4	Yes	0.25

Table 28 (continued)

Criterion	1	2	3	4	5	6	7	8	9	10
Alternative	Wetland Disturbance?	Flood Easement Required?[a]	Nonpoint Source Pollution Control Provided?	Change in 100-Year Flood Stage within South Detention Basin (feet)[b]	Does Alternative Permit Development of 500-Foot Zone North of Proposed Wisconsin Avenue Extension without the Provision of Compensatory Storage?	Does Alternative Call for the Construction of a Dam and Compliance with Chapter NR 333?	Number of Buildings in the 100-Year Floodplain that Are to Be Floodproofed[c]	Number of Buildings in the 100-Year Floodplain that Are to Be Elevated or Acquired and Removed[c,d]	Alternative Causes Increased Tailwater Elevation on Certain Tributary Culverts	Benefit-Cost Ratio of Flood Control Element
No. 8—Expanded Two-Basin Detention Storage with Excavation Maximized and Structure Floodproofing and Elevation	Yes	Yes	Yes	0.0 to 1.8	Yes	Yes	33	4	Yes	0.21
No. 9—Two Basin Detention Storage with Excavation Minimized, No Wetland Disturbance, and Structure Floodproofing	No	Yes	Yes	0.0 to 2.4	Yes	Yes	30	3	Yes	0.29
No. 10—Limited Dousman Ditch Detention Storage, Bridge and Culvert Modification, and Maximum On-Line Storage with Structure Flood-proofing, Elevation, and Removal	Yes	Yes	Yes	-0.4 to –1.9	Yes	No	29	3	No	0.21
No. 11— Limited Dousman Ditch Detention Storage, Underwood Creek Overflow Channel and Diversion, and Compensating Storage with Structure Flood-proofing and Removal	Yes	No	Yes	-0.4 to –1.9	Yes	No	21	1	No	0.12

[a] *Includes only those cases where flood easements are required under Chapter NR 116 of the* Wisconsin Administrative Code *and under local zoning ordinances.*

[b] *Relative to planned land use, existing channel conditions.*

[c] *As additional data became available during review of the alternative plans by the Underwood Creek Flooding Task Force, including the acquisition of new large-scale topographic maps, refinements were made to the total number of buildings in the 100-year floodplain. The information presented in this table was used for comparison of alternative plans. The final data on the number of flooded buildings and damage amounts is presented in Chapter VI, "Recommended Stormwater Management System Plan."*

[d] *One building is to be acquired and removed, except under Alternative No. 9, where no buildings are to be acquired.*

[e] *Fifty buildings are to be acquired and removed from the 100-year recurrence interval floodplain under this alternative plan.*

Source: SEWRPC.

and maintenance costs, all of which are higher than those of Alternative No. 3. Furthermore, Alternative No. 3 is the most implementable of the "storage/nonstructural alternatives" group because it uses existing wetland and other floodplain storage and minimizes excavation and trucking of fill. Also, Alternative No. 3 provides a reasonable-while not the maximum-level of control of nonpoint source pollution and offsets the impact of future development on downstream flows and stages while improving outlet conditions for needed local stormwater drainage projects. Thus, Alternative Plan. No. 3—Limited Detention Storage with Structure Floodproofing, Elevation, and Removal, was selected for evaluation from the "storage/nonstructural alternatives" group. The similarity of Alternative No. 10 to Nos. 4 through 9 from the "storage/nonstructural alternatives" group leads to the selection Alternative No. 3 for further consideration over Alternative No. 10. However, since the two alternatives in the "storage/conveyance" group (Nos. 10 and 11) differ significantly in cost and in the number of buildings where flooding problems would have to be addressed through nonstructural approaches, both Alternative Nos. 10 and 11 were retained for further consideration.

Costs

Because the water quality control costs associated with each alternative are similar and because the water quality benefits are not readily subject to monetary quantification, only the alternative plan costs and benefits for water quantity control are compared here. The degree of control of nonpoint source pollution afforded by each alternative plan is considered in a subsequent section.

The degree to which floodproofing or elevation is an effective or practical solution for each individual structure cannot be determined at the systems planning level. It is likely that such a nonstructural solution to the resolution of flooding problems, which is a component of each of the 11 alternative plans, would ultimately be a combination of two approaches, with some buildings being floodproofed or elevated and some being purchased and removed. A combination approach is anticipated because the final determination of the feasibility of floodproofing individual structures requires a specific evaluation of each building to determine what floodproofing approaches and features are required. When such an evaluation is made, it is possible that certain buildings would be found to be unsuited to the application of floodproofing measures, or that the required floodproofing measures would be unacceptable to individual property owners because implementation of the measures would unsatisfactorily restrict the use of the building. An example is the possible determination that the only feasible means of floodproofing a house would be to abandon the basement entirely and relocate all utilities and basement appliances to an upper level. It could also be found that some of the necessary floodproofing measures would be considered too costly relative to the perceived benefit from their implementation. In such cases, acquisition of the structure might be a preferred alternative.

The range of capital costs and the benefit-cost comparison associated with each of the alternatives selected for further analysis is shown in Table 29. The capital cost of Alternative Plan No. 1—Structure Floodproofing, Elevation, and Removal, is estimated to be about $2 million and the capital cost of Alternative Plan No. 2—Acquisition and Removal of Floodprone Structures, is estimated to be about $20 million. Since it is unlikely that No. 1 could be fully implemented, as described above, it is appropriate for evaluation purposes to combine Alternative Nos. 1 and 2 in to a plan that would have an estimated cost between $2 and $20 million dollars.

Applying the reasoning set forth above regarding the likelihood of complete implementation of floodproofing, the water quantity control cost of Alternative No. 3—Limited Detention Storage with Structure Floodproofing, Elevation, and Removal, could range from about $4.1 million, assuming that most structures remaining in the floodplain would be floodproofed as described in Table 24, to $20.0 million if all buildings designated to be floodproofed or elevated were purchased. The water quantity control cost of Alternative No. 10—Limited Dousman Ditch Detention Storage, Bridge and Culvert Modification, and Maximum On-Line Storage with Structure Floodproofing, Elevation, and Removal, could range from about $9.9 million to $22.5 million if all buildings designated to be floodproofed or elevated were purchased. The water quantity control cost of Alternative No. 11—Limited Dousman Ditch Detention Storage, Underwood Creek Overflow Channel and Diversion, and Compensating Storage, with Structure Floodproofing and Removal, could range from about $16.9 million to $25.3 million if all buildings designated to be floodproofed or elevated were purchased. Thus, when the potential cost ranges of the alternatives are considered, the cost differences between the alternatives are narrowed. However, the relative

Table 29

POSSIBLE RANGES OF CAPITAL COSTS FOR SELECTED FLOODLAND MANAGEMENT ALTERNATIVE PLANS

Alternative	Possible Capital Cost Range[a] (million dollars)	Range of Benefit-Cost Ratio
No. 1 and No. 2—Combined Structure Floodproofing, Elevation, and Acquisition and Removal	2.0[b] to 20.0[c]	0.11 to 1.08
No. 3—Limited Detention Storage with Structure Floodproofing, Elevation, and Removal	4.1[b] to 20.0[c]	0.11 to 0.52
No. 10—Limited Dousman Ditch Detention Storage, Bridge and Culvert Modification, and Maximum On-Line Storage with Structure Floodproofing, Elevation, and Removal	9.9[b] to 22.5[c]	0.09 to 0.21
No. 11—Limited Dousman Ditch Detention Storage, Underwood Creek Overflow Channel and Diversion, and Compensating Storage with Structure Floodproofing and Removal	16.9[b] to 25.3[c]	0.08 to 0.12

[a] *Costs are based upon 1998* Engineering News Record *Construction Cost Index = 6,740.*

[b] *Base water quantity capital cost from Table 24.*

[c] *Estimated total capital cost if buildings were to be acquired and removed rather than floodproofed.*

Source: SEWRPC.

ranking of the alternatives would be unchanged with the combination of Alternative Nos. 1 and 2 being the least costly, followed in order by Alternative Nos. 3, 10, and 11.

Nonmonetary Advantages and Disadvantages of the Alternative Plans

The ideal combination of the characteristics listed in Table 28 in terms of the ability to implement the floodland management portion of the project would be one that would not disturb wetlands; would provide significant control of nonpoint source pollution; would require no flood easements; would permit development in the 500-foot zone north of the proposed extension of Wisconsin Avenue without the provision of compensatory storage; would avoid construction of a dam and, thus, would not require, compliance with Chapter NR 333 of the *Wisconsin Administrative Code* regarding dam safety; would minimize the number of buildings to be floodproofed, elevated, or acquired;[38] would not increase the tailwater elevation on tributary culverts and storm sewers during floods; and would have a reasonable relationship between benefits and costs.[39]

As set forth in Tables 25 through 27, all of the alternative plans, except for the combination of Alternative Nos. 1 and 2, provide significant levels of control of nonpoint source pollution.

While none of the alternative plans meets all of the favorable criteria, Alternative Plan Nos. 3 and 11 most fully satisfy the criteria. The nonquantifiable decision criteria designated in Table 28 as criteria 1, 2, 3, 5, 6, and 9 are all favorably addressed by Alternative Plan No. 3. In addition, that alternative would decrease the 100-year flood stage in the south detention basin, as evaluated with criterion 4. With the exception of the wetland disturbance criterion, Alternative Plan No. 11 is similar to Alternative No. 3 as regards satisfaction of the nonquantifiable criteria. Alternative No. 11 would involve the least amount of floodproofing, elevation, and removal of structures and, because it would reduce 100-year flood stages to the greatest degree, the feasibility of floodproofing would be enhanced, reducing the potential need for acquisition and removal.

The combination of Alternative Nos. 1 and 2 and Alternative No. 10 each meet the nonquantifiable criteria to a lesser degree. Implementation of the combination of Alternative Nos. 1 and 2 would require additional measures for control of nonpoint source pollution, would require the provision of compensatory storage for development in the 500-foot zone north of the proposed extension of Wisconsin Avenue, and would involve the greatest degree of floodproofing, elevation, and removal of structures. Implementation of Alternative No. 10 would require obtaining flood easements and could involve wetland disturbance.

A final nonquantifiable consideration is the effect of implementation of the recommended plan on the downtown business and commercial district of the Village of Elm Grove, which is an important component of the character of the Village. Alternatives that have the potential to require the acquisition and removal of a significant number of buildings in that district are obviously less desirable from the perspective of maintaining the viability of the business district. Alternative No. 11, which minimizes the potential of floodproofing, elevation, and removal, is the most favorable approach relative to minimizing impacts on the business district. This alternative is also favorable in that it reduces the severity and frequency of flooding of structures that remain in the floodplain, thus making floodproofing more practical.

Selection of the Preliminary Recommended Floodland Management Plan for the Dousman Ditch and Underwood Creek Subwatersheds

As set forth above, the preliminary recommended floodland management plan was selected based on the input from the Underwood Creek Task Force

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[38] *With the exception of Alternative Plan No. 2, each of the alternatives calls for floodproofing a significant number of structures. Because such floodproofing would be voluntary, complete implementation of such a program may be difficult and, therefore, there may be the possibility of residual flooding of buildings. An objection is often raised to floodproofing and elevation because it has generally been considered a private cost to be borne by the property owner. If the City and Village would offer incentives for floodproofing, the implementability of these alternatives would increase. Another potential impact of the residual street flooding under any of the alternatives is secondary basement flooding of buildings outside the 100-year recurrence interval floodplain. Such secondary flooding could occur because of backup of sanitary sewers or through infiltration through basement walls and floors. The causes of secondary flooding would be partially addressed through floodproofing, elevation, or removal of structures in the 100-year floodplain, through the provision of the stormwater drainage improvements described subsequently in this report, and through the City and Village programs to physically modify the Underwood trunk and local sanitary sewers to reduce infiltration and inflow.*

[39] *An additional issue related to the evaluation of floodland management plans is the effect which each alternative plan would have on the frequency and duration of flooding of the Bluemound Road Golf Range property. The impacts of each alternative plan on the proposed golf range are evaluated in Appendix D. Of all the alternatives being considered in this section, the implementation of Alternative Plan Nos. 3, 10, and 11 would be expected to limit sustained flooding of the golf range site to the greatest degree.*

members and local officials; on the ability to meet the principles, objectives, and standards set forth in Chapter III of this report; on the ability to positively influence the solution of stormwater drainage problems; on compatibility with stormwater drainage problem solutions; consideration of the impacts on the downtown business district in the Village of Elm Grove; and on the evaluation of the supplementary criteria set forth in Table 28 regarding:

- Wetland impacts
- The need for flood easements
- Control of nonpoint source pollution
- Increasing the 100-year flood stage
- The ability to permit development in the 500-foot zone north of the proposed extension of Wisconsin Avenue without the provision of compensatory storage
- The avoidance of construction of a dam and compliance with Chapter NR 333 of the Wisconsin Administrative Code regarding dam safety,
- Minimization of the number of buildings to be floodproofed, elevated, or removed,
- Not increasing the tailwater elevation on tributary culverts and storm sewers during floods, and
- Consideration of benefits and costs.

Based on the evaluation, Alternative Plan No. 11—Limited Dousman Ditch Detention Storage, Underwood Creek Overflow Channel and Diversion, and Compensating Storage with Structure Floodproofing and Removal was selected as the preliminary recommended plan. The components of that plan are shown graphically on Maps 20 and 28.

ALTERNATIVE STORMWATER DRAINAGE PLANS

Introduction

As indicated in Chapter II, the study area is close to being fully developed. Thus, the alternative plans set forth below are primarily intended to address problems with the existing stormwater drainage system. Alternative measures for control of nonpoint source pollution and streambank erosion and streambed scour were set forth in Chapter IV and in previous sections of this chapter. Where those measures are directly related to alternative drainage measures, they are considered in formulation of the alternative drainage plans. The water quality and quantity management plan components are integrated in Chapter VI, which presents the overall recommended plan for the subwatersheds.

Utilizing the alternative stormwater management measures described above, the following general alternative stormwater drainage approaches were developed for the solution of problems throughout the Underwood Creek and Dousman Ditch subwatersheds: 1) Culvert, Roadside Swale, and Storm Sewer Conveyance; and 2) Detention Storage with Culvert, Roadside Swale, and Storm Sewer Conveyance. Each alternative stormwater management approach proposes preservation of environmental corridors and the wetlands and floodplains contained within those corridors. The main components of each approach would supplement the existing system of storm sewers, culverts, roadside swales, and detention storage facilities. In three hydrologic units, a stormwater pumping approach was considered due to unusual drainage system conditions which either precluded a gravity solution or resulted in a relatively expensive gravity solution. In one hydrologic unit acquisition and removal of structures was considered as an alternative plan.

In order to compare and evaluate the alternative stormwater management plans, the Underwood Creek and Dousman Ditch subwatersheds were divided into 23 hydrologic units. Each unit was composed of subbasins tributary to the same reach of Underwood Creek or Dousman Ditch. A description of individual components and the estimated costs are presented for each hydrologic unit under each alternative plan.[40] The hydrologic unit boundaries are shown on Map 12.

Stormwater Drainage System Costs

The base unit cost data are presented in Chapter III and Appendix A of this report. The costs presented below reflect only the stormwater drainage plan ele-

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[40] *The computation of the present value costs of the alternatives are based on an assumed project life of 50 years and an annual interest rate of 6 percent.*

ment and do not include costs for nonpoint source pollution abatement measures. Costs for the entire stormwater management system plan, including those for nonpoint source pollution abatement measures, are presented in Chapter VI, which describes the overall recommended stormwater management plan.

Evaluation of Alternative Stormwater Drainage Plans and Selection of the Preliminary Recommended Plan for Each Hydrologic Unit

The following sections of this report describe the components of the alternative and preliminary recommended plans for each hydrologic unit.

Hydrologic Unit DD-1

Description and Evaluation of the Stormwater Management System

Hydrologic Unit DD-1 is a 113-acre area located in the extreme southwestern portion of the Dousman Ditch subwatershed in the area generally north of W. Bluemound Road and west of Calhoun Road, as shown on Map 12. Approximately 30 percent of the hydrologic unit is located in the City of Brookfield and 70 percent is in the Town of Brookfield.

About 74 percent of the hydrologic unit was developed in urban land uses under existing (1990) land use conditions with about 55 percent in commercial uses, 15 percent in low-density residential uses, and the remaining 4 percent in governmental and communication and utilities. The remaining 26 percent of the unit was in open space use. Under planned buildout land use conditions, the open space area, or about 26 percent of the total area, would be converted to medium-density residential use.

The stormwater drainage system in the unit consists of storm sewers and two private detention basins serving primarily commercial development in the Town of Brookfield.

Plan Recommendations

No deficiencies in the public stormwater management system were identified and no new stormwater management measures are recommended for this hydrologic unit.

Hydrologic Unit DD-2

Description and Evaluation of the Stormwater Management System

Hydrologic Unit DD-2 is a 323-acre area located in the western portion of the Dousman Ditch subwatershed in the area north of Hydrologic Unit DD-1 and west of Calhoun Road, as shown on Map 12. About 85 percent of the hydrologic unit is located in the City of Brookfield and about 15 percent is in the Town of Brookfield.

The hydrologic unit was essentially fully developed under existing 1990 land use conditions. About 40 percent of the land area of the unit consists of primary environmental corridor which is predominantly wetlands. About 50 percent of the unit is developed in low-density residential uses and the remaining 10 percent is in medium-density residential uses.

The stormwater drainage system in the unit consists of ditch enclosures and roadside swales.

Two portions of the system were identified as having inadequate minor system capacity: 1) the 44-foot-long, 18-inch-diameter CMP cross culvert under Patricia Lane on the west side of Calhoun Road and 2) the 108-foot-long, 21-inch-diameter section of RCP storm sewer in Lucy Circle north of Evergreen Court.

Alternative Stormwater Drainage Plans

The identified localized problems can readily be solved through the provision of relatively small increases in the hydraulic capacities of the inadequate pipes. Thus, the development of alternative plans is not considered to be necessary and a culvert and storm sewer conveyance plan was developed as described below.

Recommended Stormwater Drainage Plan for Hydrologic Unit DD-2

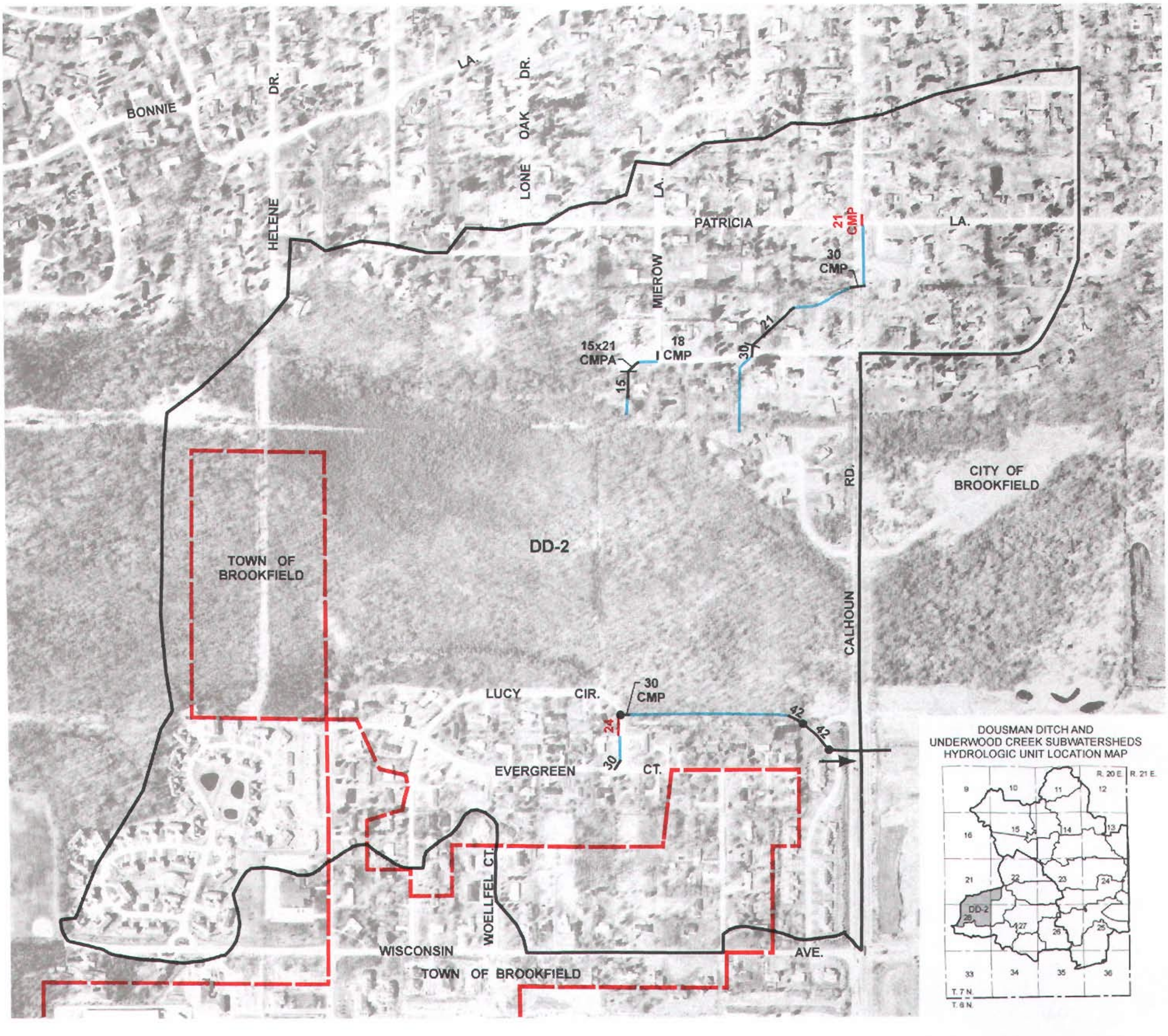
It is recommended that the 18-inch-diameter CMP cross culvert under Patricia Lane be replaced with a 21-inch-diameter CMP and that the 108-foot-long, 21-inch-diameter RCP storm sewer in Lucy Circle be replaced with a 24-inch RCP, as shown on Map 29.

Preservation of the wetlands and woodlands in the primary environmental corridor is recommended. Those wetlands provide beneficial storage of runoff in the headwaters of Dousman Ditch.

As set forth in Table 30, the total capital cost of this alternative is estimated to be $14,000. The present value cost is also estimated to be $14,000, since implementation of the recommendations would not result in an increase in annual operation and maintenance costs.

Map 29

PRELIMINARY RECOMMENDED PLAN FOR HYDROLOGIC UNIT DD-2 STORM SEWER AND CULVERT CONVEYANCE



— HYDROLOGIC UNIT BOUNDARY

DD-2 HYDROLOGIC UNIT IDENTIFICATION

→ HYDROLOGIC UNIT OUTLET

18 EXISTING STORM SEWER OR CULVERT TO BE RETAINED (SIZE IN INCHES)

● EXISTING MANHOLE OR CATCH BASIN

— EXISTING OPEN CHANNEL OR FLOW PATH

18 PROPOSED REPLACEMENT STORM SEWER OR CULVERT (SIZE IN INCHES)

NOTE:	THIS MAP GENERALLY SHOWS EXISTING STORM SEWERS OF 18-INCH DIAMETER OR LARGER. PIPES ARE CONSTRUCTED OF REINFORCED CONCRETE UNLESS DESIGNATED AS BELOW.
CMP	CORRUGATED METAL PIPE
CMPA	CORRUGATED METAL PIPE ARCH

GRAPHIC SCALE
0 200 400 600 FEET
DATE OF PHOTOGRAPHY: APRIL 1995

Source: SEWRPC.

Table 30

COMPONENTS AND COSTS OF THE CULVERT AND STORM SEWER CONVEYANCE STORMWATER DRAINAGE PLAN FOR HYDROLOGIC UNIT DD-2

Location of Component	Project and Component Designation and Description	Estimated Cost[a]	
		Capital[b]	Annual Operation and Maintenance[c]
City of Brookfield	1. DD2C1—Replace 44 feet of 18-inch CMP culvert under Patricia Lane at Calhoun Road with 21-inch CMP	$ 3,000	$0
	2. DD2C11—Replace 108 feet of 21-inch concrete storm sewer in Lucy Circle north of Evergreen Court with 24-inch RCP storm sewer	11,000	0
	Total	$14,000	$0

[a] *Costs based upon 1998* Engineering News-Record *Construction Cost Index = 6,740.*

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

[c] *Operation and maintenance costs are listed as $0 when an existing component is replaced with a component having similar operation and maintenance costs.*

Source: SEWRPC.

Hydrologic Unit DD-3

Description and Evaluation of the Stormwater Management System

Hydrologic Unit DD-3 is a 152-acre area located in the southern portion of the Dousman Ditch subwatershed in the area east of Calhoun Road and north and south of W. Bluemound Road, as shown on Map 12. The entire hydrologic unit is located in the City of Brookfield.

About 75 percent of the hydrologic unit is developed in urban uses under existing (1990) land use conditions with about 50 percent of the total area in commercial uses and about 25 percent in low-density residential uses. The rural uses include about 18 percent open space, 3 percent wetland, and the remaining area in agricultural uses. Under planned buildout land use conditions, the open and agricultural land is anticipated to be developed in commercial and medium-density residential uses, resulting in about 69 percent of the unit being in commercial uses, about 25 percent in low-density residential uses, about 3 percent in medium-density residential uses, and 3 percent in wetlands.

The stormwater drainage system in the unit consists of storm sewers in the northern two-thirds in and adjacent to W. Bluemound Road and open ditches and ditch enclosures in the southern one-third of low-density residential development.

Plan Recommendations

No stormwater drainage problems were identified in this hydrologic unit. It is recommended that the wetlands in the hydrologic unit be preserved.

Hydrologic Unit DD-4

Description and Evaluation of the Stormwater Management System

Hydrologic Unit DD-4 is a 173-acre area located in the area east of Calhoun Road and north of W. Bluemound Road, as shown on Map 12. The entire hydrologic unit is located in the City of Brookfield.

About 30 percent of the hydrologic unit is a primary environmental corridor, which is predominantly a wetland, but also includes some upland woodlands.

Under existing (1990) land use conditions about 45 percent of the total area is in low-density residential uses and 25 percent is in open space. Under planned buildout land use conditions, the open land is anticipated to be developed in low- and medium-density residential uses, resulting in about 55 percent of the unit being in low-density residential uses, about 15 percent in medium-density residential uses, and 30 percent remaining in primary environmental corridor.

The stormwater drainage system in the unit consists of storm sewers and areas of overland flow that discharge to the wetlands.

Plan Recommendations

No stormwater drainage problems were identified in this hydrologic unit. Preservation of the wetlands and woodlands in the primary environmental corridor is recommended.

Hydrologic Unit DD-5

Description and Evaluation of the Stormwater Management System

Hydrologic Unit DD-5 is a 240-acre area located in the extreme southeastern portion of the Dousman Ditch subwatershed in the area east of Pilgrim Parkway/Moorland Road and north and south of W. Bluemound Road, as shown on Map 12. Approximately 60 percent of the hydrologic unit is located in the City of Brookfield and 40 percent is in the Village of Elm Grove.

The hydrologic unit is almost completely developed under existing (1990) land use conditions with about 80 percent of the unit being in low-density residential uses, 10 percent in commercial uses, and the remaining 10 percent in governmental, medium-density residential, and recreational uses.

The stormwater drainage system in the unit consists of storm sewers in and adjacent to W. Bluemound Road; open ditches, cross culverts, and ditch enclosures in Brookfield, south of W. Bluemound Road; and open ditches and cross culverts in Elm Grove. Runoff from the entire unit drains to a ditch and culvert system in Elm Grove in the vicinity of Verdant Drive. From upstream to downstream, that culvert system consists of a 165-foot-long, 18-inch-diameter CMP culvert in the east Verdant Drive ditch north of the main east-west ditch; two parallel 38-foot-long, 33-inch-high by 49-inch-wide CMPA culverts under Verdant Drive; an open channel with a length of about 220 feet; a 257-foot-long, 48-inch-diameter CMP culvert in parallel with a 257-foot-long, 36-inch-diameter CMP culvert, both located in an easement between an office building and the parking lot of an Ace hardware store; and two parallel 52-foot-long, 33-inch-high by 49-inch-wide CMPA culverts under Pilgrim Parkway. The system discharges to an open channel on the west side of Pilgrim Parkway, which flows to the north for about 1,300 feet before discharging to Dousman Ditch.

The major system in the vicinity of Verdant Drive has inadequate capacity due to obstruction of the overland flow path to the receiving channel on the west side of Pilgrim Parkway as development occurred between Verdant Drive and Pilgrim Parkway. Under current conditions, runoff from the entire 240-acre hydrologic unit collects along Verdant Drive and, during large storms, that portion of the runoff in excess of the capacity of the existing culverts ponds to a depth of about four feet above the low point in Verdant Drive. There are 12 houses along Verdant Drive that could experience flooding during large storms. During the storm of June 20 and 21, 1997, basement flooding occurred, and during the larger storm of August 6, 1998, first floor flooding and/or basement flooding were reported.

Alternative Stormwater Drainage Plans

Three alternative plans were developed for the alleviation of drainage problems during storms with recurrence intervals up to, and including, 100 years. Those include: 1) a culvert, roadside swale, and storm sewer conveyance plan, 2) a pumping plan, and 3) acquisition and removal of the affected houses.

A detention storage alternative was investigated, but was found to be impractical. Due to downstream constraints on the elevation of a detention basin outlet, the detention volume could not be created solely through excavation. Thus, such an alternative would require dike construction and the periodic impoundment of water on the Elm Grove Lutheran Church school grounds. Within the constraints imposed by the existing development in the vicinity of the detention basin site, it was found that a large enough volume of storage could not be provided to avoid the need to replace or supplement the existing downstream culverts that convey flow from the hydrologic unit.

Hydrologic modeling of the Dousman Ditch and Underwood Creek subwatersheds demonstrated that the provision of increased hydraulic capacity at the hydrologic unit outlet would not significantly increase downstream 100-year recurrence interval flood flows, because the storage volume in wetlands and floodlands downstream from the hydrologic unit is sufficient to offset the elimination of localized storage volume in the flooded area along Verdant Drive that would occur if the hydraulic capacity at the hydrologic unit outlet were increased.

Alternative Plan No. DD-5a—Culvert, Roadside Swale, and Storm Sewer Conveyance

Under this alternative plan, the hydraulic capacities of selected storm sewers and culverts would be upgraded, as set forth in Table 31 and as shown on Map 30. The recommended measures are intended to alleviate major system problems during a 100-year storm.

In the Verdant Drive area, the system of culverts would be upgraded, beginning on the east side of Verdant Drive, and extending to the west side of Pilgrim Parkway. The objective of that upgrade would be to provide adequate hydraulic capacity to convey the peak rate of runoff during a 100-year storm so that the water surface elevation would be limited to the approximate elevation of the low point in the Verdant Drive and direct structure flooding would be eliminated.

From upstream to downstream, the alternative improvements to the culvert system consist of replacement of the 18-inch-diameter CMP in the east Verdant Drive ditch with two parallel 165-foot-long, 22-inch-high by 36-inch-wide CMPA culverts; supplementing the two parallel 33-inch-high by 49-inch-wide CMPA culverts under Verdant Drive with two additional 38-foot-long, 22-inch-high by 36-inch-wide CMPA culverts; and constructing a 330-foot-long, four-foot-high by eight-foot-wide reinforced concrete box culvert next to the existing parallel CMP and CMPA culverts which are located downstream of the open ditch in the easement between the office building and the parking lot of the Ace hardware store and under Pilgrim Parkway. Installation of the culvert pipes may require obtaining additional drainage easements. Some modification of the existing channel between Verdant Drive and the proposed box culvert would be required to accommodate the proposed culverts.

A minor system problem was identified outside of the Verdant Drive area at the intersection of Mount Vernon Avenue and Westmoor Drive where the existing 30-foot-long, 15-inch-diameter CMP culvert under Mount Vernon on the west side of Westmoor has inadequate hydraulic capacity to convey the peak rate of runoff from a 10-year storm without overtopping the roadway. Adequate minor system capacity could be achieved through replacement of the existing pipe with an 18-inch-diameter CMP culvert.

The total present value cost of this alternative is estimated to be $310,000. This is based upon an estimated capital cost of $307,000 and an estimated annual operation and maintenance cost increase of $220.

Alternative Plan No. DD-5b—Stormwater Pumping

As shown on Map 31, under this alternative plan, the planned configuration of the culverts in the immediate vicinity of Verdant Drive would be the same as under Alternative Plan No. DD-5a. From upstream to downstream, the improvements to the culvert system consist of replacement of the 18-inch-diameter CMP in the east Verdant Drive ditch with two parallel 165-foot-long, 22-inch-high by 36-inch-wide CMPA culverts and supplementing the two parallel 33-inch-high by 49-inch-wide CMPA culverts under Verdant Drive with two additional 38-foot-long, 22-inch-high by 36-inch-wide CMPA culverts.

The additional hydraulic capacity needed to convey the peak rate of runoff from a 100-year storm would be provided by a stormwater pump station located west of Verdant Drive and south of the existing east-west ditch. The pump station would discharge to the ditch on the west side of Pilgrim Parkway through a 400-foot-long, 48-inch-diameter RCP force main. The force main would be located on private property and would require easements from affected property owners. Some modification of the existing channel between Verdant Drive and the proposed pump station would be required to accommodate the proposed culverts and pump station. The pump station would be provided with a backup power source that would automatically be activated in the event of a power failure.

The components of this alternative plan are set forth in Table 32. As with Alternative No. DD-5a, the recommended measures are intended to alleviate major system problems during a 100-year storm.

The solution to the minor system problem identified at the intersection of Mount Vernon Avenue and

Table 31

COMPONENTS AND COSTS OF THE CULVERT, ROADSIDE SWALE, AND STORM SEWER CONVEYANCE ALTERNATIVE PLAN FOR HYDROLOGIC UNIT DD-5 (ALTERNATIVE PLAN NO. DD-5a)

Location of Component	Project and Component Designation and Description	Estimated Cost[a]	
		Capital[b]	Annual Operation and Maintenance[c]
Village of Elm Grove	1. DD5C24—Replace 165 feet of 18-inch CMP culvert on N. Verdant Drive north of Watertown Plank Road with twin 22-inch by 36-inch CMPA	$ 40,000	$ 90
	2. DD5C25—Retain the 38-foot-long, twin 33-inch by 49-inch CMPA culverts crossing N. Verdant Drive north of Watertown Plank Road and add two parallel 22-inch by 36-inch CMPA	10,000	40
	3. DD5C33/A—Retain one 257-foot-long, 48-inch CMP culvert and one 257-foot-long, 36-inch CMP north of Watertown Plank Road east of Pilgrim Parkway and add a 270-foot-long, four-foot by eight-foot reinforced concrete (RC) box	210,000	70
	4. DD5C33D/E—Retain the two 52-foot-long, 49-inch by 33-inch CMPA culvert crossing Pilgrim Parkway north of Watertown Plank Road and add a 60-foot-long, four-foot by eight-foot RC box	45,000	20
	Subtotal	$305,000	$220
City of Brookfield	5. DD5C26—Replace 30 feet of 15-inch CMP culvert crossing Mt. Vernon Avenue west of Westmoor Drive with 18-inch CMP	$ 2,000	$ 0
- -	Total	$307,000	$220

[a] *Costs based upon 1998* Engineering News-Record *Construction Cost Index = 6,740.*

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

[c] *Operation and maintenance costs are listed as $0 when an existing component is replaced with a component having similar operation and maintenance costs.*

Source: SEWRPC.

Westmoor Drive would be the same as described under Alternative No. DD-5a. Adequate minor system capacity could be achieved through replacement of the existing pipe under Mount Vernon with an 18-inch-diameter CMP culvert.

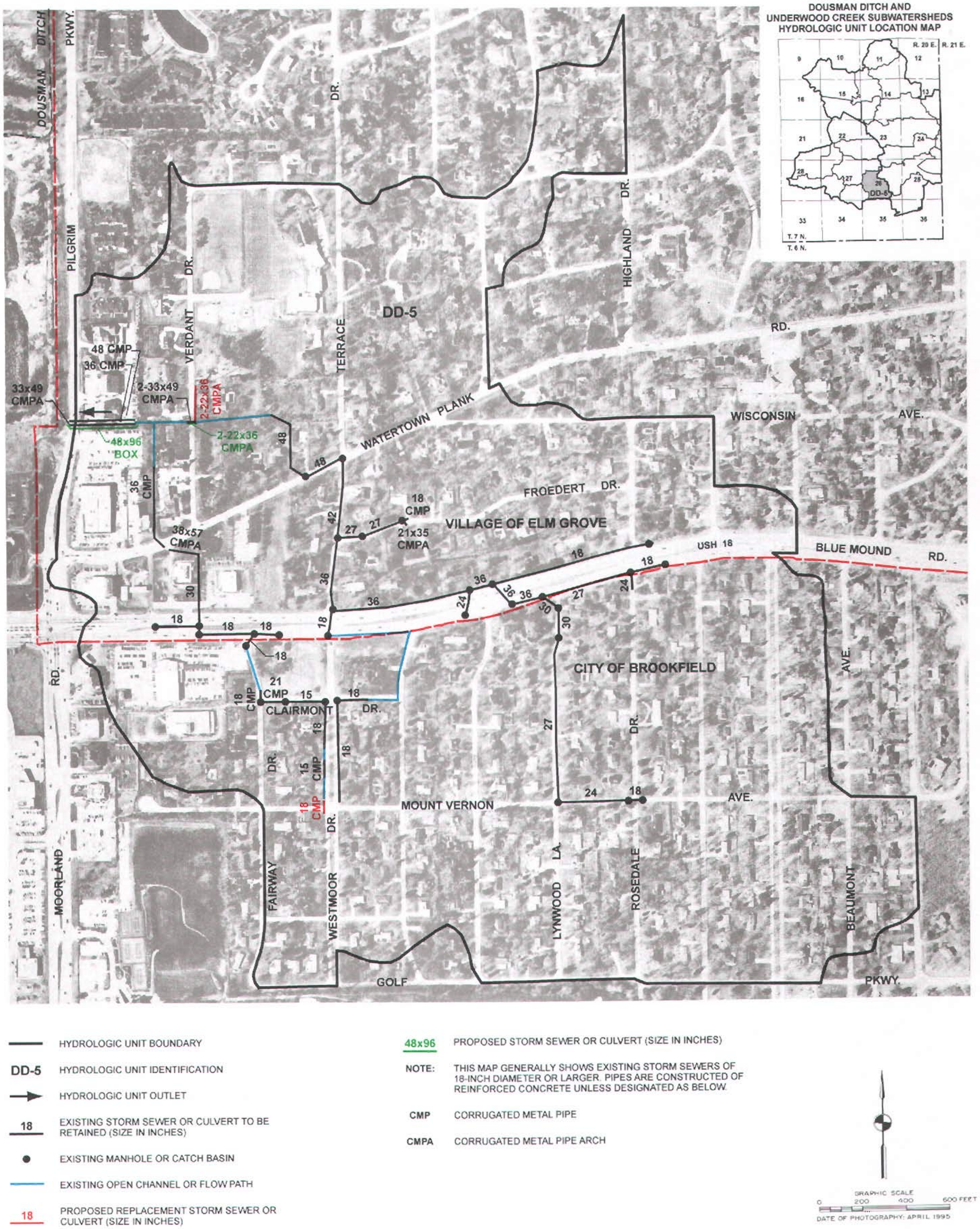
The total present value cost of this alternative is estimated at $2,863,000. This is based upon an estimated capital cost of $2,722,000 and an estimated annual operation and maintenance cost increase of $8,930.

Alternative Plan No. DD-5c— Structure Acquisition and Removal

This alternative calls for the purchase and removal of the three existing houses along Verdant Drive that could be directly flooded during a 100-year storm. Those houses are located at 675, 725, and 755

Map 30

ALTERNATIVE PLAN DD-5a
CULVERT, ROADSIDE SWALE, AND STORM SEWER CONVEYANCE



Source: SEWRPC.

Table 32

COMPONENTS AND COSTS OF THE STORMWATER PUMPING ALTERNATIVE PLAN FOR HYDROLOGIC UNIT DD-5 (ALTERNATIVE PLAN NO. DD-5b)

Location of Component	Component Designation and Description	Estimated Cost[a]	
		Capital[b]	Annual Operation and Maintenance[c]
Village of Elm Grove	1. Construct stormwater pump station with 160 cfs pumping capacity	$2,600,000	$8,700
	2. 400 feet of 48-inch-diameter reinforced concrete force main	70,000	100
	3. Same as Items 1 and 2 of Alternative No. DD-5a	50,000	130
	Subtotal	$2,720,000	$8,930
City of Brookfield	4. Same as Item 5 of Alternative No. DD-5a	$ 2,000	$ 0
- -	Total	$2,722,000	$8,930

[a] *Costs based upon 1998* Engineering News-Record *Construction Cost Index = 6,740.*

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

[c] *Operation and maintenance costs are listed as $0 when an existing component is replaced with a component having similar operation and maintenance costs.*

Source: SEWRPC.

Verdant Drive, as shown on Map 32. Following purchase and removal of the houses, the three lots would be maintained in open space use.

The estimated total cost of purchase and removal of the houses is $870,000. That cost is based on the fair market value of the houses and lots, plus relocation expenses paid to the owner, the cost of demolition or relocation of the structure, and miscellaneous administrative expenses.

Evaluation of Alternative Stormwater Drainage Plans

The foregoing information provides a basis for a comparative evaluation of the three alternative plans. The principal criteria for the comparative evaluation were cost, implementability, and degree of protection.

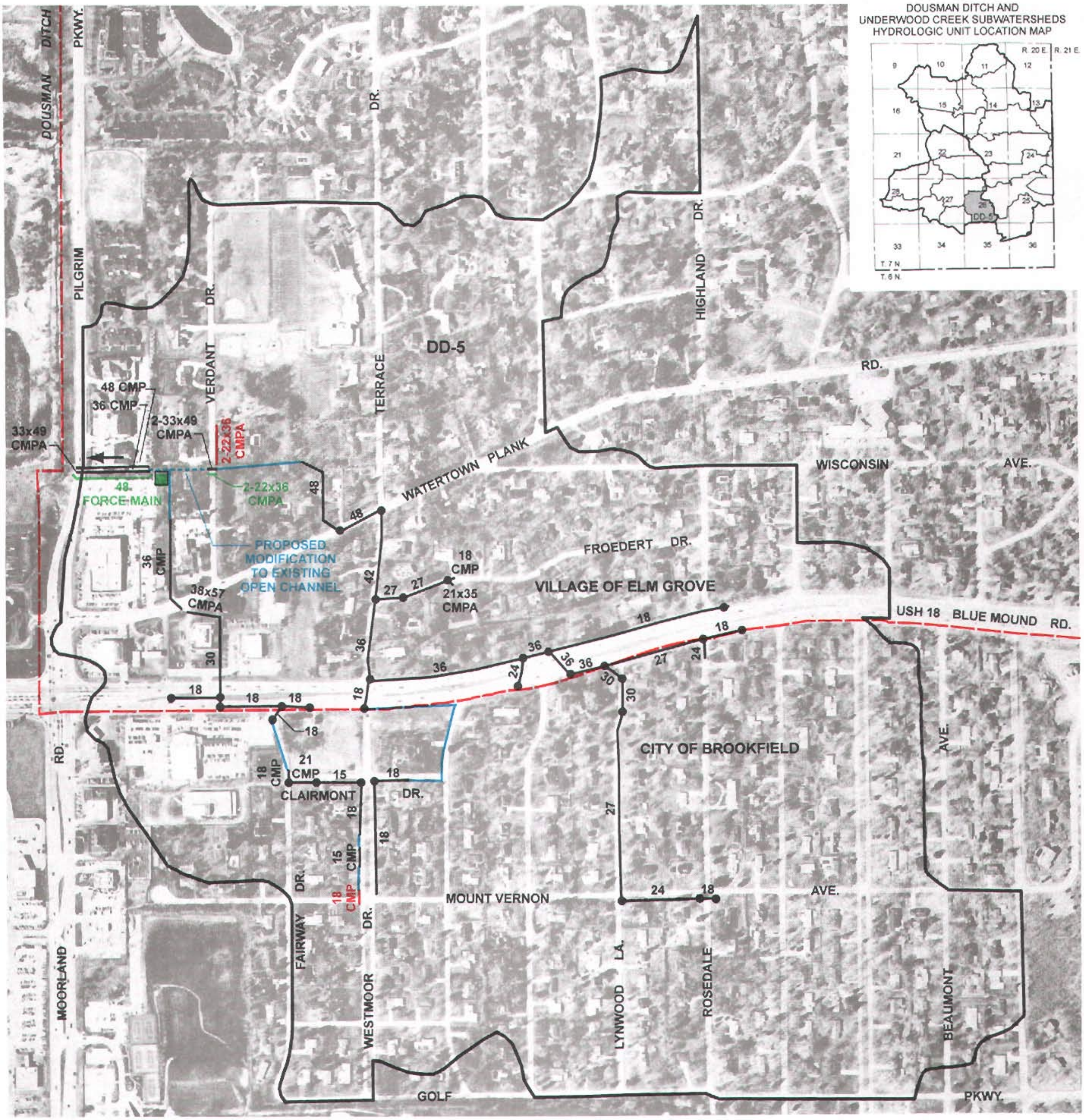
Alternative Plan No. DD-5a is the least costly of the three alternatives.

Full implementation of Alternative Plan No. DD-5c is likely to be more difficult than implementation of the other alternatives, since it would require the acquisition of three houses. Alternative Plan Nos. DD-5a and 5b would both require obtaining drainage easements from several property owners for the installation of pipes, but because some of those owners would directly benefit from implementation of the alternatives, it is likely that the easements could be readily obtained.

Nine additional houses along Verdant Drive are susceptible to flooding during storms greater than the 100-year storm, such as those that occurred on June 20 and 21, 1997, and August 6, 1998. While each of the alternative plans provides protection from direct overland flooding of structures during storms with recurrence intervals, up to and including, 100-years, only Alternative Plan Nos. DD-5a and DD-5b would also mitigate to some degree the effects of flooding during greater storms.

Map 31

ALTERNATIVE PLAN DD-5b
STORMWATER PUMPING



—	HYDROLOGIC UNIT BOUNDARY
DD-5	HYDROLOGIC UNIT IDENTIFICATION
→	HYDROLOGIC UNIT OUTLET
18	EXISTING STORM SEWER OR CULVERT TO BE RETAINED (SIZE IN INCHES)
●	EXISTING MANHOLE OR CATCH BASIN
—	EXISTING OPEN CHANNEL OR FLOW PATH
18	PROPOSED REPLACEMENT STORM SEWER OR CULVERT (SIZE IN INCHES)
🟩	PROPOSED PUMP STATION
48x96	PROPOSED STORM SEWER OR CULVERT (SIZE IN INCHES)

NOTE: THIS MAP GENERALLY SHOWS EXISTING STORM SEWERS OF 18-INCH DIAMETER OR LARGER. PIPES ARE CONSTRUCTED OF REINFORCED CONCRETE UNLESS DESIGNATED AS BELOW.

CMP	CORRUGATED METAL PIPE
CMPA	CORRUGATED METAL PIPE ARCH

GRAPHIC SCALE
0 200 400 600 FEET
DATE OF PHOTOGRAPHY: APRIL 1995

Source: SEWRPC.

Preliminary Recommended Stormwater Drainage Plan for Hydrologic Unit DD-5

Based on cost, implementability, and degree of protection, Alternative Plan No. DD-5a—Culvert, Roadside Swale, and Storm Sewer Conveyance, is selected as the preliminary recommended plan.

Hydrologic Unit DD-6

Description and Evaluation of the Stormwater Management System

Hydrologic Unit DD-6 is a 192-acre area located predominantly southwest of the intersection of Pilgrim Parkway/Moorland Road and W. Bluemound Road, as shown on Map 12. Almost the entire unit is located in the City of Brookfield.

The hydrologic unit is almost completely developed under existing (1990) land use conditions, with the exception of about 2 percent which is wetland and 4 percent which is in open uses. About 81 percent of the unit is in commercial uses, including the Brookfield Square shopping center and nearby businesses; 8 percent is in recreational (golf course) use; and the remaining 6 percent in low-density residential uses. Under planned buildout conditions, the existing open land would be converted to commercial uses, resulting in 85 percent of the unit being in commercial uses.

The stormwater drainage system consists predominantly of storm sewers with a portion being drained by an unnamed tributary to Dousman Ditch which flows through a wetland east of Executive Drive, upstream of the Brookfield Square shopping center. That stream discharges to the main 60- to 72-inch-diameter RCP storm sewer which runs through the west parking lot of the shopping center before discharging to an 84-inch-diameter RCP storm sewer under W. Bluemound Road, followed by a six-foot by six-foot reinforced concrete box culvert that discharges to a previously-modified open channel section of the tributary to Dousman Ditch.

Plan Recommendations

No stormwater drainage problems were identified in this hydrologic unit. Preservation of the natural stream and the adjacent wetlands west of the Brookfield Square shopping center is recommended.

Hydrologic Unit DD-7

Description and Evaluation of the Stormwater Management System

Hydrologic Unit DD-7 is a 354-acre area centered around Dousman Ditch in the central portion of the subwatershed. The unit is located north of W. Bluemound Road and both east and west of Pilgrim Parkway, as shown on Map 12. About 80 percent of the hydrologic unit is located in the City of Brookfield and about 20 percent is in the Village of Elm Grove.

Under 1990 land use conditions, about 58 percent of the unit was in rural uses with 16 percent of the unit being wetlands or water, 35 percent being in agricultural uses, and 7 percent being in open lands. Most of the rural lands are located in a primary environmental corridor along Dousman Ditch. The urban development in the unit consisted of about 27 percent low-density residential, 10 percent commercial, 3 percent high-density residential, and 2 percent recreational. Under buildout conditions, some of the agricultural and open lands would be converted to commercial and medium-density residential uses, resulting in urban uses in about 60 percent of the unit. The primary environmental corridor, including existing wetlands, would comprise about 40 percent of the unit, commercial uses about 16 percent, low-density residential about 27 percent, medium-density residential about 12 percent, high-density residential about 3 percent, and recreational about 2 percent.

West of Pilgrim Parkway in the City of Brookfield, the stormwater drainage system consists of agricultural ditches that receive runoff from overland flow or from a system of roadside swales and ditch enclosures in the northwest corner of the unit and then convey that flow to Dousman Ditch. East of Pilgrim Parkway in the Village of Elm Grove, the stormwater drainage system consists of a system of roadside swales and cross culverts which direct runoff to storm sewers in or near Hidden Glen Court, Red Fox Lane, and Briaridge Court in the Squires Grove Subdivision. Those storm sewers convey runoff to a pond that discharges through an open channel followed by a 36-inch-diameter CMP culvert under Pilgrim Parkway and another short open channel that flows into Dousman Ditch.

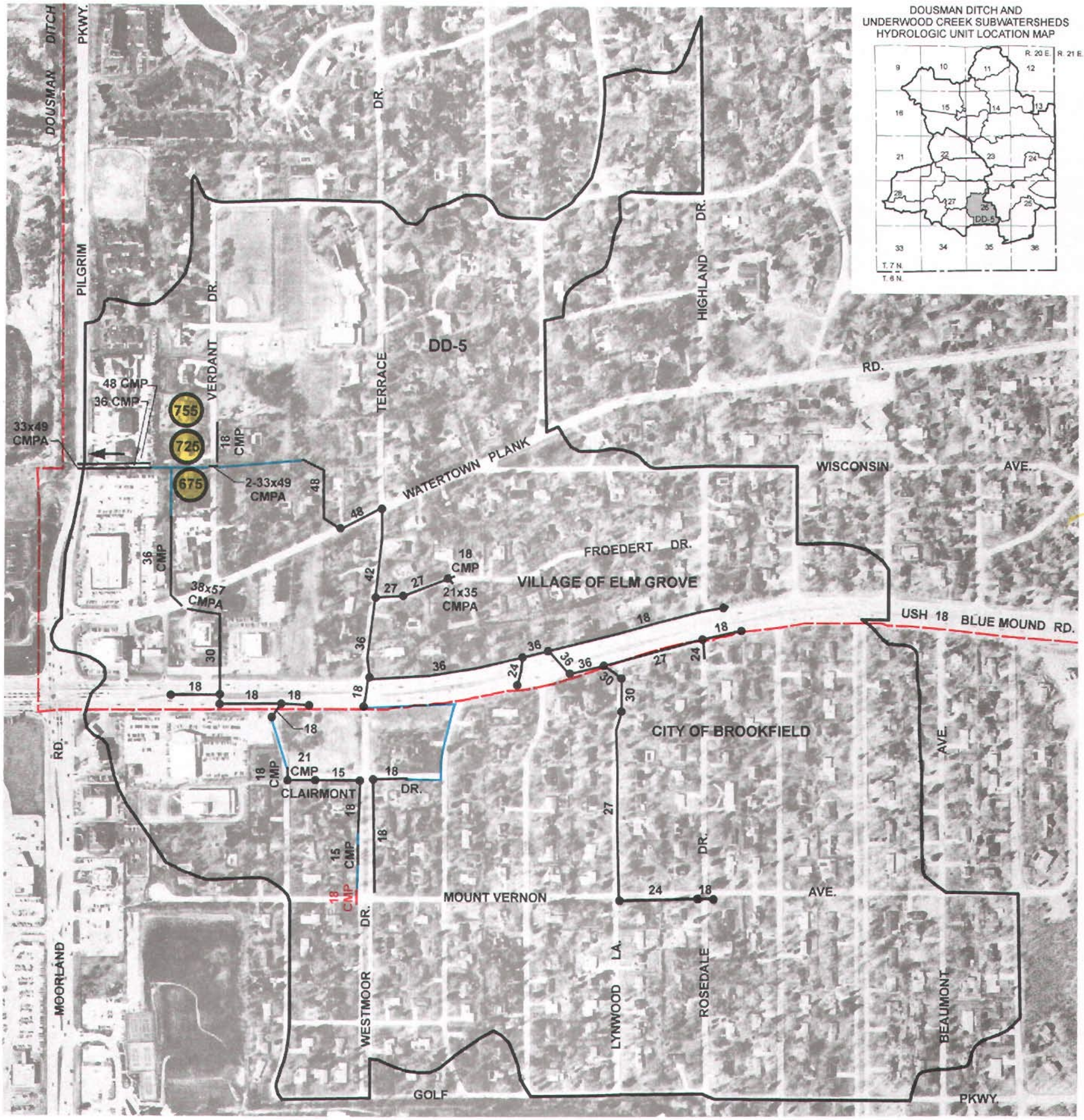
Inadequate major system capacity was identified in the vicinity of Briaridge Court and Terrace Drive. Runoff in excess of the capacity of the existing 24-inch-diameter storm sewer would pond in a mid-block sag in Briaridge Court.

Alternative Stormwater Drainage Plans

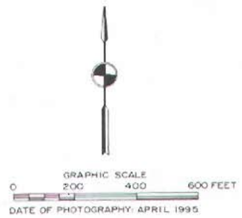
The identified localized problems can readily be solved through the provision of increases in the hydraulic capacities of several of the existing storm

Map 32

ALTERNATIVE PLAN DD-5c
STRUCTURE ACQUISITION AND REMOVAL



—	HYDROLOGIC UNIT BOUNDARY
DD-5	HYDROLOGIC UNIT IDENTIFICATION
→	HYDROLOGIC UNIT OUTLET
18	EXISTING STORM SEWER OR CULVERT TO BE RETAINED (SIZE IN INCHES)
●	EXISTING MANHOLE OR CATCH BASIN
—	EXISTING OPEN CHANNEL OR FLOW PATH
18	PROPOSED REPLACEMENT STORM SEWER OR CULVERT (SIZE IN INCHES)
755	LOCATION AND HOUSE NUMBER OF STRUCTURE PROPOSED TO BE ACQUIRED AND REMOVED
NOTE:	THIS MAP GENERALLY SHOWS EXISTING STORM SEWERS OF 18-INCH DIAMETER OR LARGER. PIPES ARE CONSTRUCTED OF REINFORCED CONCRETE UNLESS DESIGNATED AS BELOW.
CMP	CORRUGATED METAL PIPE
CMPA	CORRUGATED METAL PIPE ARCH



Source: SEWRPC.

Table 33

COMPONENTS AND COSTS OF THE STORM SEWER CONVEYANCE PLAN FOR HYDROLOGIC UNIT DD-7

Location of Component	Project and Component Designation and Description	Estimated Cost[a]	
		Capital[b]	Annual Operation and Maintenance[c]
Village of Elm Grove	1. DD7C3—Replace 318 feet of 24-inch storm sewer east of Briaridge Court with 27-inch by 44-inch RCPA storm sewer	$ 55,000	$0
	2. DD7C4—Replace 295 feet of 24-inch corrugated polyethylene storm sewer west of Briaridge Court with 27-inch by 44-inch RCPA storm sewer	51,000	0
	Total	$106,000	$0

[a] *Costs based upon 1998* Engineering News-Record *Construction Cost Index = 6,740.*

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

[c] *Operation and maintenance costs are listed as $0 when an existing component is replaced with a component having similar operation and maintenance costs.*

Source: SEWRPC.

sewers located upstream of the existing pond and the Dousman Ditch floodplain. The floodplain area provides storage of runoff. The development of alternative plans is not considered to be necessary and a culvert and storm sewer conveyance plan was developed as described below.

Preliminary Recommended Stormwater Drainage Plan for Hydrologic Unit DD-7

It is recommended that the 318 feet of 24-inch-diameter RCP storm sewer located in an easement from Terrace Drive to Briaridge Court and in Briaridge Court and the 295 feet of corrugated polyethylene pipe located in an easement between Briaridge Court and the pond be replaced with 613 feet of 27-inch-high by 44-inch-wide reinforced concrete pipe arch (RCPA) storm sewer, as shown on Map 33.

As set forth in Table 33, the total capital cost of this plan is estimated to be $106,000. The present value cost is also estimated to be $106,000, since implementation of the recommendations would not result in an increase in annual operation and maintenance costs.

Hydrologic Unit DD-8

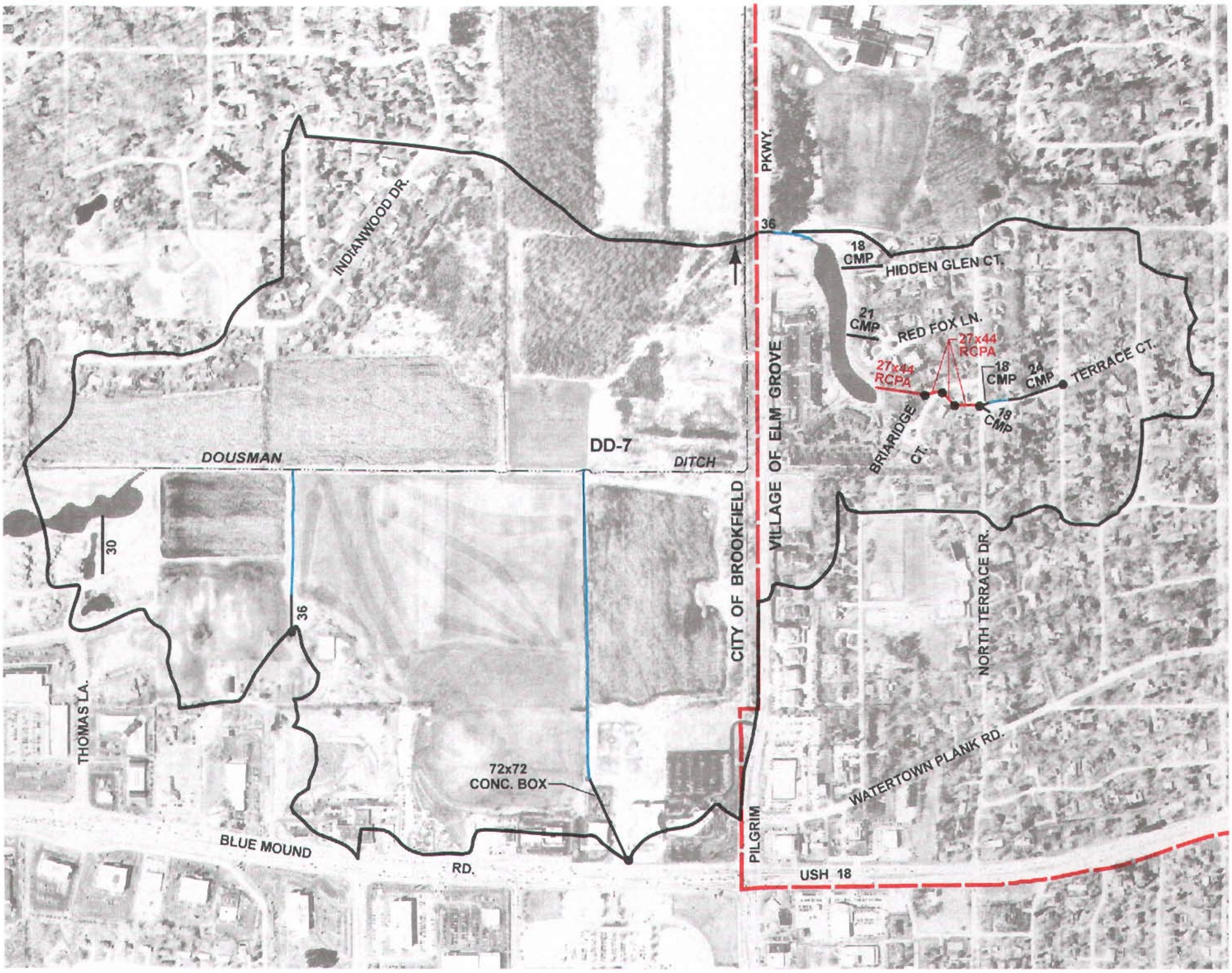
Description and Evaluation of the Stormwater Management System

Hydrologic Unit DD-8 is a 314-acre area centered around Dousman Ditch in the central portion of the subwatershed. The unit is located south of Gebhardt Road on either side of Pilgrim Parkway, as shown on Map 12. About 60 percent of the hydrologic unit is located in the City of Brookfield and about 40 percent is in the Village of Elm Grove.

Under 1990 land use conditions, about 31 percent of the unit was in rural uses with 14 percent of the unit being wetlands or water, 3 percent being woodlands, and 14 percent being in open lands. Most of the rural lands are located in a primary environmental corridor along Dousman Ditch. The urban development in the unit consisted of about 60 percent low-density residential and about 9 percent governmental and institutional. Under buildout conditions, some of the open

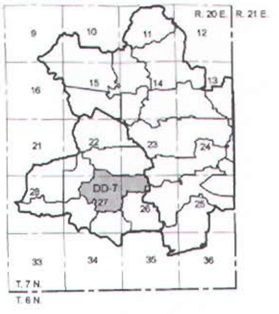
Map 33

PRELIMINARY RECOMMENDED STORMWATER DRAINAGE PLAN FOR HYDROLOGIC UNIT DD-7



▬	HYDROLOGIC UNIT BOUNDARY
DD-7	HYDROLOGIC UNIT IDENTIFICATION
⟶	HYDROLOGIC UNIT OUTLET
18	EXISTING STORM SEWER OR CULVERT TO BE RETAINED (SIZE IN INCHES)
●	EXISTING MANHOLE OR CATCH BASIN
—	EXISTING OPEN CHANNEL OR FLOW PATH
18	PROPOSED REPLACEMENT STORM SEWER OR CULVERT (SIZE IN INCHES)
NOTE:	THIS MAP GENERALLY SHOWS EXISTING STORM SEWERS OF 18-INCH DIAMETER OR LARGER. PIPES ARE CONSTRUCTED OF REINFORCED CONCRETE UNLESS DESIGNATED AS BELOW.
CMP	CORRUGATED METAL PIPE
RCPA	REINFORCED CONCRETE PIPE ARCH

DOUSMAN DITCH AND
UNDERWOOD CREEK SUBWATERSHEDS
HYDROLOGIC UNIT LOCATION MAP



Source: SEWRPC.

lands would be converted to low-density residential uses, resulting in urban uses in about 74 percent of the unit. The primary environmental corridor, including existing wetlands, would comprise about 26 percent of the unit, low-density residential about 65 percent, and government and institutional about 9 percent.

West of Pilgrim Parkway in the City of Brookfield, the stormwater drainage system consists of a combination of roadside swales with cross culverts, roadside swales and ditch enclosures, and storm sewers that convey runoff to the wetland along Dousman Ditch, and ultimately to the Ditch itself. East of Pilgrim Parkway in the Village of Elm Grove, the stormwater drainage system along Cascade Drive and Westover Road consists of roadside swales and cross culverts which direct runoff to Pilgrim Parkway where cross culverts convey runoff under the Parkway to Dousman Ditch.

Inadequate minor and major system capacity was identified in the vicinity of Indianwood Drive and Onondaga Circle. Runoff from that area discharges to a wetland in the floodplain of Dousman Ditch. The 400-foot-long, 24-inch-diameter corrugated polyethylene storm sewer outfall from that area has inadequate capacity to convey the peak rate of runoff during a 10-year storm. In addition, there is no adequate overland flow path during a 100-year storm. The overland flow path was restricted after 1995 when three houses were constructed along the east side of Indianwood Drive at its "T" intersection with Onondaga Circle. The 1998 large-scale topographic map for the area indicates that the filling associated with development of the lots causes runoff in excess of the capacity of the 24-inch-diameter storm sewer to pond to an elevation that would flood Indianwood Drive and would have a maximum depth of about four feet above the low point in the eastern roadside swale before overflow to the wetland would begin.

Inadequate minor and major system capacity was also identified in the vicinity of Victoria Circle North in the Village of Elm Grove. Under existing conditions runoff ponds in a mid-block sag in Victoria Circle North. Because the upstream invert of the 15-inch-diameter CMP storm sewer at the sag is about two feet higher than the bottom of the sag, runoff cannot adequately drain from the area under existing conditions. In addition, two newer houses along the north side of Victoria Circle North, and adjacent to a wetland that is less than two acres in area, were constructed with partially exposed basements that were subject to direct overland flooding in 1997 and 1998. An abandoned tennis court at the Pilgrim Park Middle School is located at the west end of the wetland. The tennis court and the adjacent ground are about two to 2.5 feet above the wetland and about two feet above the exposed basement floor elevation at the lower of the two houses that have been flooded. The obstruction created by the tennis courts contributes to flooding of the houses by obstructing outflow and causing water to pond in the wetland.

Alternative Stormwater Drainage Plans for the Indianwood Drive/Onondaga Circle Area

Three alternative plans were considered for the alleviation of drainage problems in the Indianwood Drive/Onondaga Circle area during storms with recurrence intervals up to, and including, 100 years. Those include: 1) a storm sewer conveyance and stormwater pumping plan, 2) a storm sewer conveyance and overflow swale plan, and 3) a storm sewer conveyance and building acquisition plan.

The measures considered area are generally intended to alleviate major system problems during a 100-year storm and to alleviate sanitary sewer backup problems by reducing ponding in streets during storms with recurrence intervals up to, and including, 100 years. The solution of the stormwater drainage problems in this area would be facilitated by the construction of the Dousman Ditch detention basin as recommended under the floodland management element of this plan. Construction of that basin could reduce 100-year flood stages along Dousman Ditch adjacent to the Indianwood/Onondaga area by about 0.1 foot, marginally reducing backwater effects caused by Dousman Ditch.

Alternative Plan No. DD-8a—
Storm Sewer Conveyance and Stormwater Pumping

Under this alternative plan, the storm sewer outfall from the area would be replaced and stormwater pumping facilities would be provided, as set forth in Table 34 and as shown on Map 34.

In order to provide gravity drainage during storms with recurrence intervals up to, and including 10 years, this alternative calls for the existing 24-inch-diameter storm sewer in the drainage easement between Indianwood Drive and the wetland along Dousman Ditch to be replaced with a 27-inch-high by 44-inch-wide RCPA storm sewer. Adequate major system capacity would be provided through con-

Table 34

COMPONENTS AND COSTS OF THE STORM SEWER CONVEYANCE AND STORMWATER PUMPING PLAN FOR THE INDIANWOOD/ONONDAGA AREA OF HYDROLOGIC UNIT DD-8 (ALTERNATIVE PLAN NO. DD-8a)

Location of Component	Component Designation and Description	Estimated Cost[a]	
		Capital[b]	Annual Operation and Maintenance[c]
City of Brookfield	1. Construct stormwater pump station with 25 cfs pumping capacity	$580,000	$9,000
	2. 400 feet of 30-inch-diameter RCP force main	35,000	- -[d]
	3. DD8C5—Replace 400 feet of 24-inch corrugated polyethylene storm sewer with 27-inch by 44-inch RCPA storm sewer	70,000	0
	Total	$685,000	$9,000

[a] *Costs based upon 1998* Engineering News-Record *Construction Cost Index = 6,740.*

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

[c] *Operation and maintenance costs are listed as $0 when an existing component is replaced with a component having similar operation and maintenance costs.*

[d] *Cost included with pump station.*

Source: SEWRPC.

struction of a stormwater pump station with a pumping capacity of about 25 cubic feet per second (cfs) near the intersection of Indianwood Drive and Onondaga Circle. The discharge line for the pump station would be a 400-foot-long, 30-inch-diameter RCP force main. As set forth in Table 34, the total present value cost of this alternative is estimated to be $827,000, consisting of an estimated capital cost of $685,000 and an estimated annual operation and maintenance cost increase of $9,000.

Alternative Plan No. DD-8b—Storm Sewer Conveyance, and Overflow Swale

Under this alternative plan, the storm sewer outfall from the area would be replaced and an overflow swale would be constructed between houses on the east side of Indianwood Drive.

An overflow swale would be constructed with the intent of providing adequate major system capacity. However, it was found that, given the available space between houses, adequate capacity could not be obtained in the swale. Therefore, this alternative was not developed further.

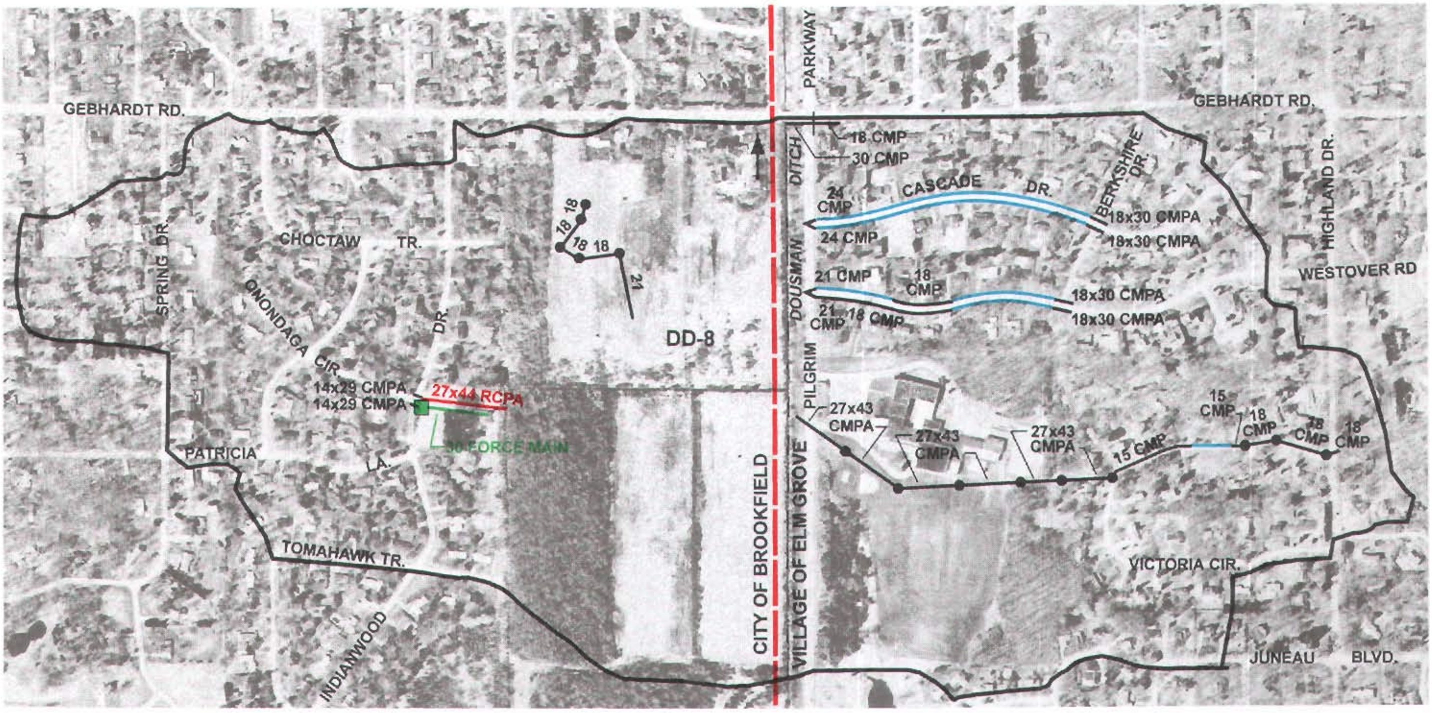
Alternative Plan No. DD-8c— Storm Sewer Conveyance and Building Acquisition

Under this alternative plan, the storm sewer outfall from the area would be replaced and a house and lot would be acquired to provide an adequate overland flow path as shown on Map 35.

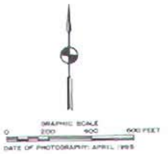
As under Alternative Plan Nos. DD-8a and 8b, the existing 24-inch-diameter storm sewer in the drainage easement east of Indianwood Drive would be replaced with a 27-inch-high by 44-inch-wide RCPA storm sewer. Adequate major system capacity would be provided by purchasing and demolishing one of the houses of the houses along the east side of Indianwood Drive. Removal of a house would enable the conveyance of runoff in excess of the replacement storm sewer capacity. As set forth in Table 35, the

Map 34

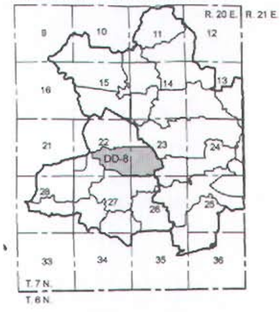
ALTERNATIVE PLAN NO. DD-8a
STORM SEWER CONVEYANCE AND STORMWATER PUMPING IN THE INDIANWOOD/ONONDAGA AREA



—	HYDROLOGIC UNIT BOUNDARY
DD-8	HYDROLOGIC UNIT IDENTIFICATION
→	HYDROLOGIC UNIT OUTLET
18	EXISTING STORM SEWER OR CULVERT TO BE RETAINED (SIZE IN INCHES)
●	EXISTING MANHOLE OR CATCH BASIN
—	EXISTING OPEN CHANNEL OR FLOW PATH
27x44	PROPOSED REPLACEMENT STORM SEWER OR CULVERT (SIZE IN INCHES)
🟩	PROPOSED STORMWATER PUMPING STATION
30	PROPOSED STORM SEWER OR CULVERT (SIZE IN INCHES)
NOTE:	THIS MAP GENERALLY SHOWS EXISTING STORM SEWERS OF 18-INCH DIAMETER OR LARGER. PIPES ARE CONSTRUCTED OF REINFORCED CONCRETE UNLESS DESIGNATED AS BELOW.
CMP	CORRUGATED METAL PIPE
CMPA	CORRUGATED METAL PIPE ARCH
RCPA	REINFORCED CONCRETE PIPE ARCH



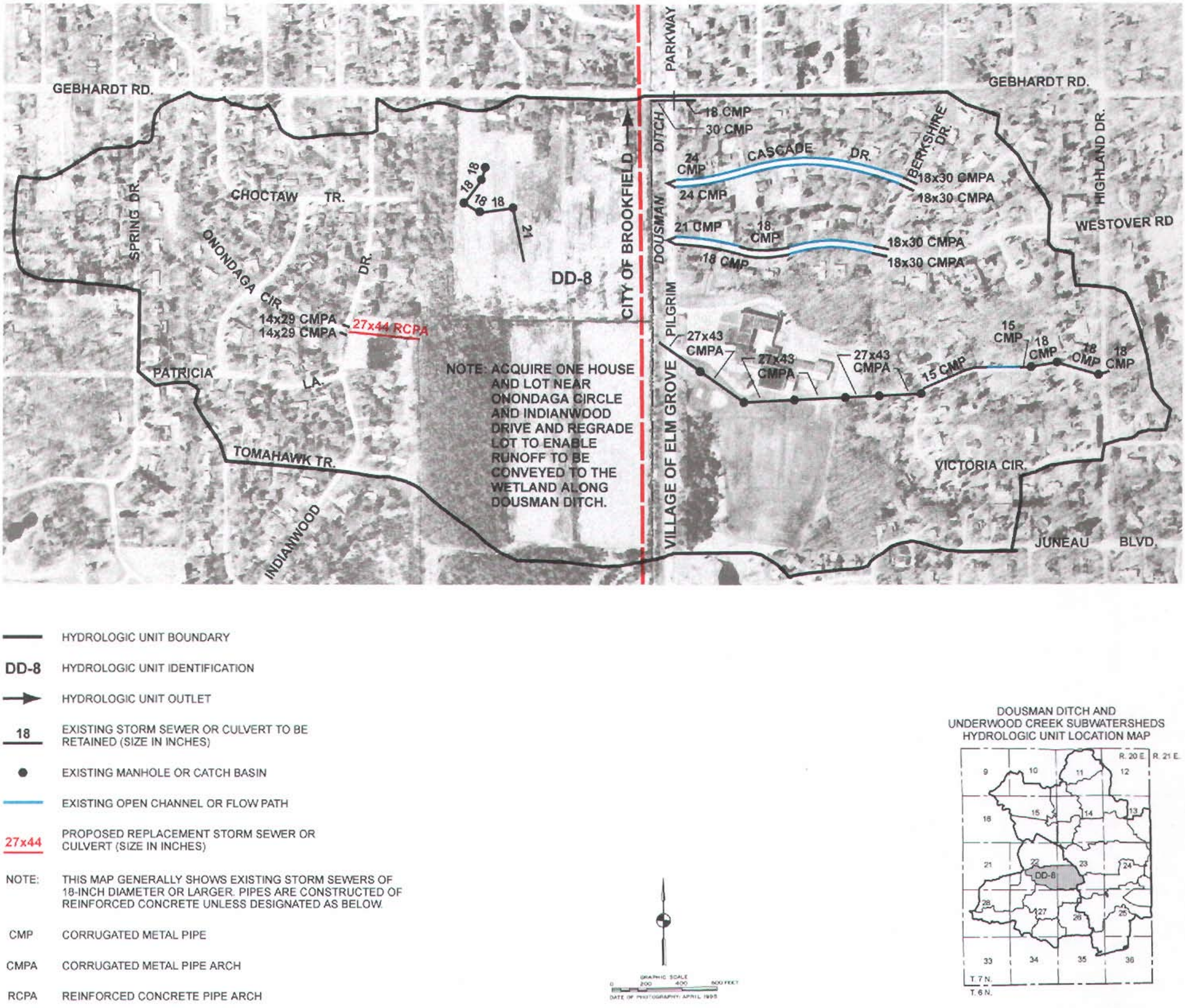
DOUSMAN DITCH AND
UNDERWOOD CREEK SUBWATERSHEDS
HYDROLOGIC UNIT LOCATION MAP



Source: SEWRPC.

Map 35

ALTERNATIVE PLAN NO. DD-8c
STORM SEWER CONVEYANCE AND BUILDING ACQUISITION IN THE INDIANWOOD/ONONDAGA AREA



Source: SEWRPC.

Table 35

COMPONENTS AND COSTS OF THE STORM SEWER CONVEYANCE AND BUILDING ACQUISITION ALTERNATIVE PLAN FOR THE INDIANWOOD/ONONDAGA AREA OF HYDROLOGIC UNIT DD-8 (ALTERNATIVE PLAN NO. DD-8c)

Location of Component	Project and Component Designation and Description	Estimated Cost[a]	
		Capital[b]	Annual Operation and Maintenance[c]
City of Brookfield	1. DD8C5—Replace 400 feet of 24-inch corrugated polyethylene storm sewer with 27-inch by 44-inch RCPA storm sewer	$ 70,000	$ 0
	2. House and lot acquisition	270,000	0
	3. Lot and ditch regrading and landscaping	15,000	500
	Total	$355,000	$500

[a] *Costs based upon 1998* Engineering News-Record *Construction Cost Index = 6,740.*

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

[c] *Operation and maintenance costs are listed as $0 when an existing component is replaced with a component having similar operation and maintenance costs.*

Source: SEWRPC.

total present value cost of this alternative is estimated to be $363,000, consisting of an estimated capital cost of $355,000 and an estimated annual operation and maintenance cost increase of $500.

Evaluation of Alternative Stormwater Drainage Plans in the Indianwood Drive/Onondaga Circle Area

The foregoing information provides a basis for a comparative evaluation of the two alternative plans. The principal criteria for the comparative evaluation were cost and implementability. The alternatives provide similar levels of protection.

Alternative Plan No. DD-8c is the least costly alternative. However, full implementation of Alternative Plan No. DD-8c is likely to be more difficult than implementation of Alternative Plan No. DD-8a, since it would require the acquisition of a house.

Preliminary Recommended Stormwater Drainage Plan for the Indianwood Drive/Onondaga Circle Portion of Hydrologic Unit DD-8

Based on cost, Alternative Plan No. DD-8c—Storm Sewer Conveyance and Building Acquisition, is selected as the preliminary recommended plan. If it were not possible to acquire the necessary house and lot, Alternative Plan No. 8a could be implemented.

Stormwater Drainage Plan for the Victoria Circle North Area

Two alternative plans were developed for the alleviation of drainage problems in the Victoria Circle North area during storms with recurrence intervals up to, and including, 100 years. These plans were synthesized from several alternatives that were developed by Ruekert & Mielke, Inc., the Elm Grove Village engineer, at the request of the Village. Those alternatives provided varying levels of protection, which were generally less than the 100-year standard adopted for the major system under this planning effort. Thus, it was necessary to combine various components to obtain a plan to provide a 100-year level of protection. The alternatives evaluated by the Village included various combinations of conveyance, stormwater pumping, floodproofing of houses, and road grade raises. The final alternative that was independently chosen by the Village for implementation calls for the installation of a 18-inch-diameter RCP storm sewer beginning at the low point in

Victoria Circle North and extending to a location about 1,400 feet downstream where it would discharge to the existing 27-inch-wide by 44-inch-high CMPA storm sewer that currently drains the Victoria Circle area. A new 12-inch-diameter RCP, approximately 50 feet long, would be installed from the wetland area north of Victoria Circle North to the new 18-inch pipe. The 12-inch pipe would be provided with a backwater gate to avoid flooding of the wetland and the two adjacent houses due to backwater from Dousman Ditch. Two alternative plans that expand on the Village alternative to provide a 100-year level of protection were developed for this planning effort. The alternative plans include: 1) a storm sewer and swale conveyance with structure floodproofing plan and 2) a storm sewer conveyance and structure floodproofing plan.

The measures considered area are generally intended to reduce major system problems during a 100-year storm. The solution of the stormwater drainage problems in this area would be facilitated by the construction of the Dousman Ditch detention basin as recommended under the floodland management element of this plan. Construction of that basin could reduce 100-year flood stages along Dousman Ditch adjacent to the Indianwood/Onondaga area by about 0.1 foot, marginally reducing backwater effects caused by Dousman Ditch.

Alternative Plan No. DD-8d—Storm Sewer and Swale Conveyance with Structure Floodproofing

Under this alternative plan, a portion of the storm sewer in Victoria Circle North would be replaced as noted above, an overflow swale would be constructed to convey excess runoff from the wetland, and limited structure floodproofing measures would be implemented to protect the two buildings on the north side of Victoria Circle North, as set forth in Table 36 and as shown on Map 36.

In order to provide gravity drainage during storms with recurrence intervals up to, and including 10 years, this alternative calls for 340 feet of the existing 15-inch-diameter CMP in Victoria Circle North to be replaced with an 18-inch-diameter polyvinyl chloride (PVC) storm sewer that would have a total length of about 1,400 feet and would connect to the existing downstream 27-inch-wide by 44-inch-high CMPA storm sewer. The abandoned tennis courts would be removed and a grass-lined, trapezoidal swale with a 60-foot-wide bottom would be constructed from the west end of the wetland to a location 570 feet downstream on the grounds of the Pilgrim Park Middle School. Swale construction may require some reconfiguration of athletic fields at the middle school. Disturbance of the wetland would be avoided and the upstream invert elevation of the swale would be set such that the low and normal flow hydrology of the wetland would not be disturbed. Finally, structure floodproofing measures would be implemented to protect the basements of the two houses from possible flooding to a depth of less than 0.5 foot during a 100-year storm.

Under this alternative, some of the runoff that is now stored in the wetland, and which creates the flooding problem at the two houses, would be stored on the Pilgrim Park Middle School grounds, which are currently in the floodplain of Dousman Ditch. Storage of runoff on open portions of the school grounds would serve to mitigate any increases in flows due to reducing the storage in the wetland.

As set forth in Table 36, the total present value cost of this alternative is estimated to be $187,000, consisting of an estimated capital cost of $170,000 and an estimated annual operation and maintenance cost increase of $1,100.

Alternative Plan No. DD-8e—Storm Sewer Conveyance and Structure Floodproofing

Under this alternative plan, the storm sewer outlet from Victoria Circle North would be replaced as under Alternative Plan No. DD-8d and extensive floodproofing measures would be implemented to protect the two houses from flooding during a 100-year storm. The alternative plan measures are set forth in Table 37 and shown on Map 37.

This alternative calls for 340 feet of the existing 15-inch-diameter CMP in Victoria Circle North to be replaced with an 18-inch-diameter PVC storm sewer that would have a total length of about 1,400 feet and would connect to the existing downstream 27-inch-wide by 44-inch-high CMPA storm sewer. A 50-foot-long, 12-inch-diameter PVC storm sewer with a backwater valve would be installed from the wetland outlet to the new 18-inch-diameter storm sewer. Extensive structure floodproofing measures would be implemented to protect the basements of the two houses from possible flooding to an estimated maximum depth of about 1.5 feet. As set forth in Table 37, the total present value cost of this alternative is estimated to be $203,000, consisting of an estimated

Table 36

COMPONENTS AND COSTS OF THE STORM SEWER AND SWALE CONVEYANCE WITH STRUCTURE FLOODPROOFING PLAN FOR THE VICTORIA CIRCLE NORTH AREA OF HYDROLOGIC UNIT DD-8 (ALTERNATIVE PLAN NO. DD-8d)

Location of Component	Project and Component Designation and Description	Estimated Cost[a]	
		Capital[b]	Annual Operation and Maintenance[c]
Village of Elm Grove	1. Replace 340 feet of 15-inch-diameter CMP storm sewer in Victoria Circle North with 1,400 feet of 18-inch-diameter PVC storm sewer and add a 50-foot-long, 12-inch-diameter PVC wetland outlet with a backwater gate	$ 97,000	$ 600
	2. Construct a 570-foot-long, grass-lined, trapezoidal overflow swale with one vertical on four horizontal side slopes and a 60-foot-wide bottom	50,000[d]	300
	3. Floodproof two houses on the north side of Victoria Circle North	23,000	200
	Total	$170,000	$1,100

[a] *Costs based upon 1998* Engineering News-Record *Construction Cost Index = 6,740.*

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

[c] *Operation and maintenance costs are listed as $0 when an existing component is replaced with a component having similar operation and maintenance costs.*

[d] *Includes removal of abandoned tennis court at Pilgrim Park Middle School.*

Source: SEWRPC.

capital cost of $190,000 and an estimated annual operation and maintenance cost increase of $800.

Evaluation of Alternative Stormwater Drainage Plans in the Victoria Circle North Area

The foregoing information provides a basis for a comparative evaluation of the two alternative plans. The principal criteria for the comparative evaluation were cost and implementability. The alternatives provide similar levels of protection.

Alternative Plan No. DD-8d is the least costly alternative. However, implementation of that alternative would involve some disruption and possible reconfiguration of the grounds of the Pilgrim Park Middle School as well as a relatively small increase in the volume of runoff stored on the school grounds during floods. An advantage of Alternative Plan No. DD-8d is that it would require a lesser degree of floodproofing than would the other alternative.

Preliminary Recommended Stormwater Drainage Plan for the Victoria Circle North Portion of Hydrologic Unit DD-8

Based on the evaluation above, Alternative Plan No. DD-8d—Storm Sewer and Swale Conveyance with Structure Floodproofing, is selected as the preliminary recommended plan for the Victoria Circle North Area.

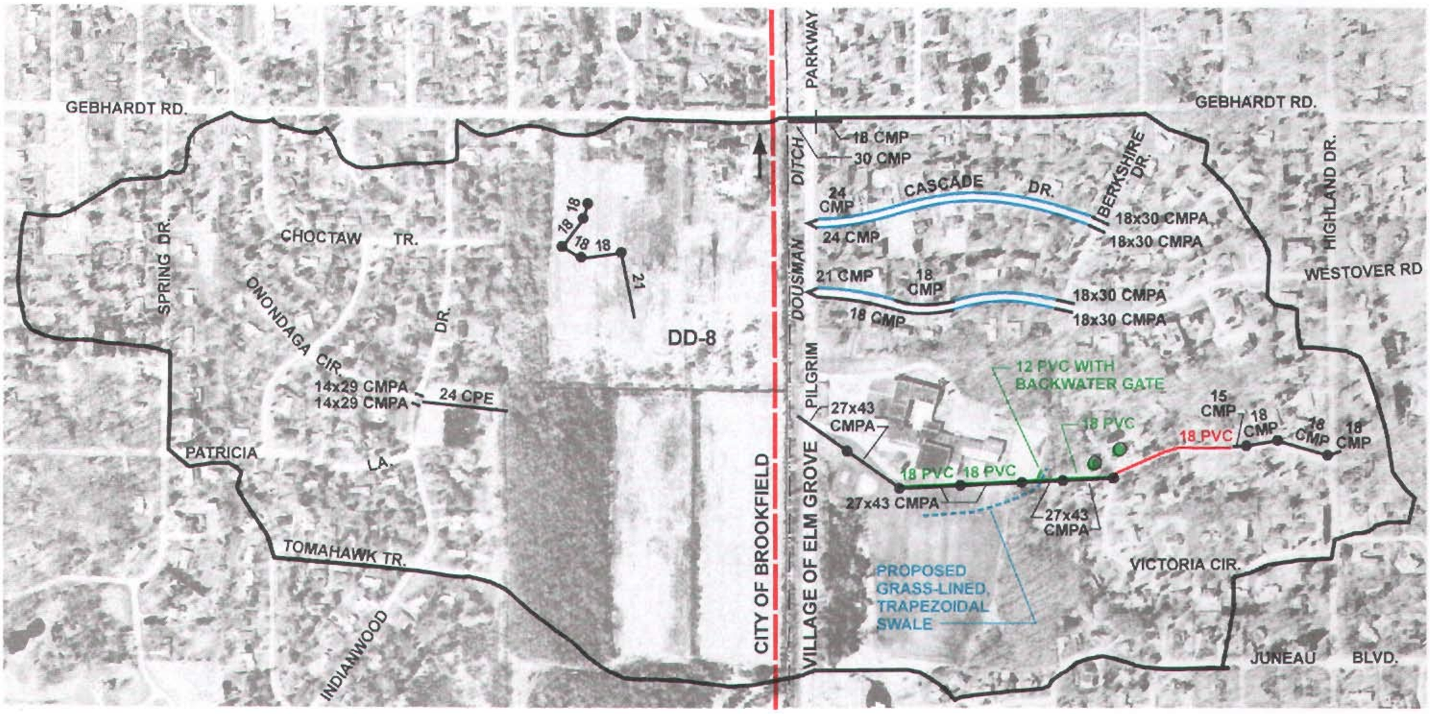
Hydrologic Unit DD-9

Description and Evaluation of the Stormwater Management System

Hydrologic Unit DD-9 is a 433-acre area centered around Dousman Ditch in the northern portion of the subwatershed. Most of the unit is located north of

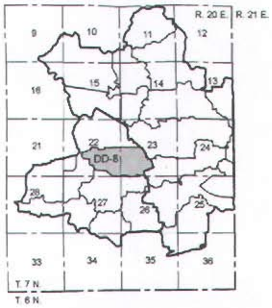
Map 36

ALTERNATIVE PLAN NO. DD-8d
STORM SEWER AND SWALE CONVEYANCE WITH STRUCTURE FLOODPROOFING IN THE VICTORIA CIRCLE NORTH AREA



▬	HYDROLOGIC UNIT BOUNDARY
DD-8	HYDROLOGIC UNIT IDENTIFICATION
→	HYDROLOGIC UNIT OUTLET
18	EXISTING STORM SEWER OR CULVERT TO BE RETAINED (SIZE IN INCHES)
●	EXISTING MANHOLE OR CATCH BASIN
▬	EXISTING OPEN CHANNEL OR FLOW PATH
18	PROPOSED REPLACEMENT STORM SEWER OR CULVERT (SIZE IN INCHES)
18	PROPOSED STORM SEWER OR CULVERT (SIZE IN INCHES)
●	BUILDING PROPOSED TO BE FLOODPROOFED
NOTE:	THIS MAP GENERALLY SHOWS EXISTING STORM SEWERS OF 18-INCH DIAMETER OR LARGER. PIPES ARE CONSTRUCTED OF REINFORCED CONCRETE UNLESS DESIGNATED AS BELOW.
CMP	CORRUGATED METAL PIPE
CMPA	CORRUGATED METAL PIPE ARCH
CPE	CORRUGATED POLYETHYLENE
PVC	POLYVINYL CHLORIDE

DOUSMAN DITCH AND UNDERWOOD CREEK SUBWATERSHEDS HYDROLOGIC UNIT LOCATION MAP



Source: SEWRPC.

Table 37

COMPONENTS AND COSTS OF THE STORM SEWER CONVEYANCE AND STRUCTURE FLOODPROOFING STORMWATER DRAINAGE PLAN FOR THE VICTORIA CIRCLE NORTH AREA OF HYDROLOGIC UNIT DD-8 (ALTERNATIVE PLAN NO. DD-8e)

Location of Component	Project and Component Designation and Description	Estimated Cost[a]	
		Capital[b]	Annual Operation and Maintenance[c]
Village of Elm Grove	1. Replace 340 feet of 15-inch-diameter CMP storm sewer in Victoria Circle North with 1,400 feet of 18-inch-diameter PVC storm sewer and add a 50-foot-long, 12-inch-diameter PVC wetland outlet with a backwater gate	$ 97,000	$600
	2. Floodproof two houses on the north side of Victoria Circle North	93,000	200
	Total	$190,000	$800

[a] *Costs based upon 1998* Engineering News-Record *Construction Cost Index = 6,740.*

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

[c] *Operation and maintenance costs are listed as $0 when an existing component is replaced with a component having similar operation and maintenance costs.*

Source: SEWRPC.

Gebhardt Road, south of W. North Avenue, and both east and west of Pilgrim Parkway, as shown on Map 12. About 90 percent of the hydrologic unit is located in the City of Brookfield and about 10 percent is in the Village of Elm Grove.

Under 1990 land use conditions, about 90 percent of the unit was in urban uses, including about 80 percent in low-density residential uses and 10 percent in governmental and institutional uses. In 1990, 10 percent of the unit that was in rural uses, with most of that area being open lands. Under buildout conditions, some of the open lands would be converted to urban recreational uses, resulting in urban uses in about 96 percent of the unit. Low-density residential land would comprise about 80 percent of the unit, governmental and institutional uses about 10 percent, and recreational about 6 percent. The remaining rural land would be primary environmental corridor.

West of Pilgrim Parkway in the City of Brookfield, the stormwater drainage system consists of a system of roadside swales and ditch enclosures and storm sewers that convey flow to Dousman Ditch. East of Pilgrim Parkway in the Village of Elm Grove, the stormwater drainage system consists of a system of roadside swales and cross culverts. Storm sewers are installed in W. North Avenue.

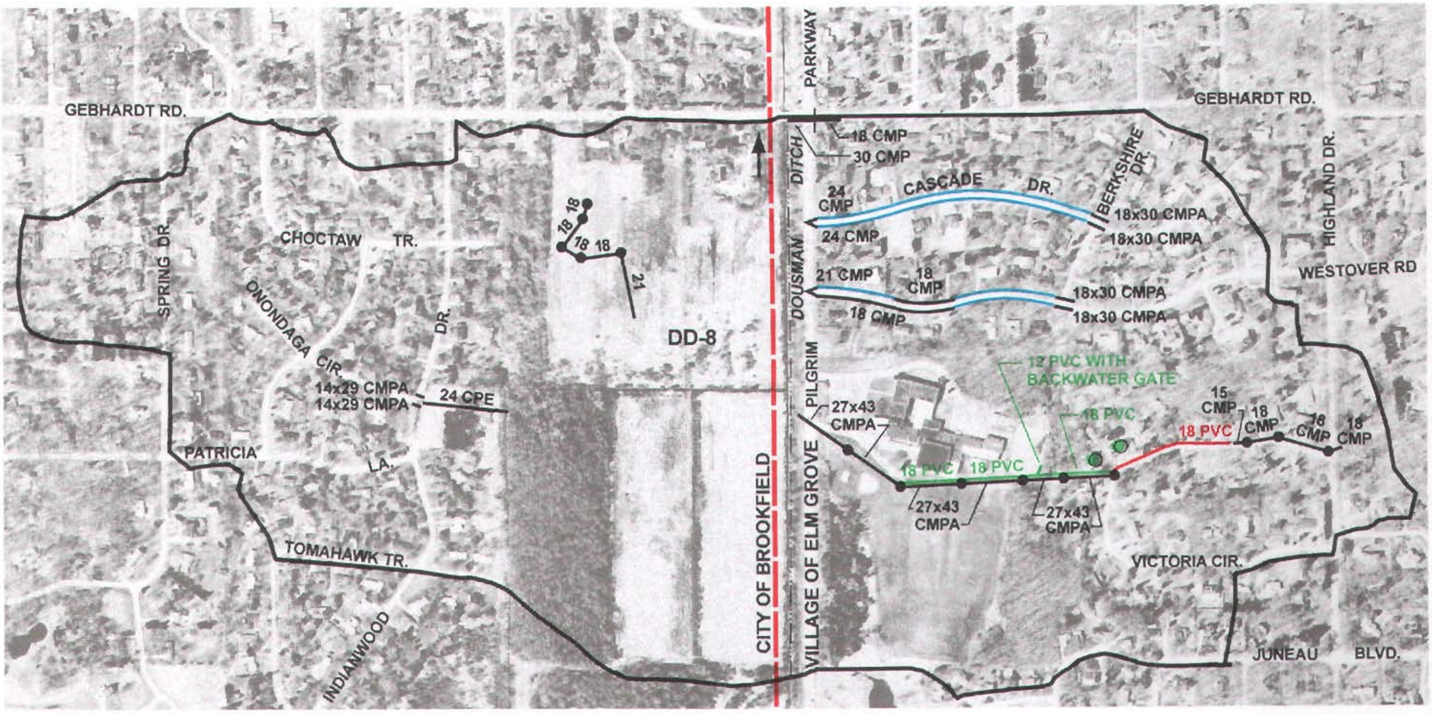
Inadequate minor system capacity was identified in the City of Brookfield along Eileen Court north of Gebhardt Road and along Gebhardt Road between Church View Drive and Alverno Drive. Inadequate capacity was identified in Elm Grove at one culvert under Pilgrim Parkway just north of Gebhardt Road. Because Pilgrim Parkway is planned to be designated as an arterial highway, that culvert should have a 50-year storm capacity to meet the standards established for this plan.

Alternative Stormwater Drainage Plans

The identified localized problems can readily be solved through the provision of increases in the hydraulic capacities of the existing storm sewers and the culvert. The development of alternative plans is not considered to be necessary and a culvert and storm sewer conveyance plan was developed as described below.

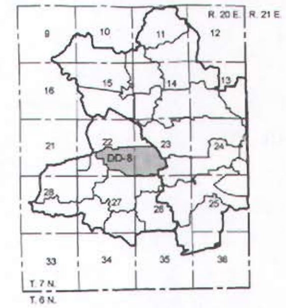
Map 37

ALTERNATIVE PLAN NO. DD-8e
STORM SEWER CONVEYANCE AND STRUCTURE FLOODPROOFING IN THE VICTORIA CIRCLE NORTH AREA



▬	HYDROLOGIC UNIT BOUNDARY
DD-8	HYDROLOGIC UNIT IDENTIFICATION
→	HYDROLOGIC UNIT OUTLET
18	EXISTING STORM SEWER OR CULVERT TO BE RETAINED (SIZE IN INCHES)
●	EXISTING MANHOLE OR CATCH BASIN
▬	EXISTING OPEN CHANNEL OR FLOW PATH
18	PROPOSED REPLACEMENT STORM SEWER OR CULVERT (SIZE IN INCHES)
18	PROPOSED STORM SEWER OR CULVERT (SIZE IN INCHES)
●	BUILDING PROPOSED TO BE FLOODPROOFED
NOTE:	THIS MAP GENERALLY SHOWS EXISTING STORM SEWERS OF 18-INCH DIAMETER OR LARGER. PIPES ARE CONSTRUCTED OF REINFORCED CONCRETE UNLESS DESIGNATED AS BELOW.
CMP	CORRUGATED METAL PIPE
CMPA	CORRUGATED METAL PIPE ARCH
CPE	CORRUGATED POLYETHYLENE
PVC	POLYVINYL CHLORIDE

DOUSMAN DITCH AND UNDERWOOD CREEK SUBWATERSHEDS HYDROLOGIC UNIT LOCATION MAP



Source: SEWRPC.

Preliminary Recommended Stormwater Drainage Plan for Hydrologic Unit DD-9

It is recommended that 1) the 247 feet of double 21-inch-diameter RCP storm sewer located at the north end of Eileen Court be replaced with a double 27-inch-diameter RCP, 2) the 630 feet of 18-inch-diameter CMP along Gebhardt Road between Church View Drive and Alverno Drive be replaced with a 27-inch-diameter RCP, and 3) that the 42-foot-long 18-inch-diameter CMP under Pilgrim Parkway north of Gebhardt Road be replaced with a 30-inch-diameter CMP. The recommended system is shown on Map 38.

As set forth in Table 38, the total capital cost of this plan is estimated to be $132,000. The present value cost is also estimated to be $132,000, since implementation of the recommendations would not result in an increase in annual operation and maintenance costs.

Hydrologic Unit UC-1

Description and Evaluation of the Stormwater Management System

Hydrologic Unit UC-1 is a 566-acre area located at the headwaters of Underwood Creek in the northwestern portion of the subwatershed. The unit is located entirely in the City of Brookfield, north of the Canadian Pacific Railway and west of Pilgrim Road, as shown on Map 12.

Under 1990 land use conditions, about 52 percent of the unit was in urban uses, including about 45 percent in low-density residential uses, 5 percent in governmental and institutional uses, and 2 percent divided between railway, and medium-high and high-density residential uses. In 1990, 48 percent of the unit was in rural uses, including 31 percent in wetlands, 12 percent in open lands, and 5 percent in agricultural uses. Under buildout conditions, some of the open lands would be converted to residential uses, resulting in urban uses in about 66 percent of the unit.[41] Low-density residential land would comprise about 53 percent of the unit, medium-density residential about 6 percent, high-density residential about 1 percent, and recreational and industrial each less than 1 percent. The 34 percent of the unit in rural land use would be primary environmental corridor consisting almost entirely of the large wetland complex in the headwaters area upstream of the Canadian Pacific railway.

West of Calhoun Road, the stormwater drainage system consists of a system of roadside swales, culverts, and ditch enclosures that convey flow to the western portion of the wetland. East of Calhoun Road, in the areas of earliest development, the stormwater drainage system consists of a system of roadside swales, culverts, and ditch enclosures along with one wet detention basin between Smith Court and Mark Drive and one dry detention basin at Fieldside Court. In the areas of the most recent development east of Calhoun Road, the stormwater management system consists of storm sewers and urban street cross sections and one wet detention basin. The area east of Calhoun Road ultimately discharges to the large headwaters wetland.

Inadequate minor system capacity was identified at a storm sewer in Smith Drive and along a drainage easement located southeast of Smith Drive, at another storm sewer in an easement between Brooklawn Drive and W. Burleigh Road, and at a culvert under Kings View Lane just north of Burleigh Boulevard.

The City of Brookfield recently received permission from the WDNR for modification and revegetation of the small stream channel that flows through the southwest side of the large wetland complex east of Calhoun Road. Those modifications were implemented and the grade of Calhoun Road was raised, effectively alleviating past flooding problems along that portion of Calhoun Road.

Alternative Stormwater Drainage Plans

The identified localized problems can readily be solved through the provision of increases in the hydraulic capacities of the existing storm sewers and the culvert. Increased flows from the storm sewers or culverts to be upgraded should be adequately attenuated since each discharges either to a detention basin and then to the large wetland, or directly to the wetland. The development of alternative plans is not considered to be necessary and a culvert and storm sewer conveyance plan was developed as described below.

Preliminary Recommended Stormwater Drainage Plan for Hydrologic Unit UC-1

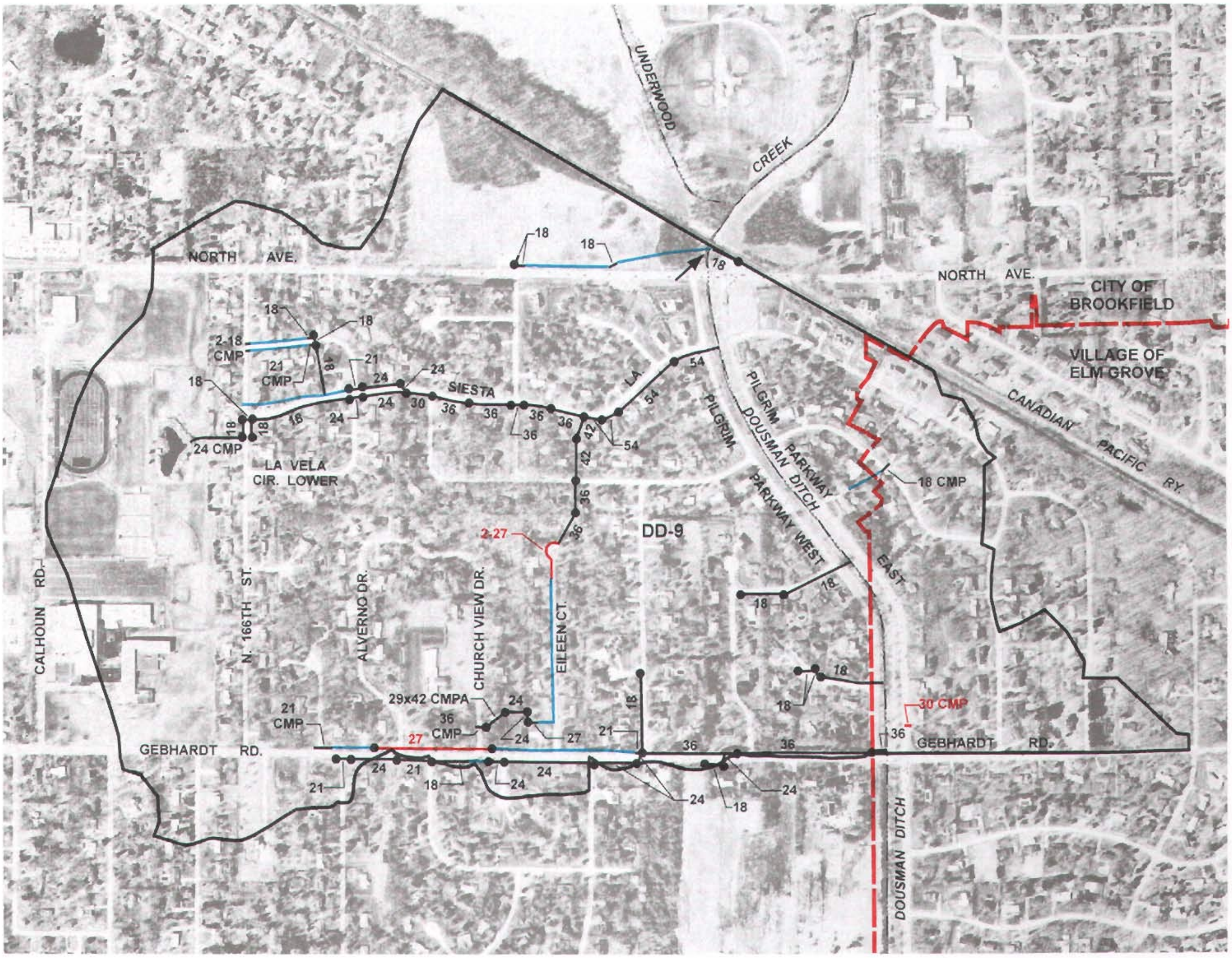
It is recommended that 1) the 175 feet of eight-inch-diameter concrete pipe, 389 feet of 16-inch-diameter

---

[41] *Almost all of the conversion of land to urban uses had occurred as of 1999.*

Map 38

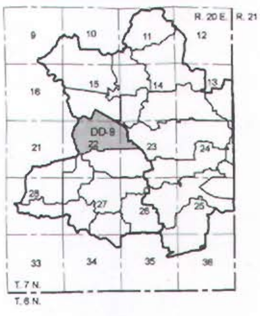
PRELIMINARY RECOMMENDED PLAN FOR HYDROLOGIC UNIT DD-9 STORM SEWER AND CULVERT CONVEYANCE



—	HYDROLOGIC UNIT BOUNDARY
DD-9	HYDROLOGIC UNIT IDENTIFICATION
→	HYDROLOGIC UNIT OUTLET
18	EXISTING STORM SEWER OR CULVERT TO BE RETAINED (SIZE IN INCHES)
●	EXISTING MANHOLE OR CATCH BASIN
—	EXISTING OPEN CHANNEL OR FLOW PATH
18	PROPOSED REPLACEMENT STORM SEWER OR CULVERT (SIZE IN INCHES)
NOTE:	THIS MAP GENERALLY SHOWS EXISTING STORM SEWERS OF 18-INCH DIAMETER OR LARGER. PIPES ARE CONSTRUCTED OF REINFORCED CONCRETE UNLESS DESIGNATED AS BELOW.
CMP	CORRUGATED METAL PIPE
CMPA	CORRUGATED METAL PIPE ARCH

GRAPHIC SCALE
0 200 400 800 FEET
DATE OF PHOTOGRAPHY: APRIL 1995

DOUSMAN DITCH AND UNDERWOOD CREEK SUBWATERSHEDS HYDROLOGIC UNIT LOCATION MAP



Source: SEWRPC.

Table 38

COMPONENTS AND COSTS OF THE PRELIMINARY RECOMMENDED STORM SEWER AND CULVERT CONVEYANCE STORMWATER DRAINAGE PLAN FOR HYDROLOGIC UNIT DD-9

Location of Component	Project and Component Designation and Description	Estimated Cost[a]	
		Capital[b]	Annual Operation and Maintenance[c]
City of Brookfield	1. DD9C18—Replace 630 feet of 18-inch CMP storm sewer on Gebhardt Road between Church View Drive and Alverno Drive with 27-inch RCP storm sewer	$ 72,000	$0
	2. DD9C12—Replace 247 feet of twin 21-inch storm sewer at Eileen Court north of Gebhardt Road with twin 27-inch RCP storm sewer	56,000	0
	Subtotal	$128,000	$0
Village of Elm Grove	3. DD9C30—Replace 42 feet of 18-inch CMP culvert crossing Pilgrim Parkway north of Gebhardt Road with 30-inch CMP	$ 4,000	$0
- -	Total	$132,000	$0

[a] *Costs based upon 1998* Engineering News-Record *Construction Cost Index = 6,740.*

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

[c] *Operation and maintenance costs are listed as $0 when an existing component is replaced with a component having similar operation and maintenance costs.*

Source: SEWRPC.

cast iron pipe, and 44 feet of 18-inch-diameter CMP located in Smith Drive and the easement to the southeast of Smith Drive be replaced with 608 feet of 18-inch-diameter RCP, 2) the 166 feet of 18-inch-diameter RCP between Brooklawn Drive and W. Burleigh Road with a 21-inch-diameter RCP, and 3) the 59-foot-long 15-inch-diameter RCP under Kings View Lane be replaced with an 18-inch-wide by 29-inch-high RCPA. The recommended system is shown on Map 39.

As set forth in Table 39, the total capital cost of this plan is estimated to be $76,000. The present value cost is also estimated to be $76,000, since implementation of the recommendations would not result in an increase in annual operation and maintenance costs.

Hydrologic Unit UC-2

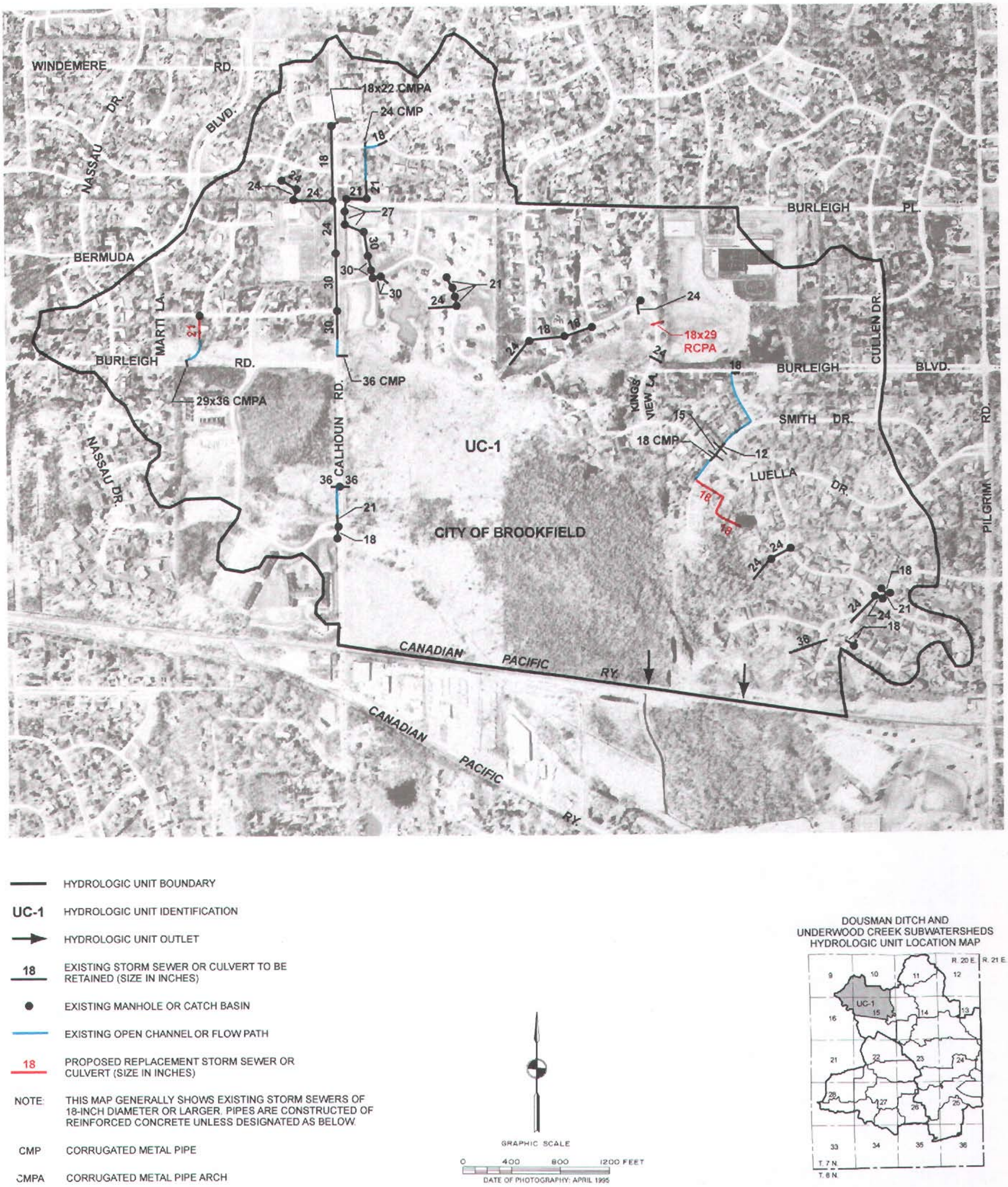
Description and Evaluation of the Stormwater Management System

As shown on Map 12, Hydrologic Unit UC-2 is a 174-acre area located entirely in the City of Brookfield just south of Hydrologic Unit UC-1 and east of Calhoun Road between North Avenue and the Canadian Pacific Railway. This unit contains most of Franklin Wirth Park. Underwood Creek traverses the unit from northwest to southeast.

Under 1990 land use conditions, about 52 percent of the unit was in urban uses, including about 32 percent in recreational uses, 8 percent railway, 5 percent industrial, 5 percent low-density residential, and 2 percent commercial, uses. In 1990, 48 percent

Map 39

PRELIMINARY RECOMMENDED PLAN FOR HYDROLOGIC UNIT UC-1 STORM SEWER AND CULVERT CONVEYANCE



Source: SEWRPC.

Table 39

COMPONENTS AND COSTS OF THE STORM SEWER AND CULVERT CONVEYANCE STORMWATER DRAINAGE PLAN FOR HYDROLOGIC UNIT UC-1

Location of Component	Project and Component Designation and Description	Estimated Cost[a]	
		Capital[b]	Annual Operation and Maintenance[c]
City of Brookfield	1. UC-1C37—Replace 59 feet of 15-inch storm sewer crossing Kings View Lane north of Burleigh Boulevard with 18-inch by 29-inch RCPA storm sewer	$ 7,000	$0
	2. UC-1C19—Replace 389 feet of 16-inch-diameter cast iron storm sewer east of Smith Drive south of Luella Drive with 18-inch RCP storm sewer	34,000	0
	3. Replace 44 feet of 18-inch CMP culvert crossing Smith Drive south of Luella Drive with 18-inch RCP culvert	4,000	0
	4. Replace 175 feet of eight-inch concrete storm sewer located south of Luella Drive and east of Smith Drive with 18-inch RCP storm sewer	15,000	0
	5. UC-1C29—Replace 166 feet of 18-inch storm sewer in drainage easement north of Burleigh Road east of Marti Lane with 21-inch storm sewer	16,000	0
	Total	$76,000	$0

[a] *Costs based upon 1998* Engineering News-Record *Construction Cost Index = 6,740.*

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

[c] *Operation and maintenance costs are listed as $0 when an existing component is replaced with a component having similar operation and maintenance costs.*

Source: SEWRPC.

of the unit was in rural uses, including 35 percent in wetlands, 6 percent in woodlands, and 7 percent in open lands. Under buildout conditions, some of the open lands would be converted to industrial or governmental and institutional uses, resulting in urban uses in about 53 percent of the unit. Recreational lands would still comprise about 32 percent of the unit, the conversion of open lands and redevelopment of some other existing urban lands would result in an industrial uses in about 20 percent of the unit, and governmental and institutional uses would comprise the remaining 1 percent of the urban lands. The 47 percent of the unit in rural land use would be primary and secondary environmental corridor consisting predominantly of wetlands.

The stormwater drainage system consists primarily of a system of roadside swales, culverts, and ditch enclosures that convey flow to the wetland in Wirth Park. A storm sewer system is located along Pheasant Drive. There are two ponds located in the unit, but they are both located near the subcontinental divide and neither receives significant amounts of runoff.

Inadequate minor system capacity was identified at a culvert under Hillsdale Drive.

Alternative Stormwater Drainage Plans

The identified localized problem can readily be solved through the provision of increased hydraulic capacity for the culvert. The development of alternative plans is not considered to be necessary and a culvert conveyance plan was developed as described below.

Preliminary Recommended Stormwater Drainage Plan for Hydrologic Unit UC-2

It is recommended that the 41-foot-long, 18-inch-diameter RCP culvert under Hillsdale Drive be replaced with a 21-inch-diameter RCP. The recommended system is shown on Map 40.

As set forth in Table 40, the total capital cost of this plan is estimated to be $4,000. The present value cost is also estimated to be $4,000, since implementation of the recommendations would not result in an increase in annual operation and maintenance costs.

Hydrologic Unit UC-3

Description and Evaluation of the Stormwater Management System

As shown on Map 12, Hydrologic Unit UC-3 is a 143-acre area located generally northeast of the intersection of W. North Avenue and Pilgrim Road. Underwood Creek flows through the northwest corner of the unit. About 90 percent of the hydrologic unit is located in the City of Brookfield and about 10 percent is in the Village of Elm Grove.

The hydrologic unit was essentially under full build-out land use conditions in 1990. About 96 percent of the unit is in urban uses, including about 73 percent low-density residential, 11 percent governmental and institutional uses, 8 percent medium-density residential, and 4 percent commercial uses. The 4 percent of the unit in rural land use is secondary environmental corridor along Underwood Creek.

The stormwater drainage system consists primarily of a system of roadside swales, culverts, and ditch enclosures that convey flow to Underwood Creek. A storm sewer system is located along W. North Avenue.

No stormwater drainage problems were identified in this hydrologic unit. Therefore, no alternative plans were developed.

Hydrologic Unit UC-4

Description and Evaluation of the Stormwater Management System

Hydrologic Unit UC-4 is a 274-acre area located north of unit UC-3 in the City of Brookfield in the north central portion of the subwatershed, as shown on Map 12. Most of the hydrologic unit is southeast of the intersection of W. North Avenue and Pilgrim Road. Underwood Creek flows through the southern part of the unit.

The hydrologic unit was essentially under full buildout land use conditions in 1990. About 91 percent of the unit is in urban uses, including about 84 percent low-density residential, 6 percent recreational, and 1 percent governmental and institutional uses. The 9 percent of the unit in rural land use is primary and secondary environmental corridor along Underwood Creek. The corridors primarily consist of wetlands.

West of Pilgrim Road, the stormwater drainage system consists primarily of a system of roadside swales and culverts. East of Pilgrim Road the stormwater drainage system consists of a system of roadside swales and ditch enclosures that discharge directly to Underwood Creek. That system includes several long storm sewers that are located along drainage easements outside of public rights-of-way.

Inadequate major system capacity was identified at storm sewers in series, running from San Raphael Drive to Pomona Road in a drainage easement, in Pomona Road, and then from Pomona Road to Underwood Creek in another drainage easement. A need to increase inlet capacity in order to enable the development of the available existing storm sewer capacity and permit the major system to function adequately was identified on the south side of W. Burleigh Road, southeast of the intersection with Hidden Hills Drive.

Alternative Stormwater Drainage Plans

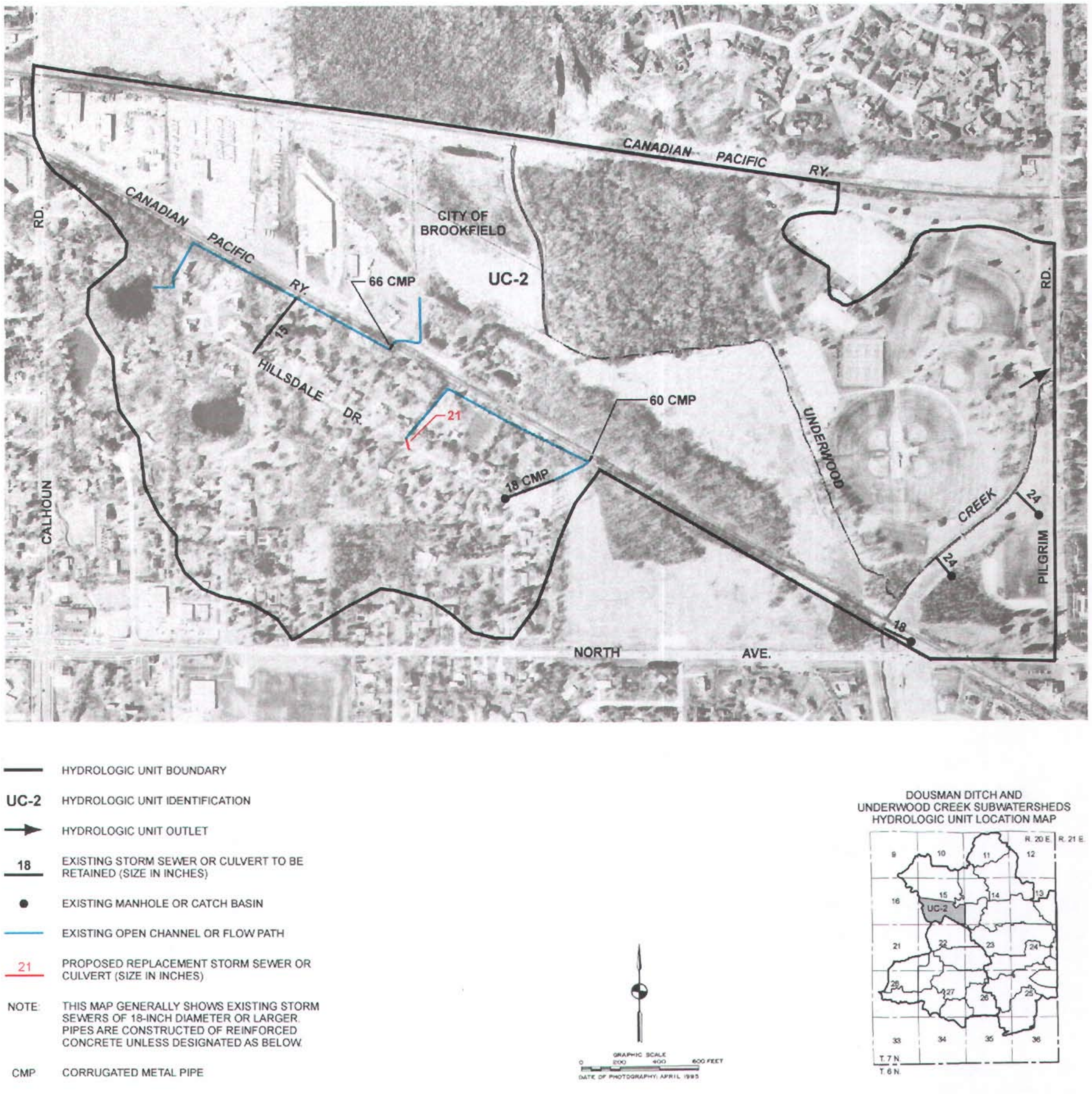
The identified localized problems can readily be solved through the provision of relatively small increases in the hydraulic capacities of the existing storm sewers. Because the increase in flow from the storm sewers to be upgraded would be relatively small, no significant increases in 100-year flood flows in Underwood Creek would be expected due to replacing the storm sewers. The development of alternative plans is not considered to be necessary and a storm sewer conveyance plan was developed as described below.

Preliminary Recommended Stormwater Drainage Plan for Hydrologic Unit UC-4

It is recommended that 1) the storm sewer inlet capacity be increased at the existing 135-foot-long, 30-inch-diameter RCP on the south side of W. Burleigh Road, southeast of the intersection with

Map 40

PRELIMINARY RECOMMENDED PLAN FOR HYDROLOGIC UNIT UC-2 CULVERT CONVEYANCE



▬	HYDROLOGIC UNIT BOUNDARY
UC-2	HYDROLOGIC UNIT IDENTIFICATION
→	HYDROLOGIC UNIT OUTLET
18	EXISTING STORM SEWER OR CULVERT TO BE RETAINED (SIZE IN INCHES)
●	EXISTING MANHOLE OR CATCH BASIN
▬	EXISTING OPEN CHANNEL OR FLOW PATH
21	PROPOSED REPLACEMENT STORM SEWER OR CULVERT (SIZE IN INCHES)
NOTE:	THIS MAP GENERALLY SHOWS EXISTING STORM SEWERS OF 18-INCH DIAMETER OR LARGER. PIPES ARE CONSTRUCTED OF REINFORCED CONCRETE UNLESS DESIGNATED AS BELOW.
CMP	CORRUGATED METAL PIPE

Source: SEWRPC.

Table 40

COMPONENTS AND COSTS OF THE CULVERT CONVEYANCE STORMWATER DRAINAGE PLAN FOR HYDROLOGIC UNIT UC-2

Location of Component	Project and Component Designation and Description	Estimated Cost[a]	
		Capital[b]	Annual Operation and Maintenance[c]
City of Brookfield	1. UC-2C7—Replace 41 feet of 18-inch storm sewer crossing Hillsdale Drive north of W. North Avenue with 21-inch RCP storm sewer	$4,000	$0
	Total	$4,000	$0

[a] *Costs based upon 1998* Engineering News-Record *Construction Cost Index = 6,740.*

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

[c] *Operation and maintenance costs are listed as $0 when an existing component is replaced with a component having similar operation and maintenance costs.*

Source: SEWRPC.

Hidden Hills Drive, 2) the 530 feet of 18-inch-diameter RCP in the drainage easement between San Raphael Drive and Pomona Road and in Pomona Road be replaced with a 24-inch-diameter RCP, and 3) the 210-foot-long, 21-inch-diameter RCP in a drainage easement from Pomona Road to Underwood Creek be replaced with a 27-inch-diameter RCP. The recommended system is shown on Map 41.

As set forth in Table 41, the total capital cost of this plan is estimated to be $79,000. The present value cost is also estimated to be $79,000, since implementation of the recommendations would not result in an increase in annual operation and maintenance costs.

Hydrologic Unit UC-5

Description and Evaluation of the Stormwater Management System

Hydrologic Unit UC-5 is a 294-acre area located in the northernmost portion of the subwatershed in the City of Brookfield south of W. Capitol Drive (STH 190) between Pilgrim and Lilly Roads, as shown on Map 12. The North Branch of Underwood Creek originates in this unit.

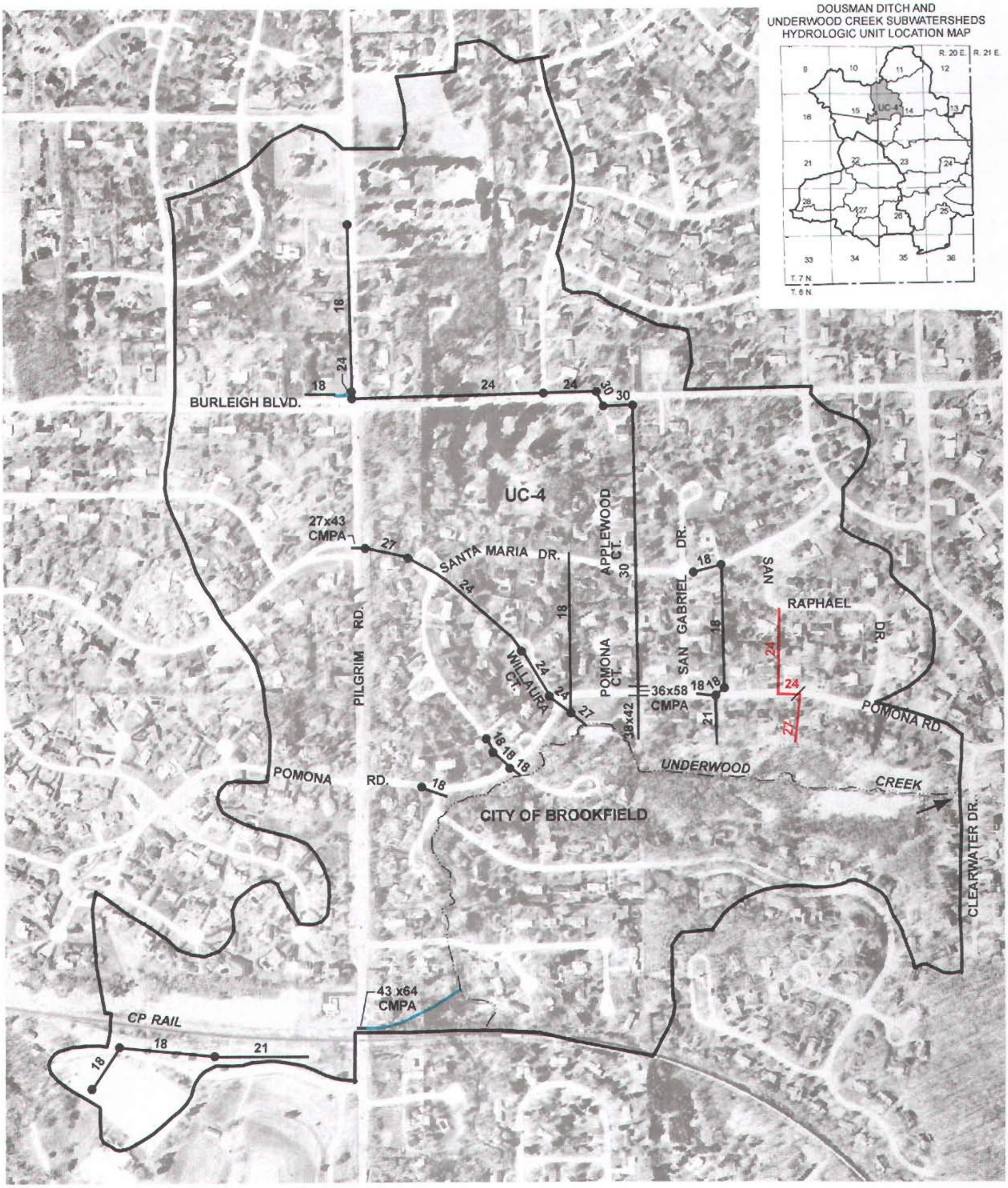
About 60 percent of the hydrologic unit was developed in urban land uses in 1990 with about 55 percent in low-density residential uses and the remaining 5 percent in commercial and governmental and institutional uses. The 40 percent of the unit that was in rural uses included 15 percent as wetlands and 22 percent open lands with the remaining 3 percent consisting of woodlands and water. Under planned buildout land use conditions the amount of urban land in the unit would increase to about 80 percent as the 1990 open space area would developed in low-density residential uses and a small amount would be converted to commercial uses. Low-density residential land would comprise about 76 percent of the unit, commercial land would comprise about 3 percent of the unit, and governmental and institutional uses would consist of about 1 percent of the unit. The 20 percent of the unit in rural uses would be primary environmental corridor that would predominantly consist of wetlands.

The stormwater drainage system in the unit consists of either storm sewers or roadside swales and ditch enclosures.

Flooding problems along the southern end of Westwood Drive were reported to the City as a result of the June 1997 and the August 1998 storms. South of Westview Court, the longitudinal slope of Westwood Drive is quite flat, resulting in inadequate major system hydraulic capacity.

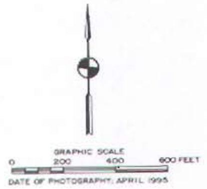
Map 41

PRELIMINARY RECOMMENDED PLAN FOR HYDROLOGIC UNIT UC-4
STORM SEWER CONVEYANCE



—	HYDROLOGIC UNIT BOUNDARY
UC-4	HYDROLOGIC UNIT IDENTIFICATION
➤	HYDROLOGIC UNIT OUTLET
18	EXISTING STORM SEWER OR CULVERT TO BE RETAINED (SIZE IN INCHES)
●	EXISTING MANHOLE OR CATCH BASIN
—	EXISTING OPEN CHANNEL OR FLOW PATH
27	PROPOSED REPLACEMENT STORM SEWER OR CULVERT (SIZE IN INCHES)

NOTE:	THIS MAP GENERALLY SHOWS EXISTING STORM SEWERS OF 18-INCH DIAMETER OR LARGER. PIPES ARE CONSTRUCTED OF REINFORCED CONCRETE UNLESS DESIGNATED AS BELOW.
CMP	CORRUGATED METAL PIPE
CMPA	CORRUGATED METAL PIPE ARCH



Source: SEWRPC.

Table 41

COMPONENTS AND COSTS OF THE STORM SEWER CONVEYANCE STORMWATER DRAINAGE PLAN FOR HYDROLOGIC UNIT UC-4

Location of Component	Project and Component Designation and Description	Estimated Cost[a]	
		Capital[b]	Annual Operation and Maintenance[c]
City of Brookfield	1. UC4C17—Replace 530 feet of 18-inch RCP storm sewer in drainage easement between San Raphael Drive and Pomona Road with 24-inch RCP storm sewer	$55,000	$ 0
	2. UC4C18—Replace 210 feet of 21-inch RCP storm sewer in drainage easement between Pomona Road and Underwood Creek with 27-inch RCP storm sewer	24,000	60
	Total	$79,000	$60

[a] *Costs based upon 1998* Engineering News-Record *Construction Cost Index = 6,740.*

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

[c] *Operation and maintenance costs are listed as $0 when an existing component is replaced with a component having similar operation and maintenance costs.*

Source: SEWRPC.

Alternative Stormwater Drainage Plans

The identified problem can readily be solved through the provision of one replacement storm sewer and additional storm sewers to supplement the existing storm sewers. Because the increase in flow from the new storm sewers would be relatively small, no significant increases in 100-year flood flows in the North Branch of Underwood Creek, or in Underwood Creek, would be expected due to installation of the new storm sewers.

Preliminary Recommended Stormwater Drainage Plan for Hydrologic Unit UC-5

It is recommended that 1) the 249-foot-long, 18-inch-diameter RCP in Westwood Drive near the intersection of Westwood and Lindsay Drives be replaced with a 24-inch-high by 38-inch-wide RCP HE, 2) the existing 195-foot-long, 21-inch-diameter RCP in Westwood Drive south of Lindsay Drive be retained and a parallel 24-inch diameter RCP be installed at a slope of 0.10 percent, 3) the existing 148-foot-long, 24-inch-diameter RCP in a drainage easement between Westwood Drive and the North Branch of Underwood Creek be retained and a parallel 24-inch diameter RCP be installed at a slope of 0.07 percent, 4) the existing 95-foot-long, 24-inch diameter RCP in the intersection of Crestview Circle and Westwood Drive be retained and a parallel 24-inch diameter RCP be installed, and 5) the existing 200-foot-long, 27-inch diameter RCP in an easement between the intersection of Crestview Circle and Westwood Drive and the North Branch of Underwood Creek be retained and a parallel 27-inch diameter RCP be installed. The recommended system is shown on Map 42.

As set forth in Table 42, the total capital cost of this plan is estimated to be $108,000. The present value cost, including an estimated annual operation and maintenance cost increase of about $400, is estimated to be $114,000.

Hydrologic Unit UC-6

Description and Evaluation of the Stormwater Management System

Hydrologic Unit UC-6 is a 507-acre area located southeast of unit UC-5 in the City of Brookfield in the north central portion of the subwatershed, as shown

Map 42

PRELIMINARY RECOMMENDED PLAN FOR HYDROLOGIC UNIT UC-5 STORM SEWER CONVEYANCE

HYDROLOGIC UNIT BOUNDARY

UC-5 HYDROLOGIC UNIT IDENTIFICATION

HYDROLOGIC UNIT OUTLET

18 EXISTING STORM SEWER OR CULVERT TO BE RETAINED (SIZE IN INCHES)

● EXISTING MANHOLE OR CATCH BASIN

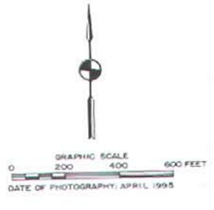
EXISTING OPEN CHANNEL OR FLOW PATH

24x38 PROPOSED REPLACEMENT STORM SEWER OR CULVERT (SIZE IN INCHES)

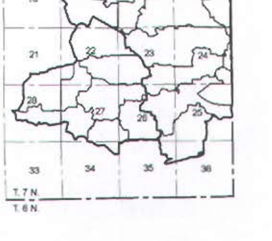
24 PROPOSED STORM SEWER OR CULVERT (SIZE IN INCHES)

NOTE: THIS MAP GENERALLY SHOWS EXISTING STORM SEWERS OF 18-INCH DIAMETER OR LARGER. PIPES ARE CONSTRUCTED OF REINFORCED CONCRETE UNLESS DESIGNATED AS BELOW.

CMP CORRUGATED METAL PIPE



DOUSMAN DITCH AND UNDERWOOD CREEK SUBWATERSHEDS HYDROLOGIC UNIT LOCATION MAP



Source: SEWRPC.

Table 42

COMPONENTS AND COSTS OF THE STORM SEWER CONVEYANCE STORMWATER DRAINAGE PLAN FOR HYDROLOGIC UNIT UC-5

Location of Component	Project and Component Designation and Description	Estimated Cost[a]	
		Capital[b]	Annual Operation and Maintenance[c]
City of Brookfield	1. UC5C30—Replace 249 feet of 18-inch RCP storm sewer in Westwood Drive with 24-inch-high by 38-inch-wide RCP HE storm sewer	$ 40,000	$ 0
	2. UC5C30A—Retain 195 feet of 21-inch RCP storm sewer in Westwood Drive and add a parallel 24-inch diameter RCP storm sewer at a slope of 0.10 percent	20,000	110
	3. UC5C31—Retain 148 feet of 24-inch RCP storm sewer in a drainage easement between Westwood Drive and the North Branch of Underwood Creek and add a parallel 24-inch diameter RCP storm sewer	15,000	100
	4. UC5C21-Retain 95 feet of 24-inch RCP storm sewer in the intersection of Crestview Circle and Westwood Drive and add a parallel 24-inch diameter RCP storm sewer	10,000	80
	5. UC5C22-Retain 200 feet of 27-inch RCP storm sewer in a drainage easement between the intersection of Westwood Drive and Crestview Circle and the North Branch of Underwood Creek and add a parallel 27-inch diameter RCP storm sewer	23,000	110
	Total	$108,000	$400

[a] *Costs based upon 1998* Engineering News-Record *Construction Cost Index = 6,740.*

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

[c] *Operation and maintenance costs are listed as $0 when an existing component is replaced with a component having similar operation and maintenance costs.*

Source: SEWRPC.

on Map 12. Most of the hydrologic unit is located west of Lilly Road on the north and south sides of W. Burleigh Road. The North Branch of Underwood Creek flows through the unit from north to south. The North Branch flows through a relatively large wetland both north and south of W. Burleigh Road. Another on-line pond is located in that wetland west of Brookfield East High School (BEHS), a small off-line pond is located in the wetland just north of the BEHS pond, and a second small off-line pond is located just south of W. Burleigh Road. The Lilly Road Tributary to the North Branch originates in a wetland east of W. Burleigh Road and flows into the North Branch at a small on-line pond located about 1,100 feet upstream from the mouth of the North Branch. The abandoned Sileno quarry is located in the southeastern portion of the unit. The total area tributary to the quarry is about 60 acres, half of which is comprised of the pond in the quarry. The pond elevation is about 23 feet below the lowest point of overflow from the quarry and there is no other outlet besides overland flow. Thus, all runoff to the quarry is stored and none is released downstream.

In 1990, about 65 percent of the unit was in urban uses, including about 49 percent low-density residential, 13 percent governmental and institutional uses, about 2 percent commercial, about 1 percent high-density residential. About 35 percent of the unit was in rural uses in 1990, including 12 percent in wetlands, 6 percent water, and 17 percent in open lands. Under buildout conditions, some of the open lands would be developed, resulting in urban uses in about 78 percent of the unit. Low-density residential lands would comprise about 54 percent of the unit, governmental and institutional uses about 14 percent, high-density residential uses about 5 percent, commercial uses about 4 percent, and recreational uses about one percent. The 22 percent of the unit in rural land use would be primary environmental corridor and isolated natural resource areas consisting predominantly of wetlands and water.

The stormwater drainage system consists primarily of a system of roadside swales, ditch enclosures, and storm sewers that are located along drainage easements outside of public rights-of-way. The system components discharge to the North Branch of Underwood Creek or the Lilly Road Tributary. In the more-recently developed Chesterwood Parc Subdivision that is located west of Lilly Road and south of W. Capitol Drive (STH 190) a storm sewer drainage system with urban street cross sections is in place.

On August 6, 1998, several houses on the east side of San Juan Trail experienced basement and first floor flooding. Less severe flooding problems were also experienced on June 21, 1997, when water ponded in San Juan Trail, but first floor flooding did not occur. The houses along San Juan Trail are outside of the 100-year floodplain; however, inadequacies in the major stormwater drainage system in and near San Juan Trail contribute to the problems they have experienced.[42] Inadequate minor system capacity was identified at the storm sewer system that collects runoff from the east side of Lilly Road and conveys it through the north parking lot of BEHS to the North Branch. In addition, the capacity of the storm sewer under Lilly Road just south of W. Burleigh Road was found to be inadequate to meet the 50-year storm standard for an arterial road.

The 100-year flood profile was determined for the Lilly Road Tributary and no flood hazard to inhabited buildings was identified, consistent with observations during recent storms.

Alternative Stormwater Drainage Plans

The identified localized problems can readily be solved through the provision of relatively small increases in the hydraulic capacities of the existing storm sewers. Because the storm sewers that are proposed to be upgraded discharge to the large wetland storage area upstream of W. Burleigh Road significant increases in 100-year flood flows in the North Branch and in Underwood Creek would not be expected due to replacing the storm sewers. The development of alternative plans is not considered to be necessary and a storm sewer conveyance plan was developed as described below.

Preliminary Recommended Stormwater Drainage Plan for Hydrologic Unit UC-6

To alleviate the major system problems in the vicinity of San Juan Trail north of W. Burleigh Road, it is recommended that 1) the existing 587-foot-long, 24-inch-diameter CMP in San Marcos Drive and in a drainage easement between San Marcos Drive and Sunny View Lane be replaced with 27-inch RCP storm sewer, 2) the 51-foot-long, 27-inch-diameter CMP and the 77-foot-long 27-inch-diameter RCP in Sunny View Lane be replaced with 27-inch-diameter RCP laid at a constant slope, 3) the 310-foot-long, 27-inch-diameter RCP in a drainage easement northeast of East View Court be replaced with 30-inch-diameter RCP storm sewer, 4) the 243-foot-long, 30-inch-diameter storm sewer in the drainage easement west of San Juan Trail, and in San Juan Trail, be replaced with 36-inch-diameter RCP storm sewer, 5) the 201-foot-long 36-inch-diameter RCP in the drainage easement between San Juan Trail and the North Branch be replaced with 42-inch-diameter RCP storm sewer, 6) the 206-foot-long, 12-inch-diameter RCP storm sewer in a drainage easement west of San Juan Trail and north of W. Burleigh Road be replaced with 21-inch-diameter RCP storm sewer, and 7) the 226-foot-long, 15-inch-diameter RCP storm sewer in San Juan Trail, and in an easement to the east of San Juan Trail, be replaced with 27-inch-diameter RCP storm sewer. To alleviate the minor system problems in the vicinity of Brookfield East High School, it is recommended that 1) the 258-foot-long, 12-inch-diameter RCP storm sewer flowing from south to north on the east side of Lilly Road opposite BEHS be replaced with 18-inch-diameter RCP storm sewer, 2) the 260-foot-long 15-inch-diameter RCP storm sewer flowing from north to south on the east side of Lilly Road

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[42] *The August 6, 1998 flood exceeded the 100-year flood.*

opposite BEHS be replaced with 18-inch-diameter RCP storm sewer, and 3) the 607-foot-long, 18-inch-diameter RCP storm sewer in Lilly Road and the BEHS north parking lot be replaced with 21-inch-diameter RCP storm sewer, 4) the 425-foot-long, 18-inch-diameter RCP storm sewer in the BEHS north parking lot be replaced with 30-inch-diameter RCP storm sewer, and 5) the 305-foot-long, 18-inch-diameter RCP storm sewer in the BEHS north parking lot be replaced with 36-inch-diameter RCP storm sewer. Finally, to provide adequate capacity to meet the 50-year storm standard for an arterial road, it is recommended that the 44-foot-long, 12-inch-diameter CMP storm sewer under Lilly Road just south of W. Burleigh Road be replaced with a 15-inch CMP. The recommended system is shown on Map 43.

As set forth in Table 43, the total capital cost of this plan is estimated to be $440,000. The present value cost is also estimated to be $440,000, since implementation of the recommendations would not result in an increase in annual operation and maintenance costs.

Hydrologic Unit UC-7

Description and Evaluation of the Stormwater Management System

As shown on Map 12, Hydrologic Unit UC-7 is a 453-acre area located generally north of W. North Avenue on either side of Lilly Road. About 95 percent of the unit is in the City of Brookfield and the remaining 5 percent is in the Village of Elm Grove. Underwood Creek flows from north to south through the western part of the unit.

In 1990, about 73 percent of the unit was in urban uses, including about 65 percent low-density residential, about 3 percent commercial, about 3 percent governmental and institutional uses, about 1 percent medium-density residential, and about 1 percent railway. About 27 percent of the unit was in rural uses in 1990, including 9 percent in wetlands, 10 percent woodlands, and 8 percent open lands. Under buildout conditions, some of the open lands and woodlands would be developed, resulting in urban uses in about 82 percent of the unit. Low-density residential lands would comprise about 73 percent of the unit, governmental and institutional uses about 3 percent, commercial uses about 3 percent, and medium-density residential uses about 2 percent, and recreational uses about 1 percent. The 28 percent of the unit in rural land use would be primary environmental corridor and isolated natural resource areas consisting predominantly of wetlands and woodlands.

The stormwater drainage system consists primarily of a system of roadside swales, culverts, and ditch enclosures. A storm sewer drainage system with an urban street cross section is in place in W. North Avenue.

Inadequate minor system capacity was identified along Oakhill Lane on either side of Lilly Road. Major system deficiencies were identified in the area northeast of the intersection of W. North Avenue and Lilly Road along Adelaide and Tru Lanes. Significant flooding occurred in that area on both June 21, 1997 and during the larger storm of August 6, 1998. A portion of that area is located in the 100-year floodplain of Underwood Creek, with inundation of the area being caused in part by high water levels in the Creek backing up through the storm sewer system. The problem is compounded by an inadequate stormwater drainage system. In addition to the possibility of direct overland flooding of houses, the extensive ponding of runoff in the area contributes to the problem of sanitary sewer backups into basements.[43] Flooding in this area on June 21, 1997 was exacerbated by the loss of electrical power. The preliminary recommended plan described below addresses the stormwater drainage aspects of the problems northeast of Lilly Road and W. North Avenue and also considers the interaction between the stormwater drainage system and flood levels along Underwood Creek. Much of the land, and several houses, along Underwood Creek west of Lilly Road are also in the 100-year floodplain. Solutions to address the flooding of those houses are presented above in the section of this chapter describing alternative floodland management plans.

Alternative Stormwater Drainage Plans

The problems identified along Oakhill Lane can be solved through the provision of relatively small increases in the hydraulic capacities of the existing ditch enclosures and culverts. A gravity flow solution

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[43] *Following the flood of August 6, 1998, the City of Brookfield purchased the house and lot at 13830 Adelaide Lane primarily with funds provided by the Federal Emergency Management Agency through the Flood Hazard Mitigation grant program. The State of Wisconsin Division of Emergency Management and the City provided additional funds for the purchase.*

to the stormwater drainage problems in the vicinity of Tru and Adelaide Lanes is not feasible because of the lack of topographic relief in the effected area and because of backwater effects from Underwood Creek. Thus, a stormwater pumping alternative plan was developed for the Tru/Adelaide area. The preliminary recommended floodland management plan described in a previous section of this chapter calls for the creation of additional floodwater storage volume along Underwood Creek immediately upstream of W. North Avenue. That storage volume is primarily recommended to reduce flood flows in the context of the recommended floodland management plan; however, it could also be beneficial in offsetting minor increases in flows due to implementation of the storm sewer/culvert conveyance and stormwater pumping plan proposed for this hydrologic unit.

Preliminary Recommended Stormwater Drainage Plan for Hydrologic Unit UC-7

To alleviate the minor system problems in the vicinity of Oakhill Lane, it is recommended that 1) the existing 250-foot-long, 12-inch-diameter RCP storm sewer in Carson Court be replaced with 27-inch-high by 44-inch-wide RCPA storm sewer, 2) the 25-foot-long, 12-inch-diameter RCP along Oakhill Lane northeast of Carson Court be replaced with 23-inch-high by 36-inch-wide RCPA storm sewer, 3) the 67-foot-long, 15-inch-diameter PVC storm sewer under Oakhill Lane near its intersection with Thornapple Lane be replaced with 23-inch-high by 36-inch-wide RCPA storm sewer, 4) the 63-foot-long, 15-inch-diameter RCP under Carson Court at its intersection with Oakhill Lane be replaced with 27-inch-high by 44-inch-wide RCPA storm sewer, 5) the 539-foot-long, 18-inch-diameter storm sewer along Oakhill Lane southwest of Carson Court be replaced with 27-inch-high by 44-inch-wide RCPA, 6) the next 464-foot-long 18-inch-diameter RCP along Oakhill Lane be replaced with 31-inch-high by 51-inch-wide RCPA storm sewer, 7) the 33-foot-long, 30-inch-diameter CMP under Lilly Road at Oakhill Lane be replaced with 31-inch-high by 51-inch-wide RCPA storm sewer, 8) the 400-foot-long swale along the north side of Oakhill Lane between Lilly Road and El Rancho Drive be modified to have a parabolic shape approximating a trapezoid with a seven-foot-wide bottom and one vertical on two horizontal side slopes, and 9) the 48-foot-long, 24-inch-diameter CMP culvert under El Rancho Drive at its intersection with Oakhill Lane be replaced with a double 31-inch-high by 51-inch-wide RCPA. The recommended system is shown on Map 44.

The stormwater pumping plan for the Tru/Adelaide area calls for maintaining the existing storm sewer system along Lilly Road and Tru and Adelaide Lanes and providing a backwater gate on the 36-inch-diameter storm sewer at the manhole located immediately northwest of the intersection of W. North Avenue and Lilly Road. Designing the pump station/storm sewer system to enable maintenance of the existing storm sewer system would enable the area to drain following small storms, reducing the amount of time that the pump station would be required to operate. Provision of the backwater gate would avoid backwater flooding of the area during periods of high stages along Underwood Creek.[44] A pump station would be installed on the east side of Lilly Road north of W. North Avenue. The station would have a peak pumping capacity of about 100 cfs in order to handle the runoff from the critical 100-year storm.[45] The station would have a 600-foot-long, 48-inch-diameter reinforced concrete force main that would discharge to Underwood Creek. New storm sewers to collect runoff during storms with recurrence intervals up to, and including, 100 years would be installed parallel to the existing storm sewers. About 291 feet of 48-inch-diameter RCP storm sewer would be installed in, and along Tru Lane, beginning midway between W. North Avenue and Adelaide Lane and extending to the

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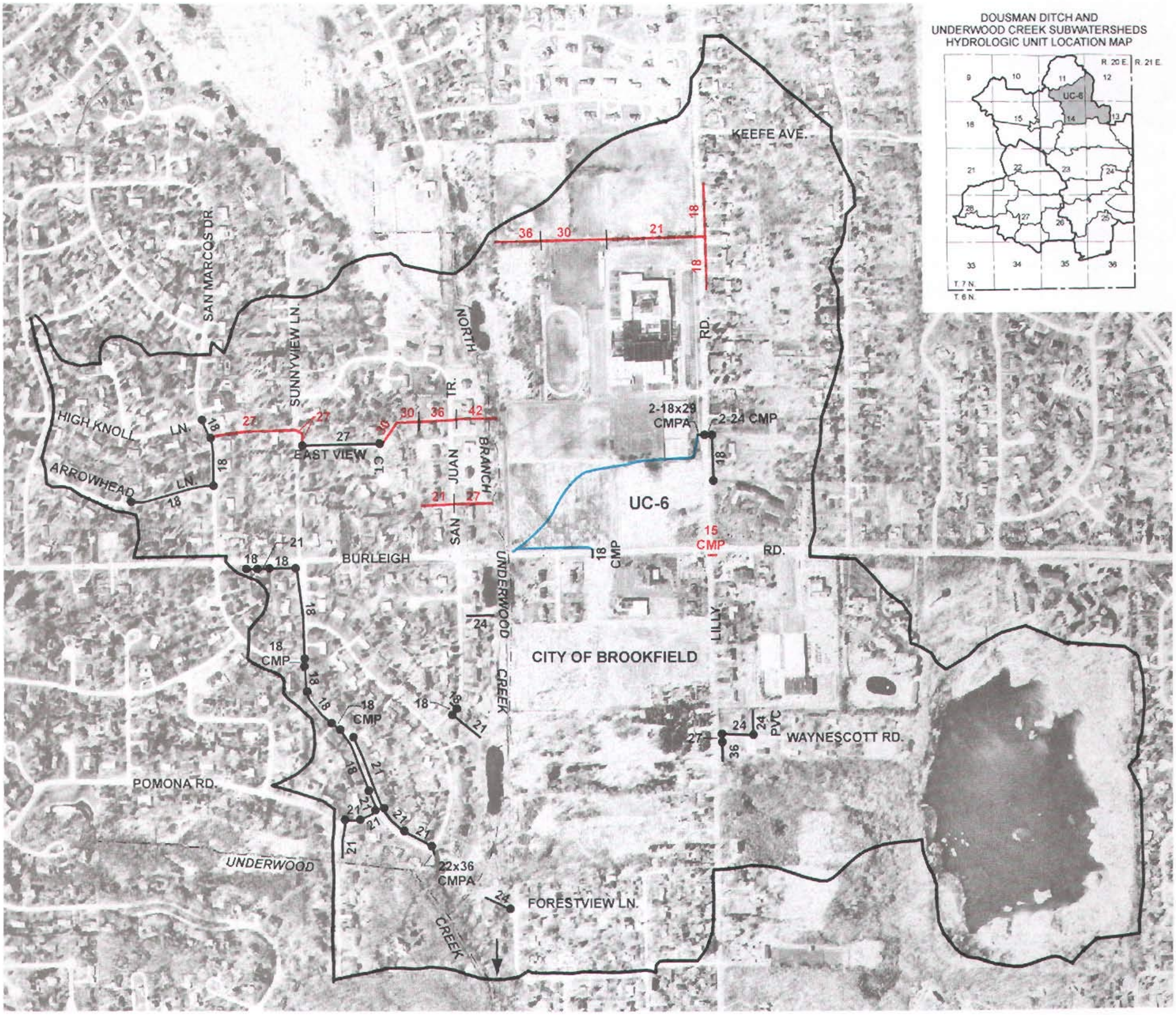
[44] *The 1998 large-scale topographic map of the area and a March 2000 field survey by the City of Brookfield indicate that the crown of Lilly Road is above the 100-year flood stage of Underwood Creek, providing a land surface barrier to block backwater from the Creek from reaching the east side of the road. As already mentioned, under existing conditions, backwater flooding of the area east of the road would still be possible through the storm sewers that drain the area east of Lilly Road.*

[45] *The effect of pumping stormwater runoff on flood flows and stages along Underwood Creek should be evaluated during the detailed design of the pump station. The pump station and the recommended downstream storage areas should be designed and constructed as a system. If necessary, the storage areas should be modified to alleviate the impacts of pumped runoff.*

Map 43

PRELIMINARY RECOMMENDED PLAN FOR HYDROLOGIC UNIT UC-6 STORM SEWER CONVEYANCE



—	HYDROLOGIC UNIT BOUNDARY
UC-6	HYDROLOGIC UNIT IDENTIFICATION
→	HYDROLOGIC UNIT OUTLET
18	EXISTING STORM SEWER OR CULVERT TO BE RETAINED (SIZE IN INCHES)
●	EXISTING MANHOLE OR CATCH BASIN
—	EXISTING OPEN CHANNEL OR FLOW PATH

18	PROPOSED REPLACEMENT STORM SEWER OR CULVERT (SIZE IN INCHES)
NOTE:	THIS MAP GENERALLY SHOWS EXISTING STORM SEWERS OF 18-INCH DIAMETER OR LARGER. PIPES ARE CONSTRUCTED OF REINFORCED CONCRETE UNLESS DESIGNATED AS BELOW.
CMP	CORRUGATED METAL PIPE
CMPA	CORRUGATED METAL PIPE ARCH
PVC	POLYVINYL CHLORIDE

Source: SEWRPC.

Table 43

COMPONENTS AND COSTS OF THE STORM SEWER CONVEYANCE STORMWATER DRAINAGE PLAN FOR HYDROLOGIC UNIT UC-6

Location of Component	Project and Component Designation and Description	Estimated Cost[a]	
		Capital[b]	Annual Operation and Maintenance[c]
City of Brookfield	1. UC6C4—Replace the existing 587-foot-long, 24-inch-diameter CMP in San Marcos Drive and in a drainage easement between San Marcos Drive and Sunny View Lane with 27-inch RCP storm sewer	$ 62,000	$0
	2. UC6C5—Replace the 51-foot-long, 27-inch-diameter CMP and the 77-foot-long, 27-inch-diameter RCP in Sunny View Lane with 27-inch-diameter RCP *laid at a constant slope*	15,000	0
	3. UC6C7—Replace the 310-foot-long, 27-inch-diameter RCP in a drainage easement northeast of East View Court with 30-inch-diameter RCP storm sewer	39,000	0
	4. UC6C8—Replace the 243-foot-long, 30-inch-diameter storm sewer in the drainage easement west of San Juan Trail and in San Juan Trail with 36-inch-diameter RCP storm sewer	36,000	0
	5. UC6C9—Replace the 201-foot-long, 36-inch-diameter RCP in the drainage easement between San Juan Trail and the North Branch with 42-inch-diameter RCP storm sewer	36,000	0
	6. Replace the 206-foot-long, 12-inch-diameter RCP storm sewer in a drainage easement west of San Juan Trail and north of W. Burleigh Road with 21-inch-diameter RCP storm sewer	20,000	0
	7. Replace the 226-foot-long, 15-inch-diameter RCP storm sewer in San Juan Trail and in an easement to the east of San Juan Trail with 27-inch-diameter RCP storm sewer	26,000	0
	8. Replace the 258-foot-long, 12-inch-diameter RCP storm sewer flowing from south to north on the east side of Lilly Road opposite BEHS with 18-inch-diameter RCP storm sewer	22,000	0
	9. Replace the 260-foot-long, 15-inch-diameter RCP storm sewer flowing from north to south on the east side of Lilly Road opposite BEHS with 18-inch-diameter RCP storm sewer	23,000	0
	10. UC6C10—Replace the 607-foot-long, 18-inch-diameter RCP storm sewer in Lilly Road and the BEHS north parking lot with 21-inch-diameter RCP storm sewer	60,000	0
	11. UC6C11—Replace the 425-foot-long, 18-inch-diameter RCP storm sewer in the BEHS north parking lot with 30-inch-diameter RCP storm sewer	53,000	0
	12. UC6C12—Replace the 305-foot-long, 18-inch-diameter RCP storm sewer in the BEHS north parking lot with 36-inch-diameter RCP storm sewer	46,000	0
	13. UC6CAA—Replace the 44-foot-long, 12-inch-diameter CMP storm sewer under Lilly Road just south of W. Burleigh Road with a 15-inch CMP	2,000	0
	Total	$440,000	$0

[a] *Costs based upon 1998* Engineering News-Record *Construction Cost Index = 6,740.*

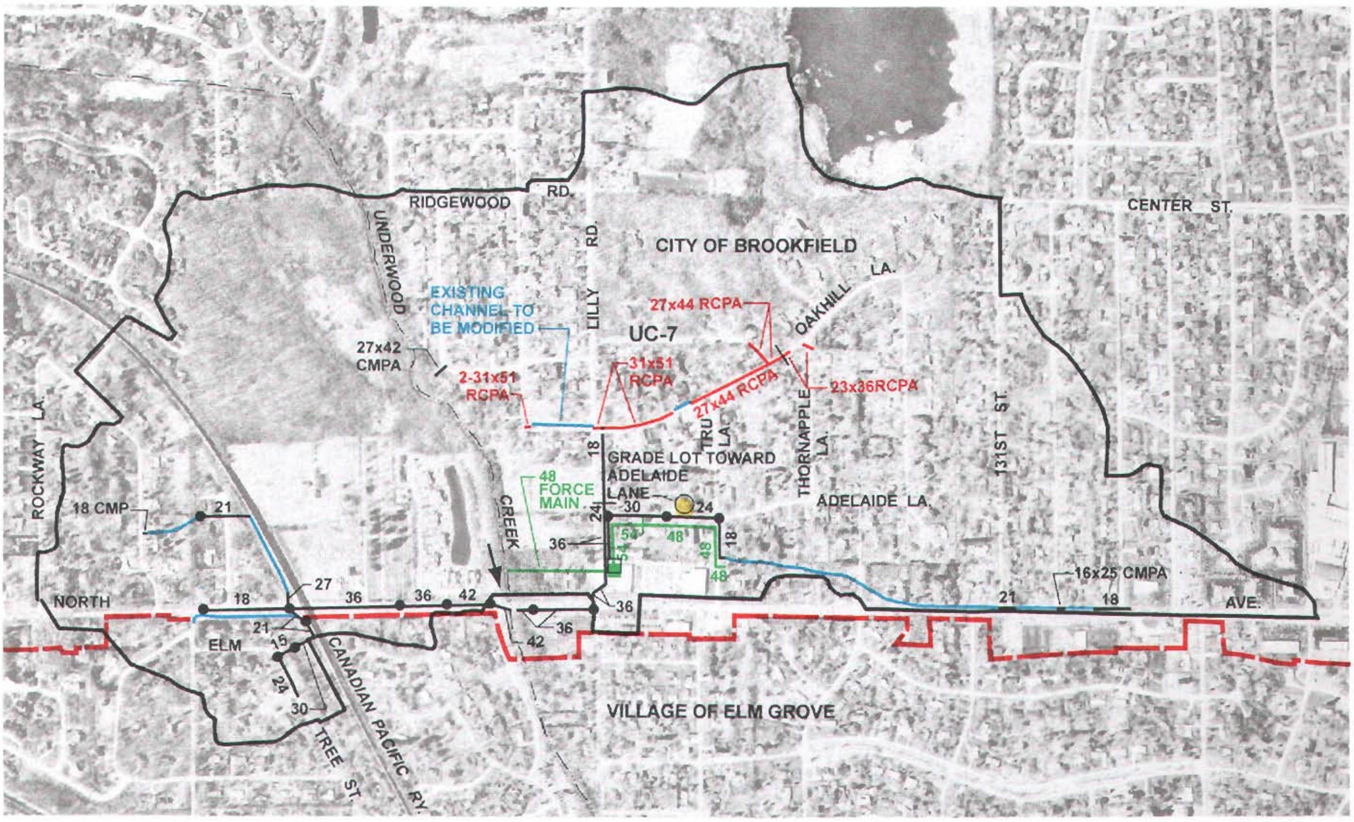
[b] *Includes 35 percent for engineering, administration, and contingencies.*

[c] *Operation and maintenance costs are listed as $0 when an existing component is replaced with a component having similar operation and maintenance costs.*

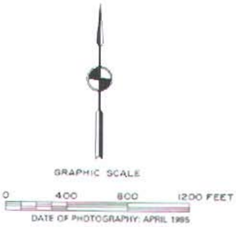
Source: SEWRPC.

Map 44

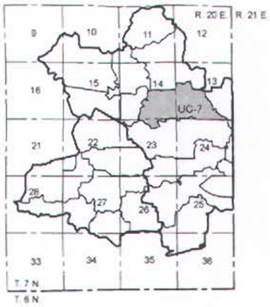
PRELIMINARY RECOMMENDED PLAN FOR HYDROLOGIC UNIT UC-7 STORM SEWER CONVEYANCE AND PUMPING



—	HYDROLOGIC UNIT BOUNDARY
UC-7	HYDROLOGIC UNIT IDENTIFICATION
→	HYDROLOGIC UNIT OUTLET
18	EXISTING STORM SEWER OR CULVERT TO BE RETAINED (SIZE IN INCHES)
●	EXISTING MANHOLE OR CATCH BASIN
—	EXISTING OPEN CHANNEL OR FLOW PATH
27x44	PROPOSED REPLACEMENT STORM SEWER OR CULVERT (SIZE IN INCHES)
🟩	PROPOSED STORMWATER PUMPING STATION
54	PROPOSED STORM SEWER OR CULVERT (SIZE IN INCHES)
NOTE:	THIS MAP GENERALLY SHOWS EXISTING STORM SEWERS OF 18-INCH DIAMETER OR LARGER. PIPES ARE CONSTRUCTED OF REINFORCED CONCRETE UNLESS DESIGNATED AS BELOW
CMP	CORRUGATED METAL PIPE
CMPA	CORRUGATED METAL PIPE ARCH
RCPA	REINFORCED CONCRETE PIPE ARCH



DOUSMAN DITCH AND UNDERWOOD CREEK SUBWATERSHEDS HYDROLOGIC UNIT LOCATION MAP



Source: SEWRPC.

intersection of Tru and Adelaide Lanes. About 464 feet of 48-inch-diameter RCP storm sewer would be installed along Adelaide Lane, beginning at its intersection with Tru Lane. Downstream from that storm sewer, about 285 feet of 54-inch-diameter RCP storm sewer would be installed along Adelaide Lane to its intersection with Lilly Road. Finally, about 216 feet of 54-inch-diameter RCP storm sewer would be installed along the east side of Lilly Road from Adelaide Lane to the proposed pump station. The pump station would be provided with a backup power source that would automatically be activated in the event of a power failure. In addition, it is recommended that the lot at 13830 Adelaide Lane be graded to permit runoff from the north to be conveyed to Adelaide Lane.

As set forth in Table 44, the total capital cost of this plan is estimated to be $2,565,000. The present value cost, including an estimated annual operation and maintenance cost increase of about $9,200, is estimated to be $2,710,000.

Hydrologic Unit UC-8

Description and Evaluation of the Stormwater Management System

Hydrologic Unit UC-8 is a 618-acre area located in the northeastern part of the Village of Elm Grove, as shown on Map 12. The hydrologic unit is generally located south of W. North Avenue between Pilgrim Parkway on the west and N. 124th Street on the east. Underwood Creek flows from north to south through the unit.

The hydrologic unit was essentially under full buildout land use conditions in 1990. About 93 percent of the unit is in urban uses, including about 80 percent low-density residential, 5 percent medium-density residential, 4 percent recreational, 2 percent commercial, and 2 percent governmental and institutional uses. The 7 percent of the unit in rural land use is secondary environmental corridor, including wetlands and open lands, along Underwood Creek.

The stormwater drainage system consists primarily of a system of roadside swales and culverts. The system components discharge to directly to Underwood Creek or to the Wrayburn Tributary and then to the Creek. The 100-year flood profile was determined for the Wrayburn Tributary and no direct overland flood hazard to inhabited buildings was identified, consistent with observations during recent storms; however, measures are recommended below to alleviate street flooding during storms with recurrence intervals up to, and including, 100 years.

Stormwater drainage problems, including street flooding and ponding, on June 21, 1997 and August 6, 1998, contributed to sanitary sewer backups in the portion of the hydrologic unit approximately bounded by Lee Court on the north, Gremoor Drive on the south, Fairhaven Boulevard on the east, and Arrowhead Court on the west. That area includes the Wrayburn Tributary, which is bounded on each side by Wrayburn Road. Other stormwater drainage and sanitary sewer backup problems have occurred at scattered locations throughout the hydrologic unit, including the area in the vicinity of San Fernando Drive south of W. North Avenue. Flooding problems along Underwood Creek are addressed in the previous floodland management plan section of this chapter.

The results of an extensive survey of residents that was conducted by the Village following the August 6, 1998 storm are set forth in Maps 13, 14, 15, 16, and 17 in a previous section of this chapter. The survey results indicate that many residences in this hydrologic unit lost power during that storm and that there were widespread occurrences of sanitary sewer backup and of water entering basements through window wells, basement walls, and overflow from sump crocks. Among those who responded to the survey, roughly half experienced flooding for the first time and half for the second time. A small number experienced their third instance of flooding.[46] The large number of residences experiencing flooding for the first time is consistent with the extreme nature of the storm.

Alternative Stormwater Drainage Plans

The identified stormwater management problems can readily be solved through the provision of increased hydraulic capacity at existing culverts. There are no available locations in this hydrologic unit for the provision of significant effective detention storage outside of those identified along Underwood Creek

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[46] *Flooding is loosely defined here as either sanitary sewer backup, clearwater basement flooding, or a combination of the two.*

under the floodland management element of this plan, which was presented previously. Hydrologic and hydraulic modeling indicates that installation of the proposed measures would not be expected to increase flood flows in Underwood Creek. The development of multiple alternative plans is not considered to be necessary and a storm sewer and culvert conveyance plan was developed as described below.

The proposed measures address identified drainage problems in the minor and major systems during storms with recurrence intervals up to, and including 100 years. The solution of those problems will also help alleviate sanitary sewer backup problems. Yard and basement flooding problems due to local yard grading conditions are not addressed by the proposed measures.

Preliminary Recommended Stormwater Drainage Plan for Hydrologic Unit UC-8

To alleviate problems in the general vicinity of Wrayburn Road, it is recommended that 1) the 77-foot-long, 21-inch-diameter CMP culvert under Fairhaven Boulevard at Wrayburn Road be replaced with a 27-inch-high by 44-inch-wide RCPA culvert; 2) the 44-foot-long, 18-inch-diameter CMP culvert crossing the southern lanes of Wrayburn Road between Arrowhead Court and Fairhaven Boulevard be replaced with an 18-inch-high by 29-inch-wide RCPA culvert; 3) the 53-foot-long, 18-inch-diameter CMP under the southern lanes of Wrayburn Road on the east side of Arrowhead Court be replaced with a 27-inch-diameter CMP culvert; 4) the 51-foot-long, 18-inch-diameter CMP under the northern lanes of Wrayburn Road on the east side of Arrowhead Court be replaced with a 24-inch-high by 35-inch-wide CMPA culvert; 5) the 52-foot-long, 18-inch-diameter CMP under the northern lanes of Wrayburn Road on the west side of Arrowhead Court be replaced with two, parallel 18-inch-high by 29-inch-wide RCPA culverts; 6) the 221-foot-long, 18-inch-diameter CMP culvert along the west side of Hollyhock Lane at its intersection with Wrayburn Road be replaced with an 18-inch-high by 29-inch-wide CMPA culvert; 7) the 180-foot-long, parallel double 33-inch-high by 48-inch-wide CMPA culverts in the Wrayburn Tributary under Hollyhock Lane be replaced with two, parallel 36-inch-high by 58-inch-wide RCPA culverts; 8) the 630-foot-long 15-inch-high by 21-inch-wide CMPA located outside of the public right-of-way between Lee Court and Wrayburn Road be replaced with a 42-inch-diameter CMP; and 9) the 74-foot-long, 21-inch-diameter RCP culvert under N. 131st Street on the north side of W. North Avenue be replaced with two, parallel 24-inch-diameter RCP culverts. To alleviate major system street flooding problems in the vicinity of San Fernando Drive, it is recommended and that 1) the 82-foot-long, 12-inch-diameter CMP storm sewers under Wrayburn Road and San Fernando Drive be replaced with 15-inch-diameter RCP storm sewer; 2) the 327-foot-long 15-inch-diameter CMP storm sewer along the north side of Wrayburn Road between San Fernando Drive and the Wrayburn Tributary be replaced with 15-inch-diameter RCP storm sewer; 3) 410 feet of 15-inch-diameter RCP storm sewer be installed from the south side of Lloyd Street through San Fernando Drive and in an easement to be obtained between San Fernando Drive and a tributary to the Wrayburn Tributary; and 4) 65 feet of 15-inch-diameter RCPA storm sewer, followed by 230 feet of 18-inch-diameter RCP storm sewer, followed by 315 feet of 18-inch-high by 29-inch-wide RCPA storm sewer be installed from the north side of Garfield Street to the north side of Lloyd Street, across San Fernando Drive, and then in an easement to be obtained between San Fernando Drive and the tributary to the Wrayburn Tributary. The recommended system is shown on Map 45.

As set forth in Table 45, the total capital cost of this plan is estimated to be $407,000. The present value cost, including an estimated annual operation and maintenance cost increase of about $700, is estimated to be $418,000.

Hydrologic Unit UC-9

Description and Evaluation of the Stormwater Management System

Hydrologic Unit UC-9 is a 409-acre area located in the central part of the Village of Elm Grove, as shown on Map 12. The hydrologic unit is located primarily north of Juneau Boulevard between Highland Drive on the west and Longwood Avenue on the east. Underwood Creek flows from north to south through the Village Park in center of the unit.

The hydrologic unit was essentially under full build-out land use conditions in 1990. About 95 percent of the unit is in urban uses, including about 85 percent low-density residential, 7 percent governmental and institutional, and 3 percent recreational uses. The 15 percent of the unit in rural land use is secondary environmental corridor, including water, wetlands, and open lands located along Underwood Creek.

Table 44

COMPONENTS AND COSTS OF THE STORMWATER CONVEYANCE AND PUMPING DRAINAGE PLAN FOR HYDROLOGIC UNIT UC-7

Location of Component	Project and Component Designation and Description	Estimated Cost[a]	
		Capital[b]	Annual Operation and Maintenance[c]
City of Brookfield	1. Replace the existing 250-foot-long, 12-inch-diameter RCP storm sewer in Carson Court with 27-inch-high by 44-inch-wide RCPA storm sewer	$ 48,000	$ 0
	2. Replace the 25-foot-long, 12-inch-diameter RCP along Oakhill Lane northeast of Carson Court with 23-inch-high by 36-inch-wide RCPA storm sewer	4,000	0
	3. Replace the 67-foot-long, 15-inch-diameter polyvinyl chloride (PVC) storm sewer under Oakhill Lane near its intersection with Thornapple Lane with 23-inch-high by 36-inch-wide RCPA storm sewer	11,000	0
	4. Replace the 63-foot-long, 15-inch-diameter RCP under Carson Court at its intersection with Oakhill Lane with 27-inch-high by 44-inch-wide RCPA storm sewer	12,000	0
	5. UC7C12—Replace the 539-foot-long, 18-inch-diameter storm sewer along Oakhill Lane southwest of Carson Court with 27-inch-high by 44-inch-wide RCPA	103,000	0
	6. UC7C12B—Replace the 464-foot-long, 18-inch-diameter RCP along Oakhill Lane with 31-inch-high by 51-inch-wide RCPA storm sewer	103,000	0
	7. UC7C12C—Replace the 33-foot-long, 30-inch-diameter CMP under Lilly Road at Oakhill Lane with 31-inch-high by 51-inch-wide RCPA storm sewer	7,000	0
	8. UC7D7A—Modify the 400-foot-long swale along the north side of Oakhill Lane between Lilly Road and El Rancho Drive to have a parabolic shape approximating a trapezoid with a seven-foot-wide bottom and one vertical on two horizontal side slopes	6,000	200
	9. UC7C10—Replace the 48-foot-long, 24-inch-diameter CMP culvert under El Rancho Drive at its intersection with Oakhill Lane with a double 31-inch-high by 51-inch-wide RCPA	21,000	0
	10. Construct stormwater pumping station with 100 cfs pumping capacity	1,830,000	8,500
	11. 600 feet of 48-inch-diameter RCP force main	130,000	200
	12. 755 feet of 48-inch-diameter storm sewer draining to pump station	160,000	200
	13. 500 feet of 54-inch-diameter storm sewer draining to pump station	120,000	100
	14. Grade lot at 13830 Adelaide Lane to drain toward street	10,000	0
	Total	$2,565,000	$9,200

[a] *Costs based upon 1998* Engineering News-Record *Construction Cost Index = 6,740.*

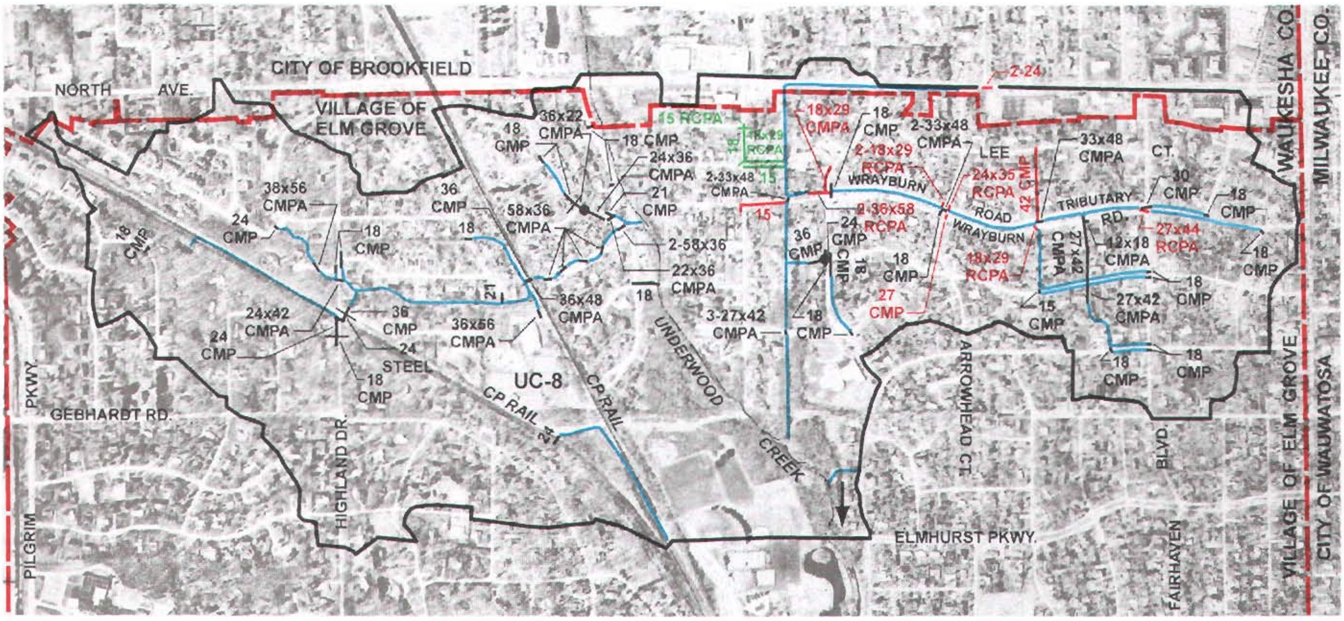
[b] *Includes 35 percent for engineering, administration, and contingencies.*

[c] *Operation and maintenance costs are listed as $0 when an existing component is replaced with a component having similar operation and maintenance costs.*

Source: SEWRPC.

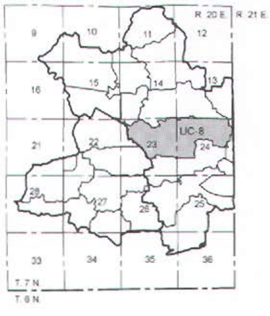
Map 45

PRELIMINARY RECOMMENDED PLAN FOR HYDROLOGIC UNIT UC-8 STORM SEWER AND CULVERT CONVEYANCE



—	HYDROLOGIC UNIT BOUNDARY
UC-8	HYDROLOGIC UNIT IDENTIFICATION
→	HYDROLOGIC UNIT OUTLET
24	EXISTING STORM SEWER OR CULVERT TO BE RETAINED (SIZE IN INCHES)
●	EXISTING MANHOLE OR CATCH BASIN
—	EXISTING OPEN CHANNEL OR FLOW PATH
15	PROPOSED REPLACEMENT STORM SEWER OR CULVERT (SIZE IN INCHES)
18	PROPOSED STORM SEWER OR CULVERT (SIZE IN INCHES)
NOTE	THIS MAP GENERALLY SHOWS EXISTING STORM SEWERS OF 18-INCH DIAMETER OR LARGER. PIPES ARE CONSTRUCTED OF REINFORCED CONCRETE UNLESS DESIGNATED AS BELOW
CMP	CORRUGATED METAL PIPE
CMPA	CORRUGATED METAL PIPE ARCH
RCPA	REINFORCED CONCRETE PIPE ARCH

DOUSMAN DITCH AND
UNDERWOOD CREEK SUBWATERSHEDS
HYDROLOGIC UNIT LOCATION MAP



Source: SEWRPC.

Table 45

COMPONENTS AND COSTS OF THE STORM SEWER AND CULVERT CONVEYANCE STORMWATER DRAINAGE PLAN FOR HYDROLOGIC UNIT UC-8

Location of Component	Project and Component Designation and Description	Estimated Cost[a]	
		Capital[b]	Annual Operation and Maintenance[c]
Village of Elm Grove	1. UC-8C3—Replace the 77-foot-long, 21-inch-diameter CMP culvert under Fairhaven Boulevard at Wrayburn Road with a 27-inch-high by 44-inch-wide RCPA culvert	$ 15,000	$ 0
	2. UC-8C7—Replace the 44-foot-long, 18-inch-diameter CMP culvert crossing the southern lanes of Wrayburn Road between Arrowhead Court and Fairhaven Boulevard with an 18-inch-high by 29-inch-wide RCPA culvert	6,000	0
	3. UC-8C13—Replace the 53-foot-long, 18-inch-diameter CMP under the southern lanes of Wrayburn Road on the east side of Arrowhead Court with a 27-inch diameter CMP culvert	4,000	0
	4. UC-8C14—Replace the 51-foot-long, 18-inch-diameter CMP under the northern lanes of Wrayburn Road on the east side of Arrowhead Court with a 24-inch-high by 35-inch-wide CMPA culvert	6,000	0
	5. UC-8C16—Replace the 52-foot-long, 18-inch-diameter CMP under the northern lanes of Wrayburn Road on the west side of Arrowhead Court with two, parallel 18-inch-high by 29-inch-wide RCPA culverts	13,000	100
	6. UC-8C25—Replace the 221-foot-long, 18-inch-diameter CMP culvert along the west side of Hollyhock Lane at its intersection with Wrayburn Road with an 18-inch-high by 29-inch-wide CMPA culvert	23,000	0
	7. UC-8C26—Replace the 180-foot-long, parallel double 33-inch-high by 48-inch-wide CMPA culverts in the Wrayburn Tributary under Hollyhock Lane with two, parallel 36-inch-high by 58-inch-wide RCPA culverts	91,000	0
	8. Replace the 630-foot-long, 15-inch-high by 21-inch-wide CMPA located outside of the public right-of-way between Lee Court and Wrayburn Road with a 42-inch-diameter CMP	73,000	0
	9. Replace the 82-foot-long, 12-inch-diameter CMP storm sewers under Wrayburn Road and San Fernando Drive with a 15-inch-diameter RCP storm sewer	7,000	0
	10. Replace the 327-foot-long, 15-inch-diameter CMP storm sewer along the north side of Wrayburn Road between San Fernando Drive and the Wrayburn Tributary with a 15-inch-diameter RCP storm sewer	28,000	0
	11. Install 410 feet of 15-inch-diameter RCP storm sewer from the south side of Lloyd Street through and San Fernando Drive and in an easement to be obtained between San Fernando Drive and a tributary to the Wrayburn Tributary[d]	41,000	200
	12. Install 65 feet of 15-inch-diameter RCPA storm sewer, followed by 230 feet of 18-inch-diameter RCP storm sewer, followed by 315 feet of 18-inch-high by 29-inch-wide RCPA storm sewer from the north side of Garfield Street to the north side of Lloyd Street, across San Fernando Drive, and then in an easement to be obtained between San Fernando Drive and the tributary to the Wrayburn Tributary[d]	89,000	400
	Subtotal	$396,000	$700
City of Brookfield	13. UC-7C21[e]—Replace the 74-foot-long, 21-inch-diameter RCP culvert under N. 131st Street on the north side of W. North Avenue with two, parallel 24-inch-diameter RCP culverts	$ 11,000	$ 0
- -	Total	$407,000	$700

[a] *Costs based upon 1998* Engineering News-Record *Construction Cost Index = 6,740.*

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

[c] *Operation and maintenance costs are listed as $0 when an existing component is replaced with a component having similar operation and maintenance costs.*

[d] *Easement assumed to cost $5,000.*

[e] *Most runoff tributary to this culvert drains to Hydrologic Unit UC-8, but some drains to UC-7, thus, it was assigned to UC-7 when it was designated.*

Source: SEWRPC.

The stormwater drainage system consists primarily of a system of roadside swales and culverts. The system components discharge directly to Underwood Creek or to the Woodlawn Tributary and then to the Creek. Flooding problems along Underwood Creek are addressed in the previous floodland management plan section of this chapter. The 100-year flood profile was determined for the Woodlawn Tributary from a pond located northwest of the intersection of Greenway Terrace and Juneau Boulevard downstream through the Canadian Pacific Railway and through the Village Park to its confluence with Underwood Creek. No direct overland flood hazard to inhabited buildings was identified, consistent with observations during recent storms; however, measures are recommended below to alleviate street flooding during storms with recurrence intervals up to, and including, 100 years.

Stormwater drainage problems, including street flooding and ponding, occurred on June 21, 1997 and August 6, 1998. Those problems contributed to sanitary sewer backups, especially in the vicinity of Elmhurst Parkway; however, the 1998 Village flooding survey (see Maps 13 through 17) indicates that most of the problems experienced in this hydrologic unit were due to clearwater flooding of basements through window wells, walls, and overflow from sump crocks. Among those who responded to the survey, slightly more than half experienced flooding for the second time. Most of the remaining respondents experienced flooding for the first time. A small number experienced their third instance of flooding. The relatively large number of residences experiencing flooding for the first time is consistent with the extreme nature of the storm.

Alternative Stormwater Drainage Plans

The identified stormwater management problems can readily be solved through the provision of increased hydraulic capacity at existing culverts. There are no available locations in this hydrologic unit for the provision of significant effective detention storage outside of those identified along Underwood Creek under the floodland management element of this plan. Significant increases in flood flows in Underwood Creek would not be expected as a result of the proposed culvert replacements. The development of multiple alternative plans is not considered to be necessary and a storm sewer and culvert conveyance plan was developed as described below.

The proposed measures address identified drainage problems in the minor and major systems. The solution of those problems will also help alleviate sanitary sewer backup problems. Yard and basement flooding problems due to local yard grading conditions are not addressed by the proposed measures.

Preliminary Recommended Stormwater Drainage Plan for Hydrologic Unit UC-9

To alleviate major system problems in the general vicinity of Elmhurst Parkway, it is recommended that 1) the 44-foot-long, 18-inch-diameter CMP culvert under Fairhaven Boulevard at Elmhurst Parkway be replaced with a 24-inch-high by 35-inch-wide CMPA culvert; 2) the 31-foot-long, 18-inch-diameter CMP culvert under Shady Lane at Elmhurst Parkway be replaced with a 24-inch-high by 35-inch-wide CMPA culvert; 3) the 37-foot-long, 21-inch-diameter CMP culvert under Blue Ridge Boulevard at Elmhurst Parkway be replaced with a 29-inch-high by 42-inch-wide CMPA culvert; 4) the 438-foot-long, 27-inch-high by 42-inch-wide CMPA storm sewer located between the northern and southern lanes of Elmhurst Parkway just west of Notre Dame Boulevard be replaced with a 36-inch-high by 58-inch-wide RCPA storm sewer; and 5) the 962-foot-long, 27-inch-high by 42-inch-wide CMPA storm sewer located between the northern and southern lanes of Elmhurst Parkway between Church Street and Legion Drive be replaced with a 40-inch-high by 65-inch-wide RCPA storm sewer. The recommended system is shown on Map 46.

As set forth in Table 46, the total capital cost of this plan is estimated to be $409,000. The present value cost is also estimated to be $409,000, since implementation of the recommendations would not result in an increase in annual operation and maintenance costs.

Hydrologic Unit UC-10

Description and Evaluation of the Stormwater Management System

As shown on Map 12, Hydrologic Unit UC-10 is a 374-acre area located in the southeastern portion of the Underwood Creek subwatershed. About 80 percent of the unit is in the City of Brookfield and 20 percent is in the Village of Elm Grove. The Brookfield portion of the unit is located south of

W. Bluemound Road between N. and S. Eastmoor Avenue on the west and Elm Grove Road on the east. That area includes the Bishops Woods business park. The Elm Grove portion of the unit is located north of W. Bluemound Road, south of Watertown Plank Road, and between Sunny Slope Road on the west and the Canadian Pacific Railway on the east. The Bishops Woods Tributary flows from southwest to northeast through the western part the hydrologic unit, receiving most of the runoff from the unit.

In 1990, about 68 percent of the unit was in urban uses, including about 27 percent low-density residential, about 27 percent commercial, about 7 percent medium-density residential, and about 7 percent freeway (IH 94). About 32 percent of the unit was in rural uses in 1990, including 14 percent in woodlands, 14 percent open lands, and 4 percent wetlands. Under buildout conditions, some of the open lands and woodlands would be developed, resulting in urban uses in about 87 percent of the unit. Commercial uses would comprise about 42 percent of the unit, low-density residential lands about 32 percent of the unit, medium-density residential lands about 11 percent of the unit, and recreational uses about 2 percent. The 13 percent of the unit in rural land use would be isolated natural resource areas consisting predominantly of wetlands and woodlands.

The stormwater drainage system in the hydrologic unit consists primarily of storm sewers and interconnected streams and drainage swales. A small pond is located at the headwaters of the Bishops Woods Tributary and there are two onsite, dry detention basins in the southwestern portion of the Bishops Woods business park.

The Bishops Woods Tributary is the source of some reported flooding problems in the hydrologic unit. The lower level parking garages of one apartment building on each side of the Tributary in Elm Grove between Elm Grove Road and the Canadian Pacific Railway were flooded on August 6, 1998. The basements of condominiums located in Brookfield, east of the Tributary, and on the west side of Elm Grove Road were reportedly flooded on June 21, 1997, but did not flood on August 6, 1998, following the removal of vegetation from the Tributary channel and banks.[47] The analyses performed for this planning effort indicate that the apartment garages could be flooded during a 100-year storm under buildout land use conditions, but the condominiums would not be expected to receive direct overland flooding during such a storm. Thus, the alternative plans set forth below address the garage flooding issue, but no measures are proposed relative to the condominiums since the planning standard for protection from direct flooding during a 100-year storm is met.

The first floor of the office building located southwest of the intersection of Bishops Court and Bishops Way was flooded to a depth of less than one foot on August 6, 1998. Based on interviews with the management contractor for the Bishops Woods Association and review of large-scale topographic maps of the area, it appears that the flooding of that office building was caused by runoff from a relatively localized area of the business park to the west of the building. The topographic map indicates there are adequate major drainage system flow paths to accommodate runoff according to the evaluation criteria established for this plan. Accordingly, the building is not expected to be directly flooded for storms up to the 100-year recurrence event. Thus, the solution of the drainage problem at the office building should be addressed through site-specific measures undertaken by the owner.

Alternative Stormwater Drainage Plans

The flooding problems at the two apartment buildings in Elm Grove could be solved either through 1) the provision of additional culvert capacity, 2) the provision of upstream detention storage, or 3) implementation of localized floodproofing measures. Those three alternative approaches were considered for the alleviation of those problems during storms with recurrence intervals up to, and including, 100 years.

Alternative Plan No. UC-10a—Culvert Conveyance

Under this alternative plan, additional culverts would be provided in the Village of Elm Grove under the Canadian Pacific Railway and the apartment complex

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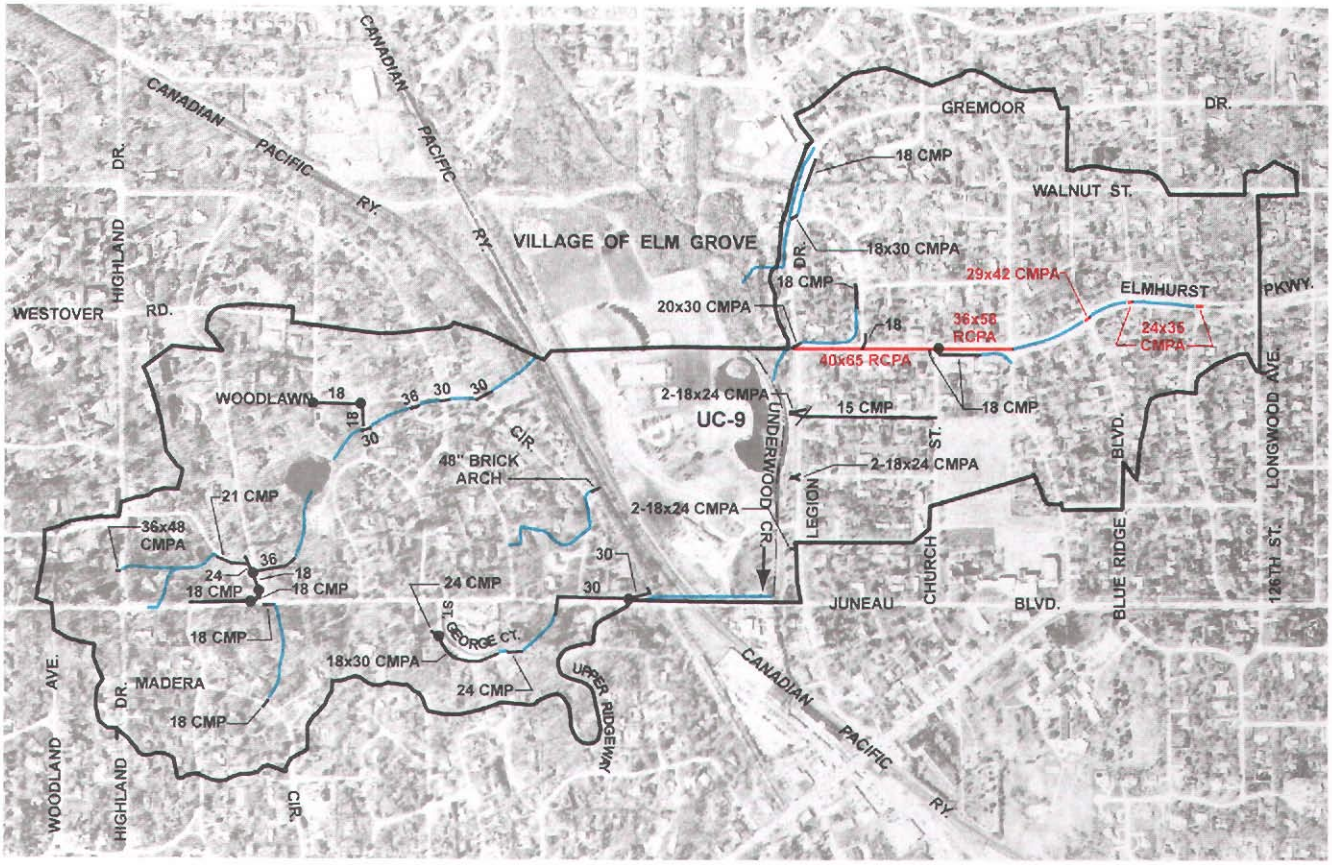
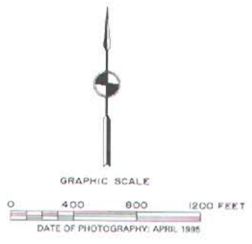
[47] *The Bishops Woods Association, rather than the City of Brookfield, is responsible for the maintenance of the Tributary channel and banks within the Bishops Woods business park.*

Map 46

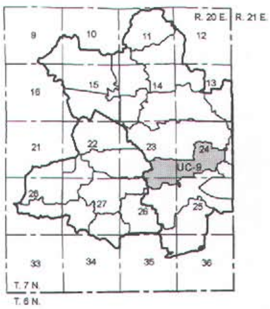
PRELIMINARY RECOMMENDED PLAN FOR HYDROLOGIC UNIT UC-9
STORM SEWER AND CULVERT CONVEYANCE



—	HYDROLOGIC UNIT BOUNDARY
UC-9	HYDROLOGIC UNIT IDENTIFICATION
→	HYDROLOGIC UNIT OUTLINE
18	EXISTING STORM SEWER OR CULVERT TO BE RETAINED (SIZE IN INCHES)
●	EXISTING MANHOLE OR CATCH BASIN
—	EXISTING OPEN CHANNEL OR FLOW PATH
40x65	PROPOSED REPLACEMENT STORM SEWER OR CULVERT (SIZE IN INCHES)
NOTE:	THIS MAP GENERALLY SHOWS EXISTING STORM SEWERS OF 18-INCH DIAMETER OR LARGER. PIPES ARE CONSTRUCTED OF REINFORCED CONCRETE UNLESS DESIGNATED AS BELOW.
CMP	CORRUGATED METAL PIPE
CMPA	CORRUGATED METAL PIPE ARCH
RCPA	REINFORCED CONCRETE PIPE ARCH



DOUSMAN DITCH AND
UNDERWOOD CREEK SUBWATERSHEDS
HYDROLOGIC UNIT LOCATION MAP



Source: SEWRPC.

Table 46

COMPONENTS AND COSTS OF STORM SEWER AND CULVERT CONVEYANCE STORMWATER DRAINAGE PLAN FOR HYDROLOGIC UNIT UC-9

Location of Component	Project and Component Designation and Description	Estimated Cost[a]	
		Capital[b]	Annual Operation and Maintenance[c]
Village of Elm Grove	1. UC9-C1—Replace the 44-foot-long, 18-inch-diameter CMP culvert under Fairhaven Boulevard at Elmhurst Parkway with a 24-inch-high by 35-inch-wide CMPA culvert	$ 5,000	$0
	2. UC9-C2—Replace the 31-foot-long, 18-inch-diameter CMP culvert under Shady Lane at Elmhurst Parkway with a 24-inch-high by 35-inch-wide CMPA culvert	4,000	0
	3. UC9-C3—Replace the 37-foot-long, 21-inch-diameter CMP culvert under Blue Ridge Boulevard at Elmhurst Parkway with a 29-inch-high by 42-inch-wide CMPA culvert	5,000	0
	4. UC9-C6—Replace the 438-foot-long, 27-inch-high by 42-inch-wide CMPA storm sewer located between the northern and southern lanes of Elmhurst Parkway just west of Notre Dame Boulevard with a 36-inch-high by 58-inch-wide RCPA storm sewer	111,000	0
	5. UC9-C8 and UC9C11—Replace the 962-foot-long, 27-inch-high by 42-inch-wide CMPA storm sewer located between the northern and southern lanes of Elmhurst Parkway between Church Street and Legion Drive with a 40-inch-high by 65-inch-wide RCPA storm sewer	284,000	0
	Total	$409,000	$0

[a] *Costs based upon 1998* Engineering News-Record *Construction Cost Index = 6,740.*

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

[c] *Operation and maintenance costs are listed as $0 when an existing component is replaced with a component having similar operation and maintenance costs.*

Source: SEWRPC.

parking lot, as set forth in Table 47 and as shown on Map 47.

A 62-foot-long, 48-inch-diameter RCP culvert would be installed under the railway to supplement the existing 70-inch-high by 95-inch-wide CMPA. A 253-foot-long, 54-inch-diameter RCP culvert would be installed under the apartment parking lot to supplement the existing 60-inch-high by 96-inch-wide HE RCP. As set forth in Table 47, the total present value cost of this alternative is estimated to be $150,000, consisting of an estimated capital cost of $148,000 and an estimated annual operation and maintenance cost increase of $100.

Table 47

COMPONENTS AND COSTS OF THE CULVERT CONVEYANCE ALTERNATIVE STORMWATER DRAINAGE PLAN FOR HYDROLOGIC UNIT UC-10 (ALTERNATIVE PLAN NO. UC-10a)

Location of Component	Project and Component Designation and Description	Estimated Cost[a]	
		Capital[b]	Annual Operation and Maintenance[c]
Village of Elm Grove	1. UC10-C33—Install a 62-foot-long, 48-inch-diameter RCP culvert under the Canadian Pacific Railway	$ 86,000[c]	$ 20
	2. UC10-C32—Install a 253-foot-long, 54-inch-diameter RCP under the apartment complex parking lot	62,000	80
	Total	$148,000	$100

[a] *Costs based upon 1998* Engineering News-Record *Construction Cost Index = 6,740.*

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

[c] *The cost of the culvert under the railway is greater than the cost of the apartment complex culvert, despite being both smaller in diameter and shorter because it was assumed that the railway culvert would have to be jacked in place, rather than constructed with an open trench.*

Source: SEWRPC.

Alternative Plan No. UC-10b—Detention Storage

The effects of providing detention storage in the Bishops Woods business park were investigated. Current City policy calls for the provision of detention storage for new development; however, comparison of the peak 100-year storm rate of runoff under existing and planned buildout land use conditions indicated that detaining runoff from new development alone would not eliminate the potential for flooding of the basement parking garages at the Elm Grove apartment complex. Thus, the provision of expanded detention storage of runoff from areas of existing and planned development was also investigated. It was found that the provision of detention basins on existing open sites would not provide sufficient control of the peak rate to eliminate flooding of the apartment garages. Because the provision of detention storage would not be a feasible means of alleviating structure flooding, alternative plan components were not developed.

Alternative Plan No. UC-10c—
Structure Floodproofing

Based on hydraulic analyses of the Bishops Woods Tributary and field inspection of the Elm Grove apartment complex site, it was determined that the basement garages at that site could be floodproofed through the implementation of parking lot and driveway grading and paving modifications. Such modifications would raise the grade at the entrances to each of the two basement garages, while enabling overland flow from west to east across the driveway area. That overland flow would reenter the Bishops Woods Tributary east of the complex. The approximate area to be regraded and repaved is shown on Map 48.

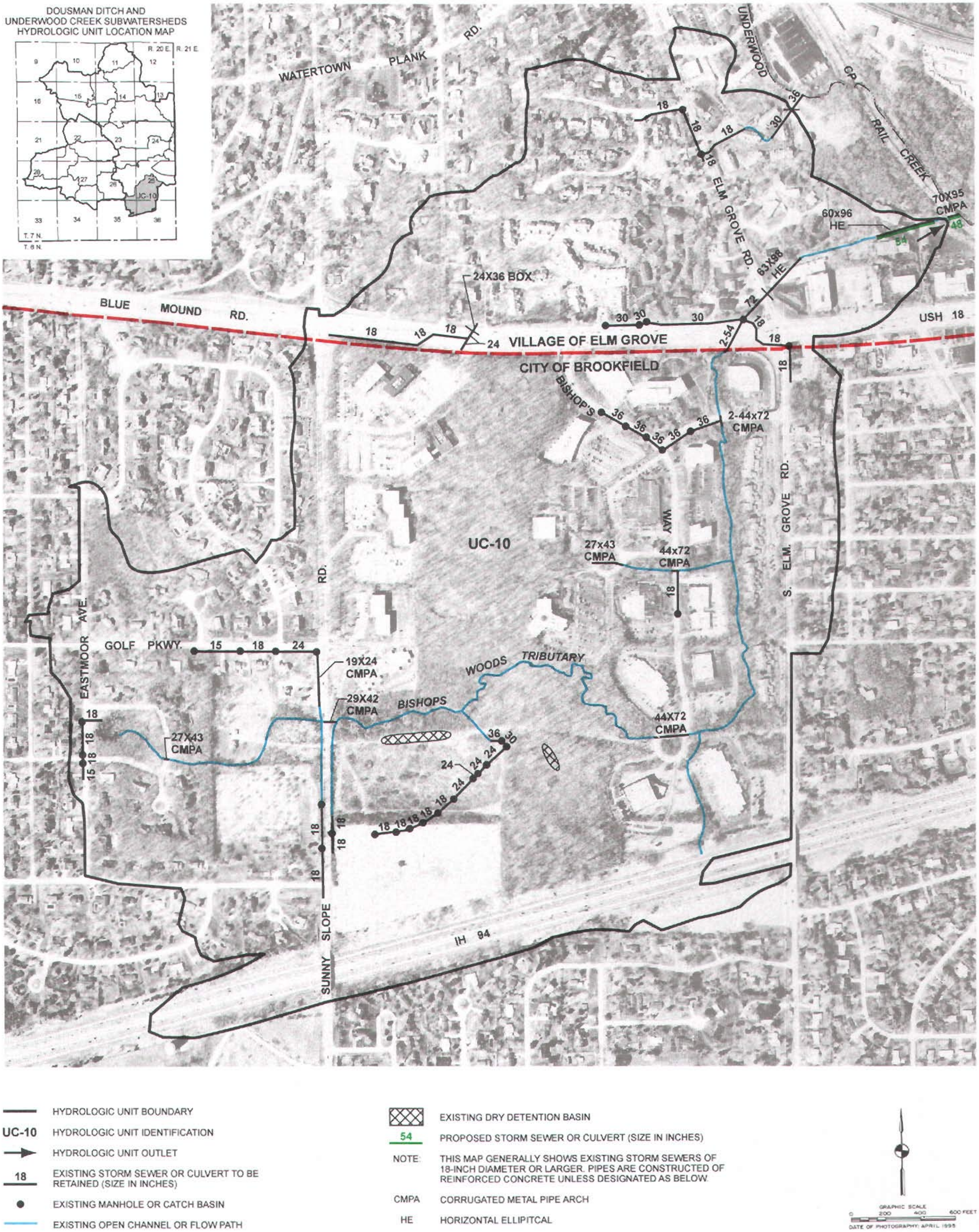
As set forth in Table 48, the total capital cost of this alternative is estimated to be $45,000. The present value cost is also estimated to be $45,000, since implementation of the recommendation would not result in an increase in annual operation and maintenance costs.

Evaluation of Alternative Stormwater Drainage Plans

The foregoing information provides a basis for a comparative evaluation of the alternative plans. The principal criteria for the comparative evaluation were cost and potential impacts on flood flows and stages

Map 47

ALTERNATIVE PLAN NO. UC-10a
CULVERT CONVEYANCE



Source: SEWRPC.

along Underwood Creek. The alternatives provide similar levels of protection. As stated above, Alternative Plan No. UC-10b, Detention Storage, was found to be not feasible and it was, therefore, eliminated from further consideration.

Alternative Plan No. UC-10c is the less costly alternative and its implementation would not increase flood flows and stages along Underwood Creek. Implementation of Alternative Plan No. UC-10a could increase peak flood flows along Underwood Creek because it would result in a significant increase in the hydraulic capacity of the Hydrologic Unit outlet at the railway.

Preliminary Recommended Stormwater Drainage Plan for Hydrologic Unit UC-10

Based on the considerations described above, Alternative Plan No. UC-10c, Structure Floodproofing, is selected as the preliminary recommended plan.

Hydrologic Unit UC-11

Description and Evaluation of the Stormwater Management System

As shown on Map 12, Hydrologic Unit UC-11 is a 425-acre area located in the southeastern portion of the Underwood Creek subwatershed. About 10 percent of the unit is in the City of Brookfield and 90 percent is in the Village of Elm Grove. The Brookfield portion of the unit is located south of W. Bluemound Road between N. Beaumont Avenue on the west and Sunny Slope Road on the east. The Elm Grove portion of the unit is generally located between W. Bluemound Road on the south, Juneau boulevard on the north, Highland Drive on the west, and the Village limits on the east. Underwood Creek flows from northwest to southeast through the eastern portion of the unit.

The hydrologic unit was essentially under full build-out land use conditions in 1990. About 96 percent of the unit is in urban uses, including about 69 percent low-density residential, 12 percent commercial, 9 percent industrial, 5 percent governmental and institutional, and 1 percent recreational uses. The 4 percent of the unit in rural land use is secondary environmental corridor, consisting of open lands along Underwood Creek.

The stormwater drainage system in the hydrologic unit consists primarily of roadside swales and culverts with storm sewers and urban street cross sections in the vicinity of both Watertown Plank Road and W. Bluemound Road.

The results of the 1998 Village flooding survey (see Maps 13 through 17) indicate that most of the problems experienced in this hydrologic unit were due to clearwater flooding of basements through window wells, walls, and overflow from sump crocks. Some of those problems may be attributable to the loss of electrical power as was reported at numerous scattered locations throughout the unit. Sanitary sewer backups were also reported, but to a lesser degree than clearwater flooding. Among those who responded to the survey, most experienced flooding for the second time.

The hydrologic and hydraulic modeling performed for this study identified minor and major stormwater drainage system problems at several locations along the drainageway along the north side of Watertown Plank Road between Highland Drive and Underwood Creek. Inadequate minor system capacity was identified at the culvert under Sunny Slope Road, just north of Watertown Plank Road. Inadequate major system capacity was identified at the culvert on the west side of Grandview Drive and the culvert under Kurtis Drive.

Alternative Stormwater Drainage Plans

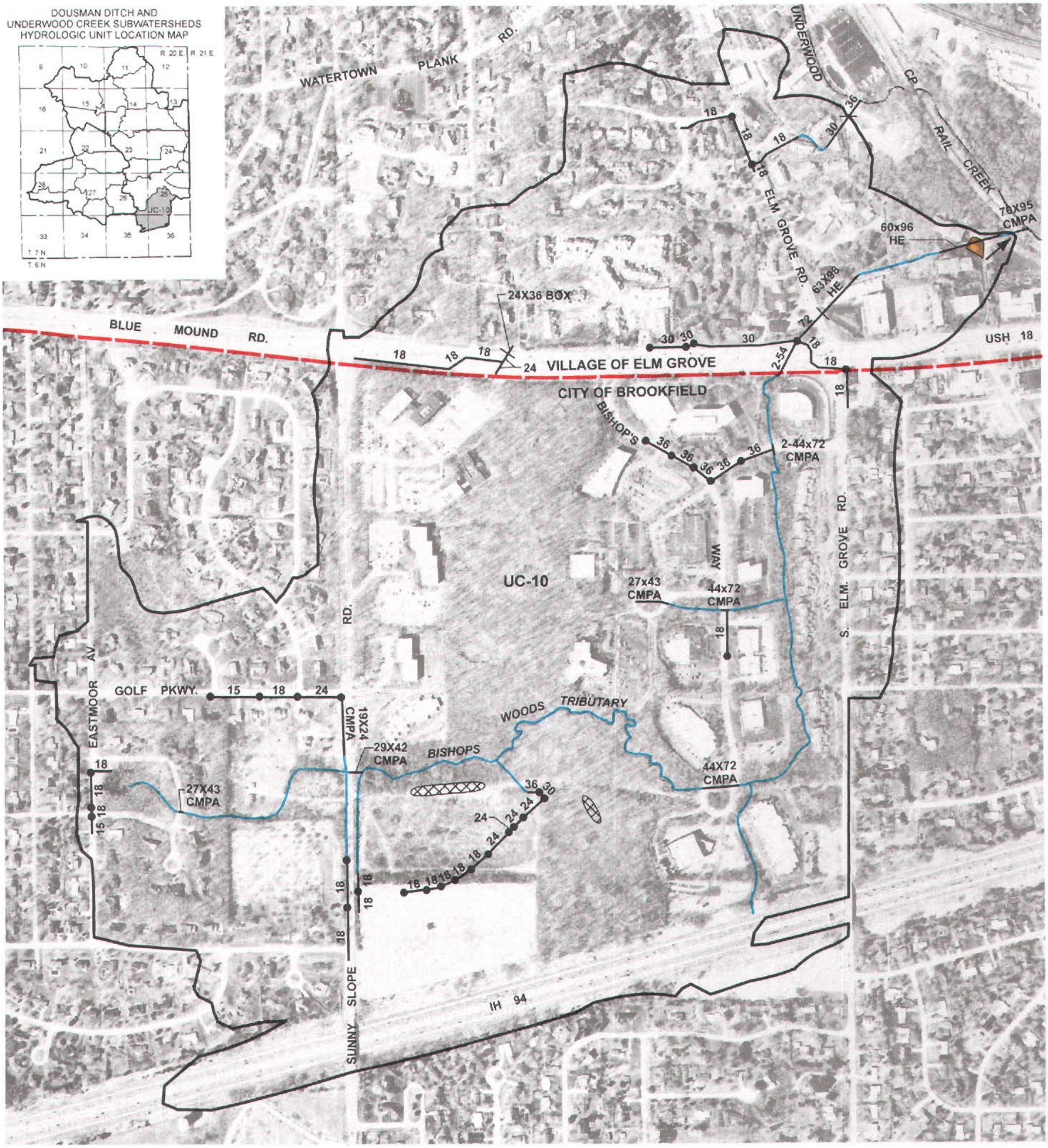
Two alternative plans were developed for the alleviation of those problems during storms with recurrence intervals up to, and including, 100 years. Those include: 1) a culvert and swale conveyance plan and 2) a detention storage with culvert and swale conveyance plan.

Alternative Plan No. UC-11a—Culvert and Swale Conveyance

As shown on Map 49, to alleviate minor and major system problems along the drainageway north of Watertown Plank Road, this alternative plan calls for 1) the 176-foot-long, combination 15-inch-diameter RCP and 24-inch-diameter CMP culvert located west of Grandview Drive to be replaced with a 27-inch-high by 44-inch-wide RCPA culvert; 2) the 55-foot-long, 21-inch-high by 36-inch-wide CMPA culvert under Kurtis Drive to be replaced with two, parallel 205-foot-long, 27-inch-high by 44-inch-wide RCPA culverts; and 3) the 37-foot-long, 15-inch-diameter CMP culvert under Sunny Slope Road north of Watertown Plank Road to be replaced with a 23-inch-high by 36-inch-wide RCPA culvert.

Map 48

ALTERNATIVE PLAN NO. UC-10c STRUCTURE FLOODPROOFING



—	HYDROLOGIC UNIT BOUNDARY
UC-10	HYDROLOGIC UNIT IDENTIFICATION
→	HYDROLOGIC UNIT OUTLET
18	EXISTING STORM SEWER OR CULVERT TO BE RETAINED (SIZE IN INCHES)
●	EXISTING MANHOLE OR CATCH BASIN
—	EXISTING OPEN CHANNEL OR FLOW PATH
▨	EXISTING DRY DETENTION BASIN
🟧	REGRADE AND REPAVE EASTERN DRIVEWAY AREA AT ELM GROVE APARTMENT COMPLEX
NOTE:	THIS MAP GENERALLY SHOWS EXISTING STORM SEWERS OF 18-INCH DIAMETER OR LARGER. PIPES ARE CONSTRUCTED OF REINFORCED CONCRETE UNLESS DESIGNATED AS BELOW.
CMPA	CORRUGATED METAL PIPE ARCH
HE	HORIZONTAL ELLIPITCAL

GRAPHIC SCALE
0 200 400 600 FEET
DATE OF PHOTOGRAPHY: APRIL 1995

Source: SEWRPC.

Table 48

COMPONENTS AND COSTS OF THE STRUCTURE FLOODPROOFING STORMWATER DRAINAGE PLAN FOR HYDROLOGIC UNIT UC-10 (ALTERNATIVE PLAN NO. UC-10c)

Location of Component	Project and Component Designation and Description	Estimated Cost[a]	
		Capital[b]	Annual Operation and Maintenance[c]
Village of Elm Grove	1. Regrade and repave eastern driveway area at Elm Grove apartment complex	$45,000	$0
	Total	$45,000	$0

[a] *Costs based upon 1998* Engineering News-Record *Construction Cost Index = 6,740.*

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

[c] *Operation and maintenance costs are listed as $0 when an existing component is replaced with a component having similar operation and maintenance costs.*

Source: SEWRPC.

annual operation and maintenance cost increase of $100.

Alternative Plan No. UC-11b—Detention Storage

As shown on Map 50, under this alternative plan, a detention basin with a maximum storage volume of about 0.9 acre-feet during a 100-year storm would be constructed on the Community United Methodist Church property south of the church building and northeast of the intersection of Highland Drive and Watertown Plank Road. The provision of detention storage would enable the sizes of the downstream replacement culverts to be reduced. In addition to constructing the detention basin, this alternative plan calls for 1) the 237-foot-long, 12-inch-diameter RCP culvert on the church property west of San Jose Drive be replaced with a new 12-inch-diameter RCP culvert to accommodate the proposed detention basin; 2) the 176-foot-long, combination 15-inch-diameter RCP and 24-inch-diameter CMP culvert located west of Grandview Drive be replaced with a 23-inch-high by 36-inch-wide RCPA culvert; 3) the 55-foot-long, 21-inch-high by 36-inch-wide CMPA culvert under Kurtis Drive be replaced with a 205-foot-long, 27-inch high by 44-inch-wide RCPA culvert; and 4) the 37-foot-long, 15-inch-diameter CMP culvert under Sunny Slope Road north of Watertown Plank Road be replaced with an 18-inch-high by 29-inch-wide RCPA culvert.

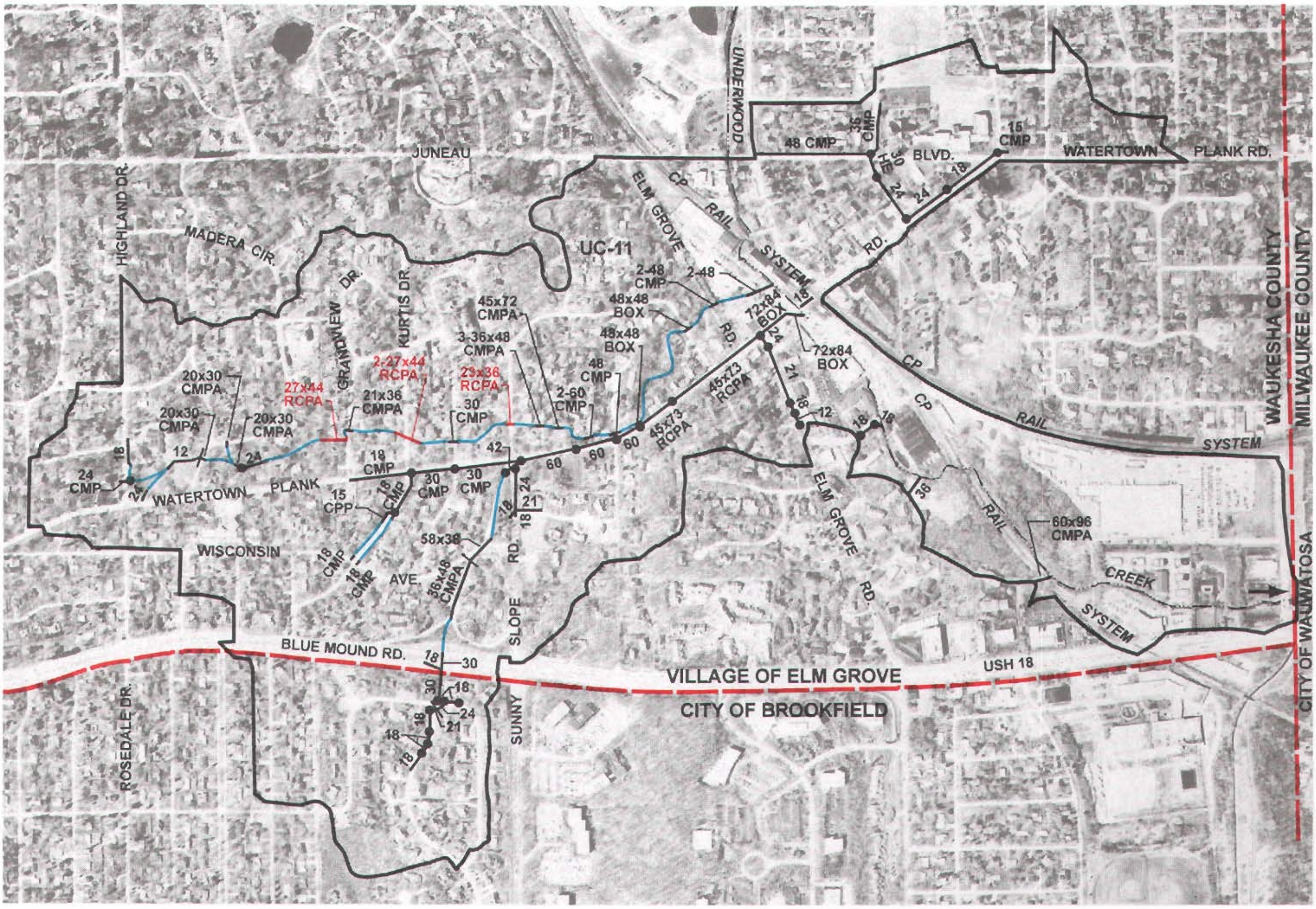
As set forth in Table 50, the total present value cost of this alternative is estimated to be $242,000, consisting of an estimated capital cost of $210,000 and an estimated annual operation and maintenance cost increase of $2,000.

Evaluation of Alternative Stormwater Drainage Plans

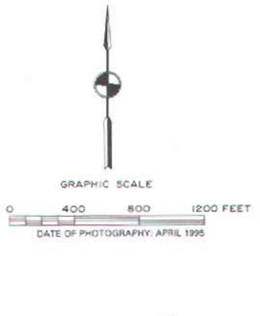
The foregoing information provides a basis for a comparative evaluation of the two alternative plans. The principal criteria for the comparative evaluation were cost and implementability. The detention alternative would reduce peak flows somewhat, especially in the reaches closest to the proposed detention basin. Thus, although both alternative plans provide a similar degree of protection of buildings, a secondary consideration in the comparison is the depths of flow in the drainageway during large storms.

Map 49

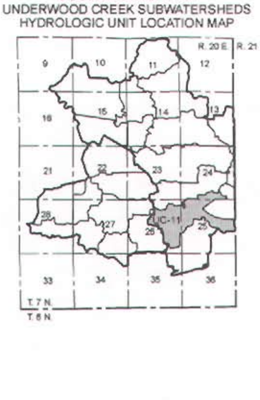
ALTERNATIVE PLAN NO. UC-11a
CULVERT AND SWALE CONVEYANCE



—	HYDROLOGIC UNIT BOUNDARY
UC-11	HYDROLOGIC UNIT IDENTIFICATION
→	HYDROLOGIC UNIT OUTLET
18	EXISTING STORM SEWER OR CULVERT TO BE RETAINED (SIZE IN INCHES)
●	EXISTING MANHOLE OR CATCH BASIN
—	EXISTING OPEN CHANNEL OR FLOW PATH
27x44	PROPOSED REPLACEMENT STORM SEWER OR CULVERT (SIZE IN INCHES)
NOTE:	THIS MAP GENERALLY SHOWS EXISTING STORM SEWERS OF 18-INCH DIAMETER OR LARGER. PIPES ARE CONSTRUCTED OF REINFORCED CONCRETE UNLESS DESIGNATED AS BELOW.
CMP	CORRUGATED METAL PIPE
CMPA	CORRUGATED METAL PIPE ARCH
CPP	CORRUGATED POLYETHYLENE PIPE
HE	HORIZONTAL ELLIPTICAL
RCPA	REINFORCED CONCRETE PIPE ARCH



DOUSMAN DITCH AND
UNDERWOOD CREEK SUBWATERSHEDS
HYDROLOGIC UNIT LOCATION MAP



Source: SEWRPC.

Table 49

COMPONENTS AND COSTS OF THE CULVERT AND SWALE CONVEYANCE STORMWATER DRAINAGE PLAN FOR HYDROLOGIC UNIT UC-11 (ALTERNATIVE PLAN NO. UC-11a)

Location of Component	Project and Component Designation and Description	Estimated Cost[a]	
		Capital[b]	Annual Operation and Maintenance[c]
Village of Elm Grove	1. UC11C8—Replace the 176-foot-long, combination 15-inch-diameter RCP and 24-inch-diameter CMP culvert located west of Grandview Drive with a 27-inch-high by 44-inch-wide RCPA culvert	$ 34,000	$ 0
	2. UC11C10—Replace the 55-foot-long, 21-inch-high by 36-inch-wide CMPA culvert under Kurtis Drive with two parallel 205-foot-long, 27-inch-high by 44-inch-wide RCPA culverts	79,000	100
	3. UC11C14—Replace the 37-foot-long, 15-inch-diameter CMP culvert under Sunny Slope Road north of Watertown Plank Road with a 23-inch-high by 36-inch-wide RCPA culvert	6,000	0
	Total	$119,000	$100

[a] *Costs based upon 1998* Engineering News-Record *Construction Cost Index = 6,740.*

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

[c] *Operation and maintenance costs are listed as $0 when an existing component is replaced with a component having similar operation and maintenance costs.*

Source: SEWRPC.

Alternative Plan No. UC-11a is the least costly alternative. Implementation of Alternative Plan No. UC-11a could increase the peak 100-year flow at the mouth of the drainageway by about 5 percent; however, the impact of that change in flow on flood flows in Underwood Creek would be negligible. Alternative Plan No. UC-11b would maintain the existing peak 100-year flow at the mouth of the drainageway and it would also reduce flow depths along the drainageway somewhat, although any reductions would not be needed to avoid flooding of buildings. Alternative Plan No. UC-11b would be more difficult to implement than the other alternative because it would require purchasing land from the Community United Methodist Church.

Preliminary Recommended Stormwater Drainage Plan for Hydrologic Unit UC-11

Based on cost and implementability, Alternative Plan No. UC-11a-Culvert and Swale Conveyance, is selected as the preliminary recommended plan.

Hydrologic Unit UC-13[48]

Description and Evaluation of the Stormwater Management System

Hydrologic Unit UC-13 is a 44-acre area located primarily in the eastern part of the Village of Elm Grove, as shown on Map 12. About 92 percent of

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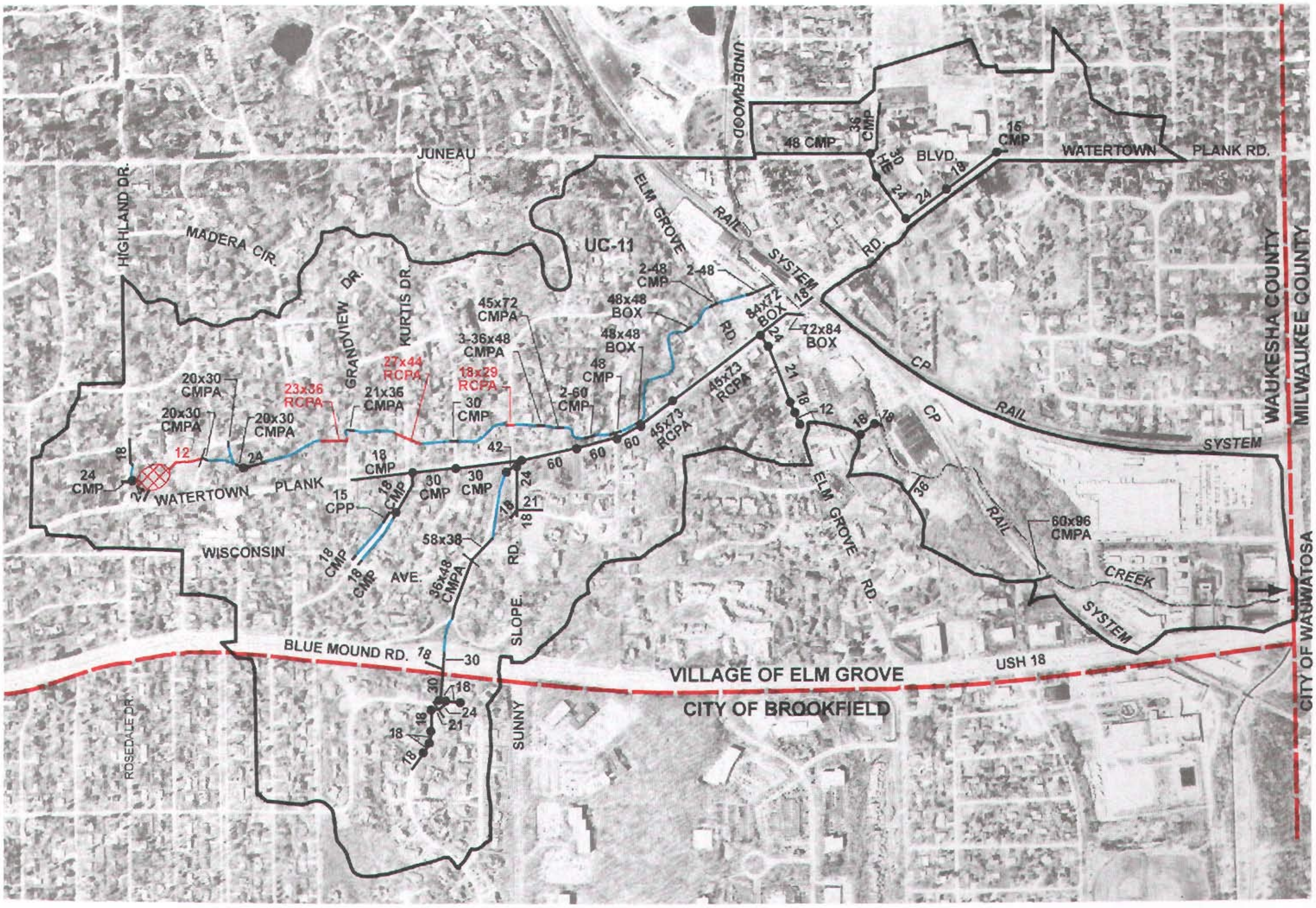
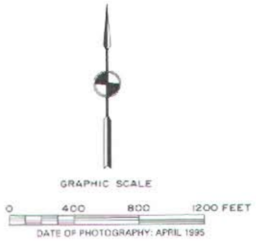
[48] *Note that there is no Hydrologic Unit UC-12.*

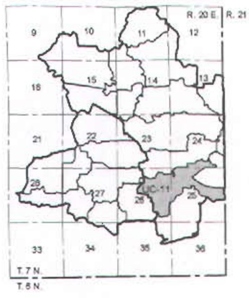
Map 50

ALTERNATIVE PLAN NO. UC-11b
DETENTION STORAGE





DOUSMAN DITCH AND UNDERWOOD CREEK SUBWATERSHEDS HYDROLOGIC UNIT LOCATION MAP



— HYDROLOGIC UNIT BOUNDARY

UC-11 HYDROLOGIC UNIT IDENTIFICATION

→ HYDROLOGIC UNIT OUTLET

18 EXISTING STORM SEWER OR CULVERT TO BE RETAINED (SIZE IN INCHES)

● EXISTING MANHOLE OR CATCH BASIN

— EXISTING OPEN CHANNEL OR FLOW PATH

RCPA PROPOSED REPLACEMENT STORM SEWER OR CULVERT (SIZE IN INCHES)

▨ PROPOSED DETENTION BASIN (0.9 ACRE FEET)

NOTE: THIS MAP GENERALLY SHOWS EXISTING STORM SEWERS OF 18-INCH DIAMETER OR LARGER. PIPES ARE CONSTRUCTED OF REINFORCED CONCRETE UNLESS DESIGNATED AS BELOW

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

Source: SEWRPC.

Table 50

COMPONENTS AND COSTS OF THE DETENTION STORAGE AND CULVERT AND SWALE CONVEYANCE STORMWATER DRAINAGE PLAN FOR HYDROLOGIC UNIT UC-11 (ALTERNATIVE PLAN NO. UC-11b)

Location of Component	Project and Component Designation and Description	Estimated Cost[a]	
		Capital[b]	Annual Operation and Maintenance[c]
Village of Elm Grove	1. Construct a 0.9 acre-foot detention basin (includes estimated land acquisition cost)	$120,000	$1,900
	2. UC11C4—Replace the 237-foot-long, 12-inch-diameter RCP culvert on the church property west of San Jose Drive with a new 12-inch-diameter RCP culvert to accommodate the proposed detention basin	17,000	0
	3. UC11C8—Replace the 176-foot-long, combination 15-inch-diameter RCP and 24-inch-diameter CMP culvert located west of Grandview Drive with a 23-inch-high by 36-inch-wide RCPA culvert	29,000	0
	4. UC11C10—Replace the 55-foot-long, 21-inch-high by 36-inch-wide CMPA culvert under Kurtis Drive with a 205-foot-long, 27-inch-high by 44-inch-wide RCPA culvert	39,000	100
	5. UC11C14—Replace the 37-foot-long, 15-inch-diameter CMP culvert under Sunny Slope Road north of Watertown Plank Road with an 18-inch-high by 29-inch-wide RCPA culvert	5,000	0
	Total	$210,000	$2,000

[a] *Costs based upon 1998* Engineering News-Record *Construction Cost Index = 6,740.*

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

[c] *Operation and maintenance costs are listed as $0 when an existing component is replaced with a component having similar operation and maintenance costs.*

Source: SEWRPC.

the unit is located in Elm Grove and the remainder is located in the City of Brookfield. The hydrologic unit is located along the Milwaukee-Waukesha County line between W. North Avenue and Elmhurst Parkway.

The hydrologic unit was essentially under full buildout land use conditions in 1990. All of the unit is developed in urban uses, including about 92 percent low-density residential and 8 percent commercial uses.

The stormwater drainage system consists of a system of roadside swales and culverts that discharge to the City of Wauwatosa stormwater management system at the intersection of Elmhurst Parkway and N. 124th Street.

The 1998 Village flooding survey (see Maps 13 through 17) indicates that most of the problems experienced in this hydrologic unit were due to clearwater flooding of basements through window wells, walls, and overflow from sump crocks. A few houses in the hydrologic unit lost electrical power and a few experienced sanitary sewer backup. Among those who responded to the survey, slightly more than half experienced flooding for the second time. The remaining respondents experienced flooding for the first time. The relatively large number of residences experiencing flooding for the first time is consistent with the extreme nature of the storm.

Alternative Stormwater Drainage Plans

The identified stormwater management problems can readily be solved through the provision of increased hydraulic capacity at existing culverts. There are no available locations in this hydrologic unit for the provision of significant effective detention storage. Significant increases in flows conveyed to the City of Wauwatosa system would not be expected as a result of upgrading the capacities of selected tributary culverts. The development of multiple alternative plans is not considered to be necessary and a culvert conveyance plan was developed as described below.

The proposed measures address identified drainage problems in the minor system. The solution of those problems will also help alleviate sanitary sewer backup problems. Yard and basement flooding problems due to local yard grading conditions are not addressed by the proposed measures.

Preliminary Recommended Stormwater Drainage Plan for Hydrologic Unit UC-13

To alleviate minor system problems, it is recommended that 1) the 48-foot-long, 15-inch-diameter CMP culvert under Gremoor Drive just west of N. 124th Street be replaced with an 18-inch-diameter CMP culvert and 2) the 100-foot-long, 18-inch-diameter CMP culvert under Walnut Street just west of N. 124th Street be replaced with a 14-inch-high by 22-inch-wide RCPA culvert. The recommended system is shown on Map 51.

As set forth in Table 51, the total capital cost of this plan is estimated to be $19,000. The present value cost is also estimated to be $19,000, since implementation of the recommendations would not result in an increase in annual operation and maintenance costs.

Hydrologic Unit UC-14

Description and Evaluation of the Stormwater Management System

Hydrologic Unit UC-14 is a 156-acre area located primarily in the east-central part of the Village of Elm Grove, as shown on Map 12. The hydrologic unit is located along the Milwaukee-Waukesha County line north and south of Watertown Plank Road.

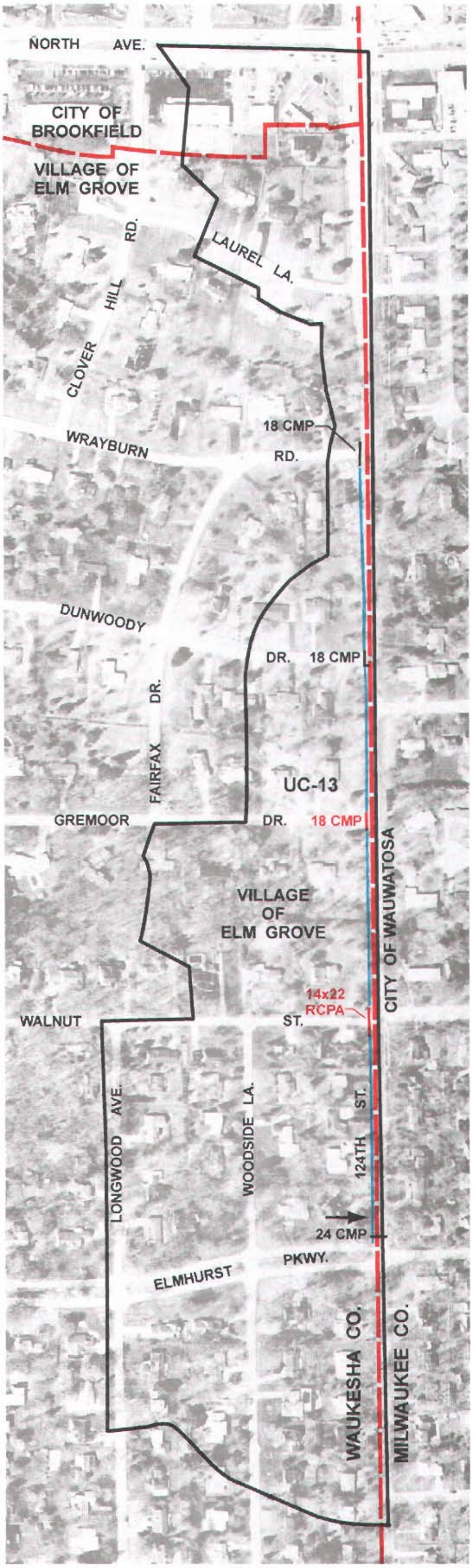
The hydrologic unit was essentially under full buildout land use conditions in 1990. All of the unit is developed in urban uses, including about 69 percent low-density residential, 24 percent governmental and institutional, 4 percent commercial, and 3 percent industrial uses.

The stormwater drainage system consists of a system of roadside swales and culverts that discharge to the City of Wauwatosa stormwater management system at the intersection of Centa Lane and N. 124th Street, at Knoll Road and N. 124th Street, and along the north side of the Canadian Pacific Railway at the Milwaukee-Waukesha County line.

The 1998 Village flooding survey (see Maps 13 through 17) indicates that most of the problems experienced in this hydrologic unit were due to clearwater flooding of basements through window wells, walls, and overflow from sump crocks. Many properties in the hydrologic unit lost electrical power and a few experienced sanitary sewer backup. Among those who responded to the survey, somewhat more than half experienced flooding for the second time. All but two of the remaining respondents experienced flooding for the first time. The relatively large number of properties experiencing flooding for the first time is consistent with the extreme nature of the storm.

Alternative Stormwater Drainage Plans

The identified stormwater management problems can readily be solved through the provision of increased hydraulic capacity at existing culverts. There are no available locations in this hydrologic unit for the provision of significant effective detention storage. The hydrologic and hydraulic models of the existing and proposed stormwater drainage system indicate that the peak flows conveyed to the City of Wauwatosa system would not be expected to increase as a result of the proposed culvert replacements. The development of multiple alternative plans is not

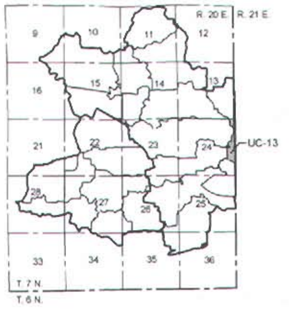


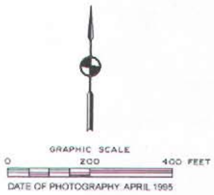
Map 51

PRELIMINARY RECOMMENDED CULVERT CONVEYANCE PLAN FOR HYDROLOGIC UNIT UC-13

—	HYDROLOGIC UNIT BOUNDARY
UC-13	HYDROLOGIC UNIT IDENTIFICATION
→	HYDROLOGIC UNIT OUTLET
18	EXISTING STORM SEWER OR CULVERT TO BE RETAINED (SIZE IN INCHES)
●	EXISTING MANHOLE OR CATCH BASIN
—	EXISTING OPEN CHANNEL OR FLOW PATH
18	PROPOSED REPLACEMENT STORM SEWER OR CULVERT (SIZE IN INCHES)
NOTE	THIS MAP GENERALLY SHOWS EXISTING STORM SEWERS OF 18-INCH DIAMETER OR LARGER. PIPES ARE CONSTRUCTED OF REINFORCED CONCRETE UNLESS DESIGNATED AS BELOW.
CMP	CORRUGATED METAL PIPE
RCPA	REINFORCED CONCRETE PIPE ARCH

DOUSMAN DITCH AND UNDERWOOD CREEK SUBWATERSHEDS HYDROLOGIC UNIT LOCATION MAP





Source: SEWRPC.

Table 51

COMPONENTS AND COSTS OF THE CULVERT CONVEYANCE STORMWATER DRAINAGE PLAN FOR HYDROLOGIC UNIT UC-13

Location of Component	Project and Component Designation and Description	Estimated Cost[a]	
		Capital[b]	Annual Operation and Maintenance[c]
Village of Elm Grove	1. UC13C3—Replace the 48-foot-long, 15-inch-diameter CMP culvert under Gremoor Drive just west of N. 124th Street with an 18-inch-diameter CMP culvert	$ 3,000	$0
	2. UC13C4—Replace the 100-foot-long, 18-inch-diameter CMP culvert under Walnut Street just west of N. 124th Street with a 14-inch-high by 22-inch-wide RCPA culvert	16,000	0
	Total	$19,000	$0

[a] *Costs based upon 1998* Engineering News-Record *Construction Cost Index = 6,740.*

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

[c] *Operation and maintenance costs are listed as $0 when an existing component is replaced with a component having similar operation and maintenance costs.*

Source: SEWRPC.

measures address identified drainage problems in the minor system.

Preliminary Recommended Stormwater Drainage Plan for Hydrologic Unit UC-14

To alleviate minor system problems, it is recommended that 1) the 55-foot-long, 12-inch-diameter CMP culvert on the west side of Longwood Avenue at Centa Lane be replaced with a 24-inch-diameter CMP culvert; 2) the 35-foot-long, 18-inch-diameter CMP culvert under Longwood Avenue at Centa Lane be replaced with a 24-inch-diameter CMP culvert; and 3) the 332-foot-long, 15- and 18-inch-diameter CMP culvert along the north side of Centa Lane between Longwood Avenue and Woodside Lane be replaced with a 24-inch-diameter CMP culvert. The recommended system is shown on Map 52.

As set forth in Table 52, the total capital cost of this plan is estimated to be $33,000. The present value cost is also estimated to be $33,000, since implementation of the recommendations would not result in an increase in annual operation and maintenance costs.

Hydrologic Unit UC-16[49]

Description and Evaluation of the Stormwater Management System

Hydrologic Unit UC-16 is a 153-acre area located in the eastern part of the City of Brookfield, as shown on Map 12. The hydrologic unit is located between N. 124th Street on the east, N. 131st Street on the west, W. North Avenue on the south, and Pinewood Road on the north.

The hydrologic unit was essentially under full build-out land use conditions in 1990. All of the unit is developed in urban uses, including about 85 percent low-density residential and 15 percent commercial.

The stormwater drainage system consists of a system of storm sewers that discharge to the City of Wauwatosa stormwater management system just south of the intersection of Arbor Drive and N. 124th Street.

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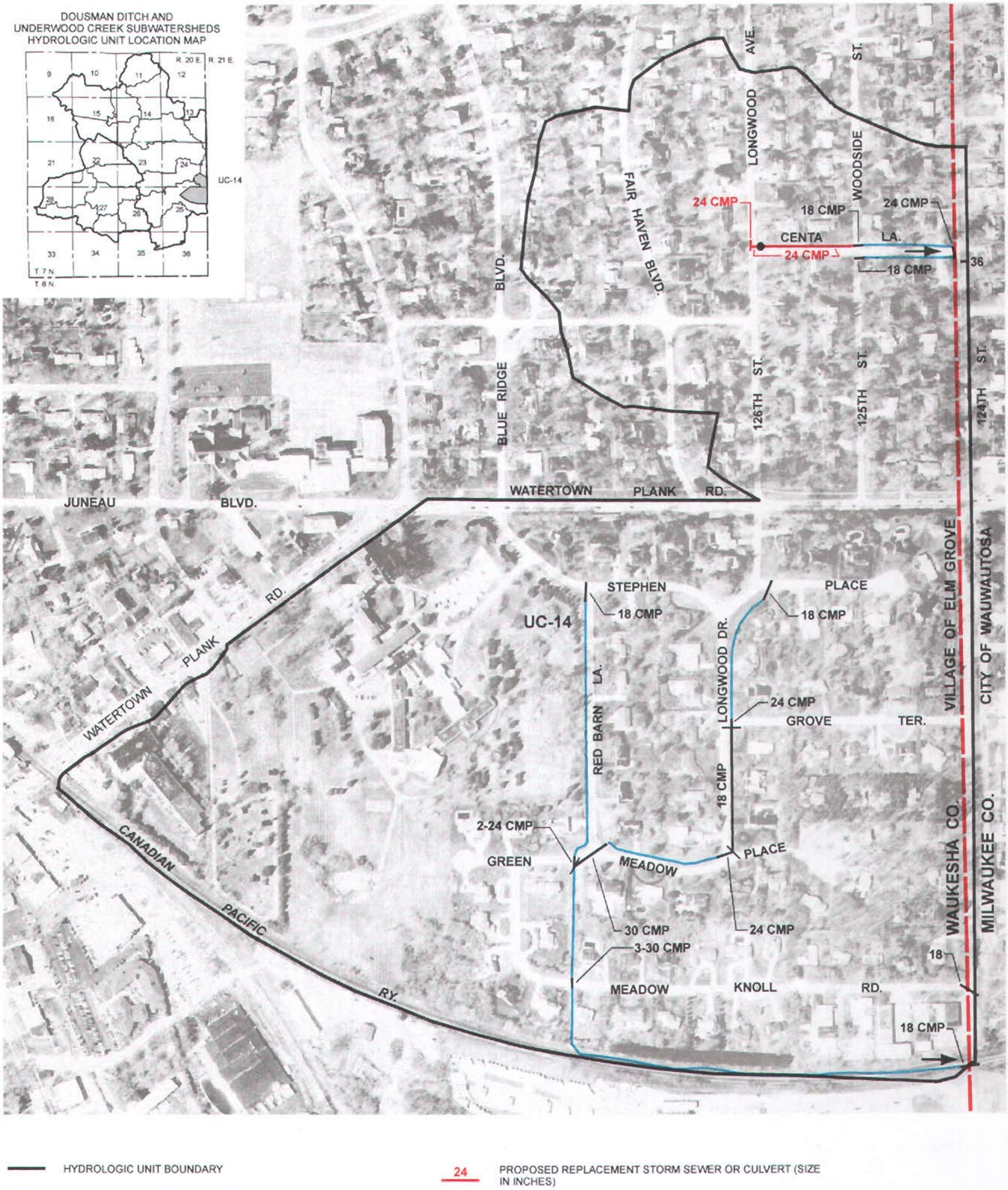
[49] *Note that there is no Hydrologic Unit UC-15.*

Map 52

PRELIMINARY RECOMMENDED CULVERT CONVEYANCE PLAN FOR HYDROLOGIC UNIT UC-14



——	HYDROLOGIC UNIT BOUNDARY
UC-14	HYDROLOGIC UNIT IDENTIFICATION
→	HYDROLOGIC UNIT OUTLET
18	EXISTING STORM SEWER OR CULVERT TO BE RETAINED (SIZE IN INCHES)
●	EXISTING MANHOLE OR CATCH BASIN
——	EXISTING OPEN CHANNEL OR FLOW PATH
24	PROPOSED REPLACEMENT STORM SEWER OR CULVERT (SIZE IN INCHES)
NOTE:	THIS MAP GENERALLY SHOWS EXISTING STORM SEWERS OF 18-INCH DIAMETER OR LARGER. PIPES ARE CONSTRUCTED OF REINFORCED CONCRETE UNLESS DESIGNATED AS BELOW.
CMP	CORRUGATED METAL PIPE

GRAPHIC SCALE
0 200 400 FEET
DATE OF PHOTOGRAPHY: APRIL 1995

Source: SEWRPC.

Table 52

COMPONENTS AND COSTS OF THE CULVERT CONVEYANCE STORMWATER DRAINAGE PLAN FOR HYDROLOGIC UNIT UC-14

Location of Component	Project and Component Designation and Description	Estimated Cost[a]	
		Capital[b]	Annual Operation and Maintenance[c]
Village of Elm Grove	1. Replace the 55-foot-long, 12-inch-diameter CMP culvert on the west side of Longwood Avenue at Centa Lane with a 24-inch-diameter CMP culvert	$ 4,000	$0
	2. Replace the 35-foot-long, 18-inch-diameter CMP culvert under Longwood Avenue at Centa Lane with a 24-inch-diameter CMP culvert	3,000	0
	3. UC14C1—Replace the 332-foot-long, 15- and 18-inch-diameter CMP culvert along the north side of Centa Lane between Longwood Avenue and Woodside Lane with a 24-inch-diameter CMP culvert	26,000	0
	Total	$33,000	$0

[a] *Costs based upon 1998* Engineering News-Record *Construction Cost Index = 6,740.*

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

[c] *Operation and maintenance costs are listed as $0 when an existing component is replaced with a component having similar operation and maintenance costs.*

Source: SEWRPC.

Limited, localized drainage and sanitary sewer backup problems were reported in this hydrologic unit during the extreme storm of August 6, 1998. The analyses conducted for this planning effort identified no system inadequacies within the context of the minor and major system criteria that were adopted.

Plan Recommendations

No deficiencies in the public stormwater management system were identified and no new stormwater management measures are recommended for this hydrologic unit.

Additional Alternative Stormwater Drainage Plans Evaluated by the Village of Elm Grove

At the request of the Elm Grove subcommittee of the Underwood Creek Task Force, Ruekert & Mielke, Inc., the Village engineer, investigated a plan that would divert runoff from those portions of Hydrologic Units UC-10 and UC-11 in the City of Brookfield south of W. Bluemound Road. It was proposed that the runoff would be conveyed in a storm sewer that would be located along the south side of W. Bluemound Road and would discharge to the South Branch of Underwood Creek near the Milwaukee County line. The preliminary evaluation of this alternative was presented in a December 14, 1998, letter report from Ruekert & Mielke to the Village. The approach was eliminated from further consideration due to high costs and the lack of a component to mitigate possible increases in downstream flows.

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Chapter VI

RECOMMENDED STORMWATER AND FLOODLAND MANAGEMENT PLAN

INTRODUCTION

The recommended stormwater and floodland management plan for the Dousman Ditch and Underwood Creek subwatersheds consists of three elements: a water quality management element, a stormwater drainage element, and a floodland management element. Preliminary recommendations for those three plan elements were presented in Chapters IV and V of this volume. This chapter describes the comprehensive recommended plan that combines the three plan elements. This chapter also presents auxiliary plan recommendations regarding preservation of natural resources and open spaces, revisions to the City and Village floodplain maps, and maintenance of stormwater management facilities; and provides estimates of the cost of the recommended plan.

RECOMMENDED STORMWATER MANAGEMENT PLAN

The components of the recommended stormwater management plan and their estimated capital and annual operation and maintenance costs are summarized in Table 53. The plan combines the preliminary recommended water quality management plan element described in Chapter IV and the preliminary recommended stormwater drainage plan element described in Chapter V. The recommended stormwater management plan is summarized in graphic form on Map 53. Detailed descriptions of the recommended stormwater management plan components for each of the hydrologic units in the study area are provided in Chapters IV and V.

The recommended stormwater management plan calls for 1) the construction of a dual-purpose wet detention basin with a permanent pond area of 19 acres along the upper reach of Dousman Ditch west of Pilgrim Parkway and north of Wisconsin Avenue extended; 2) the provision of new or replacement culverts and storm sewers at potential problem areas throughout the study area; 3) limited swale modification; 4) acquisition of one house and the associated lot on Indianwood Drive; 5) floodproofing of two houses along Victoria Circle North; 6) floodproofing of basement garages at two apartment buildings in Elm Grove; 7) the construction of a stormwater pumping station with a capacity of 100 cfs along the east side of Lilly Road , north of W. North Avenue; and 8) increased sweeping of about 23 curb-miles of streets in critical land use areas in both Brookfield and Elm Grove.

Wet Detention Basin

The recommended wet detention basin would provide about 23 acre-feet of floodwater storage and an 87 acre-foot permanent pond for the control of nonpoint source pollution. Runoff from approximately 1,240 acres of land would be controlled. The basin would have a permanent pond elevation of about 824 feet above National Geodetic Vertical Datum, 1929 adjustment (NGVD29). The basin would be excavated adjacent to Dousman Ditch and no dikes would be required for the water quality portion of the basin. Outflow from the detention basin would be controlled by a v-notch weir or similar outlet structure to produce longer residence times for settling of nonpoint source pollutants during relatively low flow conditions.

The basin site is in an area that is designated for City ownership and open space preservation in the City park and open space plan.[1] The park plan calls for the construction of a portion of the City trail system in the area adjacent to the detention basin. The basin could be landscaped and designed to be an amenity that would enhance the proposed recreation area and complement the proposed trail.

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[1] *SEWRPC Community Assistance Planning Report No. 108,* A Park and Open Space Plan for the City of Brookfield, Waukesha County, Wisconsin, *August 1991.*

Table 53

COMPONENTS AND COSTS OF THE RECOMMENDED STORMWATER AND FLOODLAND MANAGEMENT PLAN FOR THE DOUSMAN DITCH AND UNDERWOOD CREEK SUBWATERSHEDS IN THE CITY OF BROOKFIELD AND THE VILLAGE OF ELM GROVE

Hydrologic Unit	Location of Component	Project and Component Designation and Description	Estimated Cost[a]	
			Capital[b]	Annual Operation and Maintenance[c]
Stormwater Drainage Plan Element				
Dousman Ditch Subwatershed				
- -	City of Brookfield	1. Dousman Ditch detention basin	- -[d]	- -
Culvert and Storm Sewer Conveyance Plan				
DD-2	City of Brookfield	1. DD2C1—Replace 44 feet of 18-inch CMP culvert under Patricia Lane at Calhoun Drive with 21-inch CMP	$ 3,000	$ 0
		2. DD2C11—Replace 108 feet of 21-inch concrete storm sewer in Lucy Circle north of Evergreen Court with 24-inch RCP storm sewer	11,000	0
		Subtotal DD-2	$ 14,000	$ 0
Culvert, Roadside Swale, and Storm Sewer Conveyance Plan				
DD-5	Village of Elm Grove	1. DD5C24—Replace 165 feet of 18-inch CMP culvert on N. Verdant Drive north of Watertown Plank Road with twin 22-inch by 36-inch CMPA	$ 40,000	$ 90
		2. DD5C25—Retain the 38-foot-long, twin 33-inch by 49-inch CMPA culverts crossing N. Verdant Drive north of Watertown Plank Road and add two parallel 22-inch by 36-inch CMPA	10,000	40
		3. DD5C33/A—Retain one 257-foot-long, 48-inch CMP culvert and one 257-foot-long, 36-inch CMP north of Watertown Plank Road east of Pilgrim Parkway and add a 270-foot-long, four-foot by eight-foot reinforced concrete (RC) box	210,000	70
		4. DD5C33D/E—Retain the two 52-foot-long, 49-inch by 33-inch CMPA culvert crossing Pilgrim Parkway north of Watertown Plank Road and add a 60-foot-long, four-foot by eight-foot RC box	45,000	20
		Subtotal	$ 305,000	$ 220
	City of Brookfield	5. DD5C26—Replace 30 feet of 15-inch CMP culvert crossing Mt. Vernon Avenue west of Westmoor Drive with 18-inch CMP	$ 2,000	$ 0
		Subtotal DD-5	$ 307,000	$ 220
Storm Sewer Conveyance Plan				
DD-7	Village of Elm Grove	1. DD7C3—Replace 318 feet of 24-inch storm sewer east of Briaridge Court with 27-inch by 44-inch RCPA storm sewer	$ 55,000	$ 0
		2. DD7C4—Replace 295 feet of 24-inch corrugated polyethylene storm sewer west of Briaridge Court with 27-inch by 44-inch RCPA storm sewer	51,000	0
		Subtotal DD-7	$ 106,000	$ 0
Storm Sewer Conveyance and Building Acquisition Plan[e]				
DD-8 Indianwood/ Onondaga Area	City of Brookfield	1. DD8C5—Replace 400 feet of 24-inch corrugated polyethylene storm sewer with 27-inch by 44-inch RCPA storm sewer	$ 70,000	$ 0
		2. House and lot acquisition	270,000	0
		3. Lot and ditch regrading and landscaping	15,000	500
		Subtotal	$ 355,000	$ 500

Table 53 (continued)

Hydrologic Unit	Location of Component	Project and Component Designation and Description	Estimated Cost[a]	
			Capital[b]	Annual Operation and Maintenance[c]
Storm Sewer and Swale Conveyance with Structure Floodproofing Plan				
DD-8 Victoria Circle North Area	Village of Elm Grove	1. Replace 340 feet of 15-inch-diameter CMP storm sewer in Victoria Circle North with 1,400 feet of 18-inch-diameter PVC storm sewer and add a 50-foot-long, 12-inch-diameter PVC wetland outlet with a backwater gate	$ 97,000	$ 600
		2. Construct a 570-foot-long, grass-lined, trapezoidal overflow swale with one vertical on four horizontal side slopes and a 60-foot-wide bottom	50,000[f]	300
		3. Floodproof two houses on the north side of Victoria Circle North	23,000	200
		Subtotal	$ 170,000	$ 1,100
		Subtotal DD-8	$ 525,000	$ 1,600
Storm Sewer and Culvert Conveyance Plan				
DD-9	City of Brookfield	1. DD9C18—Replace 630 feet of 18-inch CMP storm sewer on Gebhardt Road between Church View Drive and Alverno Drive with 27-inch RCP storm sewer	$ 72,000	$ 0
		2. DD9C12—Replace 247 feet of twin 21-inch storm sewer at Eileen Court north of Gebhardt Road with twin 27-inch RCP storm sewer	56,000	0
		Subtotal	$ 128,000	$ 0
	Village of Elm Grove	3. DD9C30—Replace 42 feet of 18-inch CMP culvert crossing Pilgrim Parkway north of Gebhardt Road with 30-inch CMP	$ 4,000	$ 0
		Subtotal DD-9	$ 132,000	$ 0
		Subtotal Dousman Ditch Subwatershed	$ 1,084,000	$ 1,820
Underwood Creek Subwatershed				
Storm Sewer and Culvert Conveyance Plan				
UC-1	City of Brookfield	1. UC-1C37—Replace 59 feet of 15-inch storm sewer crossing Kings View Lane north of Burleigh Boulevard with 18-inch by 29-inch RCPA storm sewer	$ 7,000	$ 0
		2. UC-1C19—Replace 389 feet of 16-inch-diameter cast iron storm sewer east of Smith Drive south of Luella Drive with 18-inch RCP storm sewer	34,000	0
		3. Replace 44 feet of 18-inch CMP culvert crossing Smith Drive south of Luella Drive with 18-inch RCP culvert	4,000	0
		4. Replace 175 feet of eight-inch concrete storm sewer located south of Luella Drive and east of Smith Drive with 18-inch RCP storm sewer	15,000	0
		5. UC-1C29—Replace 166 feet of 18-inch storm sewer in drainage easement north of Burleigh Road east of Marti Lane with 21-inch storm sewer	16,000	0
		Subtotal UC-1	$ 76,000	$ 0
Culvert Conveyance Plan				
UC-2	City of Brookfield	1. UC-2C7—Replace 41 feet of 18-inch storm sewer crossing Hillsdale Drive north of W. North Avenue with 21-inch RCP storm sewer	$ 4,000	$ 0
		Subtotal UC-2	$ 4,000	$ 0
Storm Sewer Conveyance Plan				
UC-4	City of Brookfield	1. UC4C17—Replace 530 feet of 18-inch RCP storm sewer in drainage easement between San Raphael Drive and Pomona Road with 24-inch RCP storm sewer	$ 55,000	$ 0

Table 53 (continued)

Hydrologic Unit	Location of Component	Project and Component Designation and Description	Estimated Cost[a]	
			Capital[b]	Annual Operation and Maintenance[c]
UC-4 (continued)	City of Brookfield (continued)	2. UC4C18—Replace 210 feet of 21-inch RCP storm sewer in drainage easement between Pomona Road and Underwood Creek with 27-inch RCP storm sewer	$ 24,000	$ 60
		Subtotal UC-4	$ 79,000	$ 60
Storm Sewer Conveyance Plan				
UC-5	City of Brookfield	1. UC5C30—Replace 249 feet of 18-inch RCP storm sewer in Westwood Drive with 24-inch-high by 38-inch-wide RCP HE storm sewer	$ 40,000	$ 0
		2. UC5C30A—Retain 195 feet of 21-inch RCP storm sewer in Westwood Drive and add a parallel 24-inch diameter RCP storm sewer at a slope of 0.10 percent	20,000	110
		3. UC5C31—Retain 148 feet of 24-inch RCP storm sewer in a drainage easement between Westwood Drive and the North Branch of Underwood Creek and add a parallel 24-inch diameter RCP storm sewer	15,000	100
		4. UC5C21-Retain 95 feet of 24-inch RCP storm sewer in the intersection of Crestview Circle and Westwood Drive and add a parallel 24-inch diameter RCP storm sewer	10,000	80
		5. UC5C22-Retain 200 feet of 27-inch RCP storm sewer in a drainage easement between the intersection of Westwood Drive and Crestview Circle and the North Branch of Underwood Creek and add a parallel 27-inch diameter RCP storm sewer	23,000	110
		Subtotal UC-5	$ 108,000	$ 400
Storm Sewer Conveyance Plan				
UC 6	City of Brookfield	1. UC6C4—Replace the existing 587-foot-long, 24-inch-diameter CMP in San Marcos Drive and in a drainage easement between San Marcos Drive and Sunny View Lane with 27-inch RCP storm sewer	$ 62,000	$ 0
		2. UC6C5—Replace the 51-foot-long, 27-inch-diameter CMP and the 77-foot-long, 27-inch-diameter RCP in Sunny View Lane with 27-inch-diameter RCP laid at a constant slope	15,000	0
		3. UC6C7—Replace the 310-foot-long, 27-inch-diameter RCP in a drainage easement northeast of East View Court with 30-inch-diameter RCP storm sewer	39,000	0
		4. UC6C8—Replace the 243-foot-long, 30-inch-diameter storm sewer in the drainage easement west of San Juan Trail and in San Juan Trail with 36-inch-diameter RCP storm sewer	36,000	0
		5. UC6C9—Replace the 201-foot-long, 36-inch-diameter RCP in the drainage easement between San Juan Trail and the North Branch with 42-inch-diameter RCP storm sewer	36,000	0
		6. Replace the 206-foot-long, 12-inch-diameter RCP storm sewer in a drainage easement west of San Juan Trail and north of W. Burleigh Road with 21-inch-diameter RCP storm sewer	20,000	0
		7. Replace the 226-foot-long, 15-inch-diameter RCP storm sewer in San Juan Trail and in an easement to the east of San Juan Trail with 27-inch-diameter RCP storm sewer	26,000	0

Table 53 (continued)

Hydrologic Unit	Location of Component	Project and Component Designation and Description	Estimated Cost[a] Capital[b]	Annual Operation and Maintenance[c]
UC-6 (continued)	City of Brookfield (continued)	8. Replace the 258-foot-long, 12-inch-diameter RCP storm sewer flowing from south to north on the east side of Lilly Road opposite BEHS with 18-inch-diameter RCP storm sewer	$ 22,000	$ 0
		9. Replace the 260-foot-long, 15-inch-diameter RCP storm sewer flowing from north to south on the east side of Lilly Road opposite BEHS with 18-inch-diameter RCP storm sewer	23,000	0
		10. UC6C10—Replace the 607-foot-long, 18-inch-diameter RCP storm sewer in Lilly Road and the BEHS north parking lot with 21-inch-diameter RCP storm sewer	60,000	0
		11. UC6C11—Replace the 425-foot-long, 18-inch-diameter RCP storm sewer in the BEHS north parking lot with 30-inch-diameter RCP storm sewer	53,000	0
		12. UC6C12—Replace the 305-foot-long, 18-inch-diameter RCP storm sewer in the BEHS north parking lot with 36-inch-diameter RCP storm sewer	46,000	0
		13. UC6CAA—Replace the 44-foot-long, 12-inch-diameter CMP storm sewer under Lilly Road just south of W. Burleigh Road with a 15-inch CMP	2,000	0
		Subtotal UC-6	$ 440,000	$ 0
Storm Sewer Conveyance and Pumping Plan				
UC-7	City of Brookfield	1. Replace the existing 250-foot-long, 12-inch-diameter RCP storm sewer in Carson Court with 27-inch-high by 44-inch-wide RCPA storm sewer	$ 48,000	$ 0
		2. Replace the 25-foot-long, 12-inch-diameter RCP along Oakhill Lane northeast of Carson Court with 23-inch-high by 36-inch-wide RCPA storm sewer	4,000	0
		3. Replace the 67-foot-long, 15-inch-diameter polyvinyl chloride (PVC) storm sewer under Oakhill Lane near its intersection with Thornapple Lane with 23-inch-high by 36-inch-wide RCPA storm sewer	11,000	0
		4. Replace the 63-foot-long, 15-inch-diameter RCP under Carson Court at its intersection with Oakhill Lane with 27-inch-high by 44-inch-wide RCPA storm sewer	12,000	0
		5. UC7C12—Replace the 539-foot-long, 18-inch-diameter storm sewer along Oakhill Lane southwest of Carson Court with 27-inch-high by 44-inch-wide RCPA	103,000	0
		6. UC7C12B—Replace the 464-foot-long, 18-inch-diameter RCP along Oakhill Lane with 31-inch-high by 51-inch-wide RCPA storm sewer	103,000	0
		7. UC7C12C—Replace the 33-foot-long, 30-inch-diameter CMP under Lilly Road at Oakhill Lane with 31-inch-high by 51-inch-wide RCPA storm sewer	7,000	60
		8. UC7D7A—Modify the 400-foot-long swale along the north side of Oakhill Lane between Lilly Road and El Rancho Drive to have a parabolic shape approximating a trapezoid with a seven-foot-wide bottom and one vertical on two horizontal side slopes	6,000	200
		9. UC7C10—Replace the 48-foot-long, 24-inch-diameter CMP culvert under El Rancho Drive at its intersection with Oakhill Lane with a double 31-inch-high by 51-inch-wide RCPA	21,000	0

Table 53 (continued)

Hydrologic Unit	Location of Component	Project and Component Designation and Description	Estimated Cost[a] Capital[b]	Estimated Cost[a] Annual Operation and Maintenance[c]
UC-7 (continued)	City of Brookfield (continued)	10. Construct stormwater pumping station with 100 cfs pumping capacity	$ 1,830,000	$ 8,500
		11. 600 feet of 48-inch-diameter RCP force main	130,000	200
		12. 755 feet of 48-inch-diameter storm sewer draining to pump station	160,000	200
		13. 500 feet of 54-inch-diameter storm sewer draining to pump station	120,000	100
		14. Grade lot at 13830 Adelaide Lane to drain toward street	10,000	0
		Subtotal UC-7	$ 2,565,000	$ 9,200
Storm Sewer and Culvert Conveyance Plan				
UC-8	Village of Elm Grove	1. UC-8C3—Replace the 77-foot-long, 21-inch-diameter CMP culvert under Fairhaven Boulevard at Wrayburn Road with a 27-inch-high by 44-inch-wide RCPA culvert	$ 15,000	$ 0
		2. UC-8C7—Replace the 44-foot-long, 18-inch-diameter CMP culvert crossing the southern lanes of Wrayburn Road between Arrowhead Court and Fairhaven Boulevard with an 18-inch-high by 29-inch-wide RCPA culvert	6,000	0
		3. UC-8C13—Replace the 53-foot-long, 18-inch-diameter CMP under the southern lanes of Wrayburn Road on the east side of Arrowhead Court with a 27-inch diameter CMP culvert	4,000	0
		4. UC-8C14—Replace the 51-foot-long, 18-inch-diameter CMP under the northern lanes of Wrayburn Road on the east side of Arrowhead Court with a 24-inch-high by 35-inch-wide CMPA culvert	6,000	0
		5. UC-8C16—Replace the 52-foot-long, 18-inch-diameter CMP under the northern lanes of Wrayburn Road on the west side of Arrowhead Court with two, parallel 18-inch-high by 29-inch-wide RCPA culverts	13,000	100
		6. UC-8C25—Replace the 221-foot-long, 18-inch-diameter CMP culvert along the west side of Hollyhock Lane at its intersection with Wrayburn Road with an 18-inch-high by 29-inch-wide CMPA culvert	23,000	0
		7. UC-8C26—Replace the 180-foot-long, parallel double 33-inch-high by 48-inch-wide CMPA culverts in the Wrayburn Tributary under Hollyhock Lane with two, parallel 36-inch-high by 58-inch-wide RCPA culverts	91,000	0
		8. Replace the 630-foot-long, 15-inch-high by 21-inch-wide CMPA located outside of the public right-of-way between Lee Court and Wrayburn Road with a 42-inch-diameter CMP	73,000	0
		9. Replace the 82-foot-long, 12-inch-diameter CMP storm sewers under Wrayburn Road and San Fernando Drive with a 15-inch-diameter RCP storm sewer	7,000	0
		10. Replace the 327-foot-long, 15-inch-diameter CMP storm sewer along the north side of Wrayburn Road between San Fernando Drive and the Wrayburn Tributary with a 15-inch-diameter RCP storm sewer	28,000	0

Table 53 (continued)

Hydrologic Unit	Location of Component	Project and Component Designation and Description	Estimated Cost[a]	
			Capital[b]	Annual Operation and Maintenance[c]
UC-8 (continued)	Village of Elm Grove (continued)	11. Install 410 feet of 15-inch-diameter RCP storm sewer from the south side of Lloyd Street through and San Fernando Drive and in an easement to be obtained between San Fernando Drive and a tributary to the Wrayburn Tributary[f]	$ 41,000	$ 200
		12. Install 65 feet of 15-inch-diameter RCPA storm sewer, followed by 230 feet of 18-inch-diameter RCP storm sewer, followed by 315 feet of 18-inch-high by 29-inch-wide RCPA storm sewer from the north side of Garfield Street to the north side of Lloyd Street, across San Fernando Drive, and then in an easement to be obtained between San Fernando Drive and the tributary to the Wrayburn Tributary[g]	89,000	400
		Subtotal	$ 396,000	$ 700
	City of Brookfield	13. UC-7C21[h]—Replace the 74-foot-long, 21-inch-diameter RCP culvert under N. 131st Street on the north side of W. North Avenue with two, parallel 24-inch-diameter RCP culverts	$ 11,000	$ 0
		Subtotal UC-8	$ 407,000	$ 700
Storm Sewer and Culvert Conveyance Plan				
UC-9	Village of Elm Grove	1. UC9-C1—Replace the 44-foot-long, 18-inch-diameter CMP culvert under Fairhaven Boulevard at Elmhurst Parkway with a 24-inch-high by 35-inch-wide CMPA culvert	$ 5,000	$ 0
		2. UC9-C2—Replace the 31-foot-long, 18-inch-diameter CMP culvert under Shady Lane at Elmhurst Parkway with a 24-inch-high by 35-inch-wide CMPA culvert	4,000	0
		3. UC9-C3—Replace the 37-foot-long, 21-inch-diameter CMP culvert under Blue Ridge Boulevard at Elmhurst Parkway with a 29-inch-high by 42-inch-wide CMPA culvert	5,000	0
		4. UC9-C6—Replace the 438-foot-long, 27-inch-high by 42-inch-wide CMPA storm sewer located between the northern and southern lanes of Elmhurst Parkway just west of Notre Dame Boulevard with a 36-inch-high by 58-inch-wide RCPA storm sewer	111,000	$ 0
		5. UC9-C8 and UC9C11—Replace the 962-foot-long, 27-inch-high by 42-inch-wide CMPA storm sewer located between the northern and southern lanes of Elmhurst Parkway between Church Street and Legion Drive with a 40-inch-high by 65-inch-wide RCPA storm sewer	284,000	0
		Subtotal UC-9	$ 409,000	$ 0
Structure Floodproofing Plan				
UC-10	Village of Elm Grove	1. Regrade and repave eastern driveway area at Elm Grove apartment complex to floodproof basement parking garages at two apartment buildings	$ 45,000	$ 0
		Subtotal UC-10	$ 45,000	$ 0
Culvert and Swale Conveyance Plan				
UC-11	Village of Elm Grove	1. UC11C8—Replace the 176-foot-long, combination 15-inch-diameter RCP and 24-inch-diameter CMP culvert located west of Grandview Drive with a 27-inch-high by 44-inch-wide RCPA culvert	$ 34,000	$ 0
		2. UC11C10—Replace the 55-foot-long, 21-inch-high by 36-inch-wide CMPA culvert under Kurtis Drive with two parallel 205-foot-long, 27-inch-high by 44-inch-wide RCPA culverts	79,000	100

Table 53 (continued)

Hydrologic Unit	Location of Component	Project and Component Designation and Description	Estimated Cost[a]	
			Capital[b]	Annual Operation and Maintenance[c]
UC-11 (continued)	Village of Elm Grove (continued)	3. UC11C14—Replace the 37-foot-long, 15-inch-diameter CMP culvert under Sunny Slope Road north of Watertown Plank Road with a 23-inch-high by 36-inch-wide RCPA culvert	$ 6,000	$ 0
		Subtotal UC-11	$ 119,000	$ 100
Culvert Conveyance Plan				
UC-13	Village of Elm Grove	1. UC13C3—Replace the 48-foot-long, 15-inch-diameter CMP culvert under Gremoor Drive just west of N. 124th Street with an 18-inch-diameter CMP culvert	$ 3,000	$ 0
		2. UC13C4—Replace the 100-foot-long, 18-inch-diameter CMP culvert under Walnut Street just west of N. 124th Street with a 14-inch-high by 22-inch-wide RCPA culvert	16,000	0
		Subtotal UC-13	$ 19,000	$ 0
UC-14	Village of Elm Grove	1. Replace the 55-foot-long, 12-inch-diameter CMP culvert on the west side of Longwood Avenue at Centa Lane with a 24-inch-diameter CMP culvert	$ 4,000	$ 0
		2. Replace the 35-foot-long, 18-inch-diameter CMP culvert under Longwood Avenue at Centa Lane with a 24-inch-diameter CMP culvert	3,000	0
		3. UC14C1—Replace the 332-foot-long, 15- and 18-inch-diameter CMP culvert along the north side of Centa Lane between Longwood Avenue and Woodside Lane with a 24-inch-diameter CMP culvert	26,000	0
		Subtotal UC-14	$ 33,000	$ 0
		Subtotal Underwood Creek Subwatershed	$ 4,304,000	$10,460
- -	- -	Subtotal Stormwater Drainage Plan Element	$ 5,388,000	$12,280
Water Quality Management Plan Element				
Dousman Ditch Detention Basin with Increased Street Sweeping in Critical Areas				
- -	City of Brookfield	1. 19-acre, 87-acre-foot detention basin	$ 3,780,000[i]	$ 9,000
- -	City of Brookfield	2. Access roads/baffles	120,000	0
- -	City of Brookfield	3. Open channel to convey runoff to pond	100,000	0
- -	City of Brookfield	4. Land acquisition	90,000[j]	0
- -	Village of Elm Grove City of Brookfield	5. Street sweeping (23 curb-miles)[k]	6,000	7,000
- -	Village of Elm Grove City of Brookfield	6. Site-specific controls for new development or redevelopment	- -[l]	- -[l]
- -	Village of Elm Grove City of Brookfield	7. Development or expansion of public education programs and resultant improved urban "housekeeping" practices	- -[l]	- -[l]
- -	Village of Elm Grove City of Brookfield	8. Strict enforcement of construction erosion control ordinances	- -[l]	- -[l]
- -	Village of Elm Grove City of Brookfield	9. Limited streambank stabilization	- -[l]	- -[l]
- -	Village of Elm Grove City of Brookfield	10. Reduced application of street sand	- -[l]	- -[l]
- -	- -	Subtotal Water Quality Management Plan Element	$ 4,096,000	$16,000
Floodland Management Plan Element				
Limited Dousman Ditch Detention Storage, Underwood Creek Overflow Channel and Diversion, and Compensating Storage with Structure Floodproofing and Removal				
- -	City of Brookfield	1. Dousman Ditch detention basin	- -[i]	- -
- -	City of Brookfield	2. Land acquisition	$ 260,000[j]	- -

Table 53 (continued)

Hydrologic Unit	Location of Component	Project and Component Designation and Description	Estimated Cost[a]	
			Capital[b]	Annual Operation and Maintenance[c]
- -	Village of Elm Grove	3. Construct 4,100-foot-long, grass lined overflow channel[m]	$ 1,400,000	- -
- -	Village of Elm Grove	4. Install three parallel 31-foot-long, four-foot-high by 10-foot-wide reinforced concrete box culverts in the overflow channel at Marcella Avenue	85,000	- -
- -	Village of Elm Grove	5. Install two parallel 28-foot-long, five-foot-high by 10-foot-wide reinforced concrete box culverts in the overflow channel at the Village Hall Drive	140,000	- -
- -	Village of Elm Grove	6. Install 5,400-foot-long, double six-foot-high by seven-foot-wide reinforced concrete box diversion culverts	9,300,000	- -
- -	Village of Elm Grove	7. Easements for diversion culverts	100,000	- -
- -	Village of Elm Grove	8. Provide 35 acre-feet of excavated storage in the Village Park	1,500,000	- -
- -	City of Brookfield	9. Provide 14 acre-feet of excavated storage along Underwood Creek in Brookfield upstream of W. North Avenue	640,000	- -
- -	City of Brookfield	10. Purchase six houses in Brookfield for construction of storage area upstream of W. North Avenue	900,000	- -
- -	Village of Elm Grove City of Brookfield	11. Floodproof one house in Brookfield and two in Elm Grove[n]	35,000	- -
- -	Village of Elm Grove	12. Floodproof three apartment buildings in Elm Grove[o]	10,000	- -
- -	Village of Elm Grove City of Brookfield	13. Floodproof one commercial building in Brookfield and seven in Elm Grove[p]	215,000	- -
- -	Village of Elm Grove	14. Pilgrim Parkway road grade raise and associated culverts	50,000	- -
- -	City of Brookfield	15. Clearwater Drive culvert replacement, road grade raise, and provision of one acre-foot of floodwater storage volume[q]	120,000	- -
- -	- -	Subtotal Floodland Management Plan Element	$14,755,000[r,s]	$36,000
- -	- -	Total Stormwater and Floodland Management Plan	$24,239,000	$64,280

[a] *Costs based upon 1998 Engineering News-Record Construction Cost Index = 6,740.*

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

[c] *Operation and maintenance costs are listed as $0 when an existing component is replaced with a component having similar operation and maintenance costs.*

[d] *The costs for this detention basin are assigned to the water quality and floodland management elements of the plan, but the basin is listed here to emphasize that it is also an important component of the stormwater drainage system.*

[e] *The possibility of installing a large culvert to convey flows up to the peak rate of runoff from a 100-year storm and to eliminate the need to acquire a house and lot could be considered in the plan implementation/final design stage.*

[f] *Includes removal of abandoned tennis court at Pilgrim Park Middle School.*

[g] *Easement assumed to cost $5,000.*

[h] *Most runoff tributary to this culvert drains to Hydrologic Unit UC-8, but some drains to UC-7, thus, it was assigned to UC-7 when it was designated.*

[i] *A cost of $1,800,000 was assigned to the detention basin under the water quantity control element in Chapter V to enable a consistent comparison with the other floodland management alternatives. However, because it would be necessary to spend the $1,800,000 to construct the wet basin for quality control, it is assigned to the water quality management plan element in this table. If during the facilities design stage it is determined that an impervious liner is required for the wet detention basin, this cost would be increased by about $600,000.*

[j] *Land acquisition cost apportioned between floodland and water quality management elements.*

[k] *Sweep every four weeks between April 1 and October 31.*

Table 53 Footnotes (continued)

[l] *No specific costs estimated.*

[m] *The overflow channel would be located on six existing outlots and in the Village park. It would be necessary to obtain easements from the owners of the outlots. The cost of such easements would be determined in negotiations between the Village and the owners. Thus, no costs were assigned to obtaining those easements.*

[n] *One house to be floodproofed under Alternative No. 11 as described in Chapter V would be eliminated from the floodplain through implementation of recommended stormwater drainage measures. One house to be purchased under Alternative No. 11 has already been purchased and removed. Thus, no costs are included here for those two houses.*

[o] *Three additional apartment buildings in Elm Grove would be on the edge of the 100-year floodplain, but floodproofing would probably not be required.*

[p] *Three additional commercial buildings in Elm Grove would be on the edge of the 100-year floodplain, but floodproofing would probably not be required. One commercial building in Elm Grove that was to be floodproofed under Alternative No. 11 in Chapter V has been purchased (American Legion Hall). Thus, no cost is included here for that building.*

[q] *See the later section of this chapter that describes alternative and recommended plans for the Clearwater Drive area.*

[r] *The estimated lower limit cost for this alternative is $13,815,000. That cost is based on an optimistic assumption that the excavated soil could be used as topsoil and/or peat for landscaping and would be hauled from the site free of charge.*

[s] *If the buildings to be floodproofed were purchased and demolished, the cost of this alternative plan would increase by about $7,450,000.*

Source: SEWRPC.

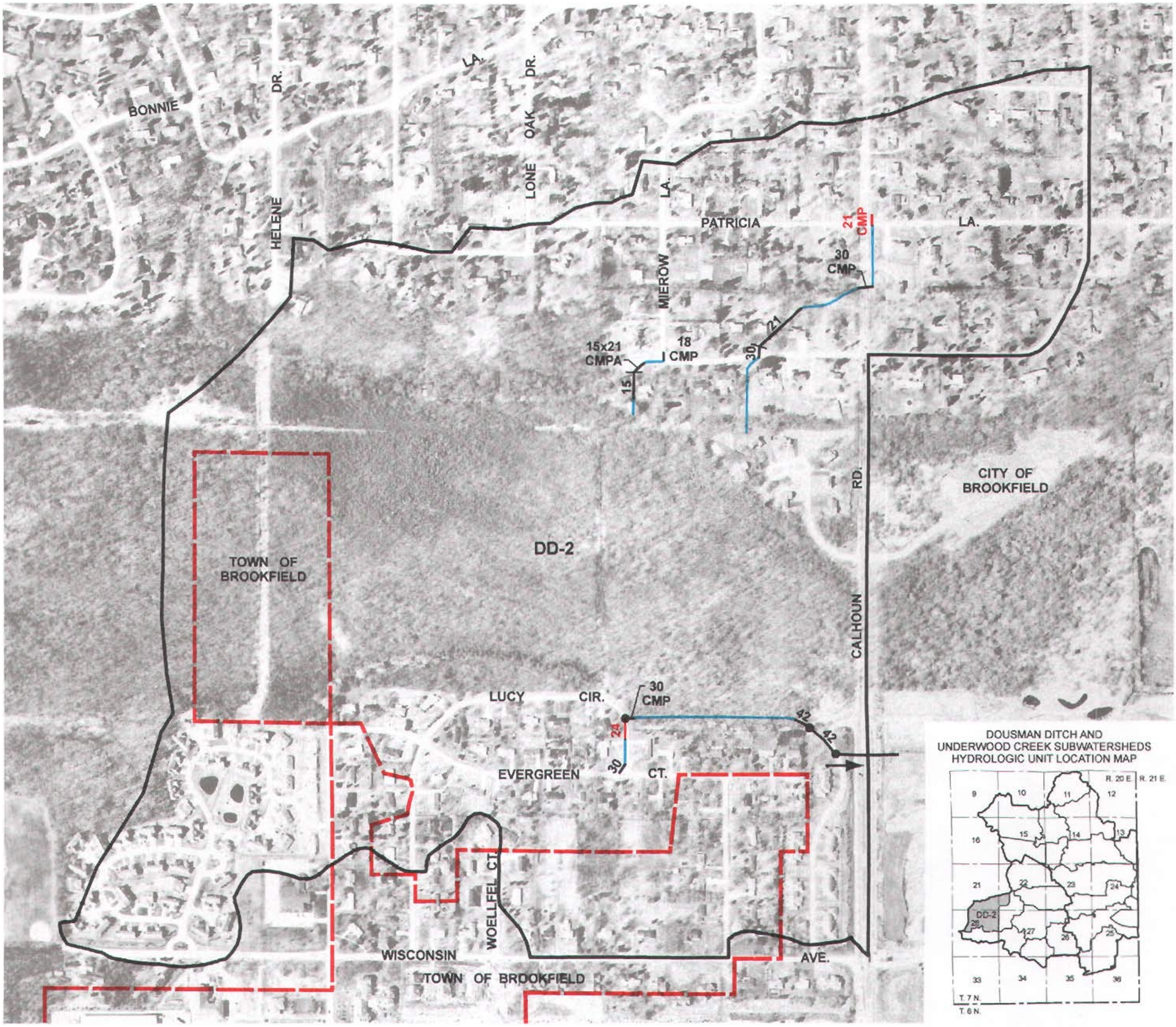
The area tributary to the wet detention basin is one of the most densely developed portions of the Dousman Ditch and Underwood Creek subwatersheds within the study area. The tributary area includes one of the highest concentrations of critical land uses targeted for management of nonpoint source pollution under the Menomonee River Priority Watershed Study. Critical land uses in the tributary area include commercial and governmental and institutional uses. Under existing 1990 land use conditions, land uses in the area are 24 percent commercial; 1 percent governmental and institutional; 38 percent medium- and low-density residential; and 37 percent open spaces, including primary environmental corridor and recreational. Under planned buildout land use conditions, land uses in the area are anticipated to be 29 percent commercial; 1 percent governmental and institutional; 46 percent medium- and low-density residential; and 24 percent open spaces, including primary environmental corridor and recreational. The wet detention basin would treat runoff from about 40 percent of the critical land use area in the study area, including a large portion of the commercial development along W. Bluemound Road.

In addition to calling for controls on nonpoint source pollution in runoff from areas of critical existing land uses, the priority watershed study also calls for controls in areas of planned development. The approximate areas of incremental planned development occurring between 1990 and the achievement of buildout conditions which would be treated by the wet detention basin include 78 acres in commercial uses, two acres in governmental and institutional uses, and 113 acres in medium- and low-density residential uses.

The levels of control of particulate and total solids, and total phosphorus, copper, lead, and zinc provided by the detention basin are set forth in Table 25 in Chapter V. The table compares annual loads under existing 1990 and planned buildout land use conditions with existing controls to loads under those conditions with the detention basin in place. The detention basin would provide a high level of control of nonpoint source pollution, reducing particulate solids loads by 76 percent, total solids loads by 23 percent, total phosphorus loads by 39 percent, total copper loads by 79 percent, total lead loads by 74 per-

Map 53

RECOMMENDED STORMWATER MANAGEMENT PLAN FOR THE DOUSMAN DITCH AND UNDERWOOD CREEK SUBWATERSHEDS IN THE CITY OF BROOKFIELD AND THE VILLAGE OF ELM GROVE
HYDROLOGIC UNIT DD-2



—	HYDROLOGIC UNIT BOUNDARY
DD-2	HYDROLOGIC UNIT IDENTIFICATION
→	HYDROLOGIC UNIT OUTLET
18	EXISTING STORM SEWER OR CULVERT TO BE RETAINED (SIZE IN INCHES)
●	EXISTING MANHOLE OR CATCH BASIN
—	EXISTING OPEN CHANNEL OR FLOW PATH
18	PROPOSED REPLACEMENT STORM SEWER OR CULVERT (SIZE IN INCHES)

NOTE: THIS MAP GENERALLY SHOWS EXISTING STORM SEWERS OF 18-INCH DIAMETER OR LARGER. PIPES ARE CONSTRUCTED OF REINFORCED CONCRETE UNLESS DESIGNATED AS BELOW.

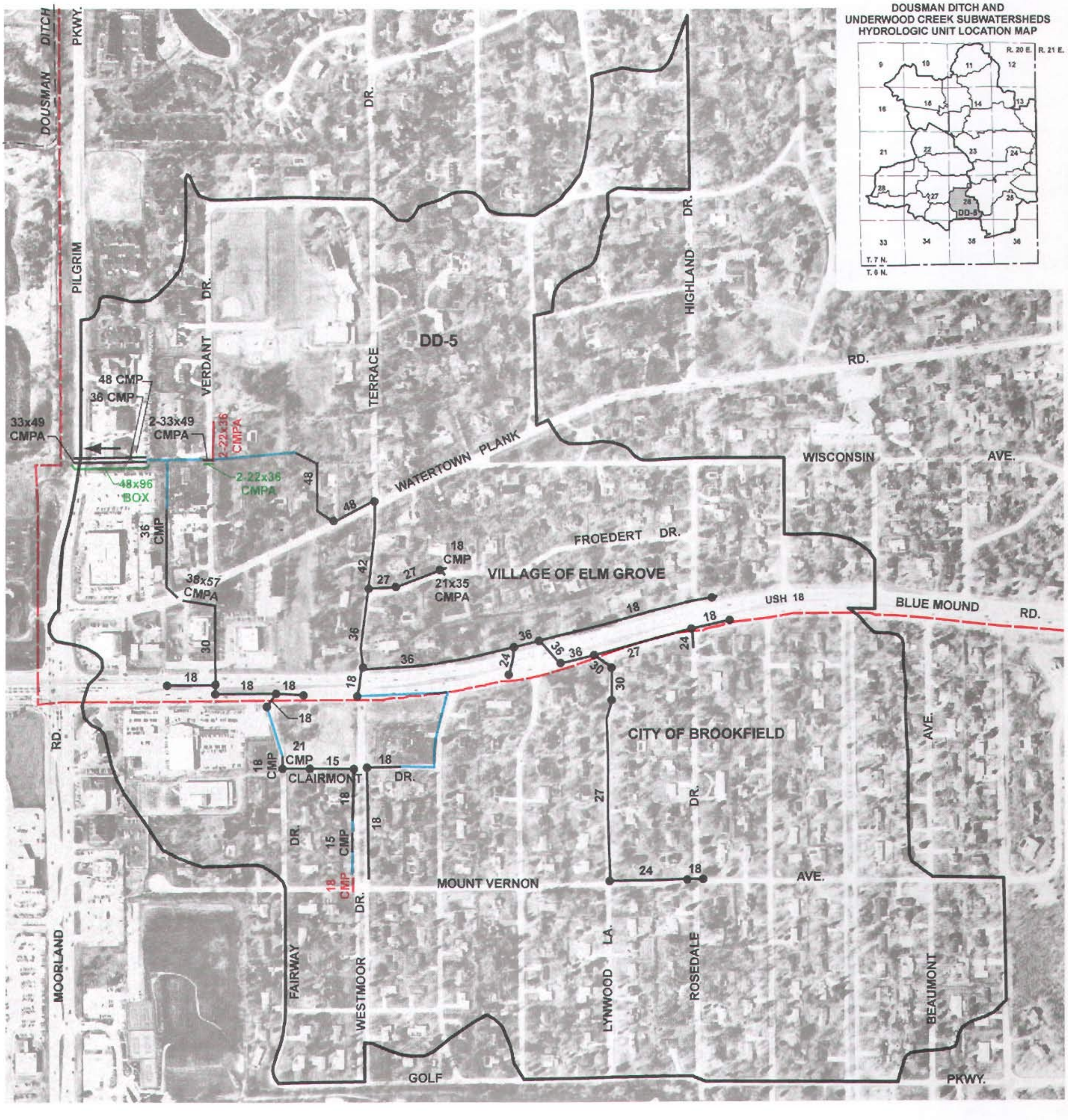
CMP	CORRUGATED METAL PIPE
CMPA	CORRUGATED METAL PIPE ARCH

GRAPHIC SCALE
0 200 400 800 FEET
DATE OF PHOTOGRAPHY: APRIL 1995

Map 53 (continued)

RECOMMENDED STORMWATER MANAGEMENT PLAN FOR THE DOUSMAN DITCH AND UNDERWOOD CREEK SUBWATERSHEDS IN THE CITY OF BROOKFIELD AND THE VILLAGE OF ELM GROVE

HYDROLOGIC UNIT DD-5



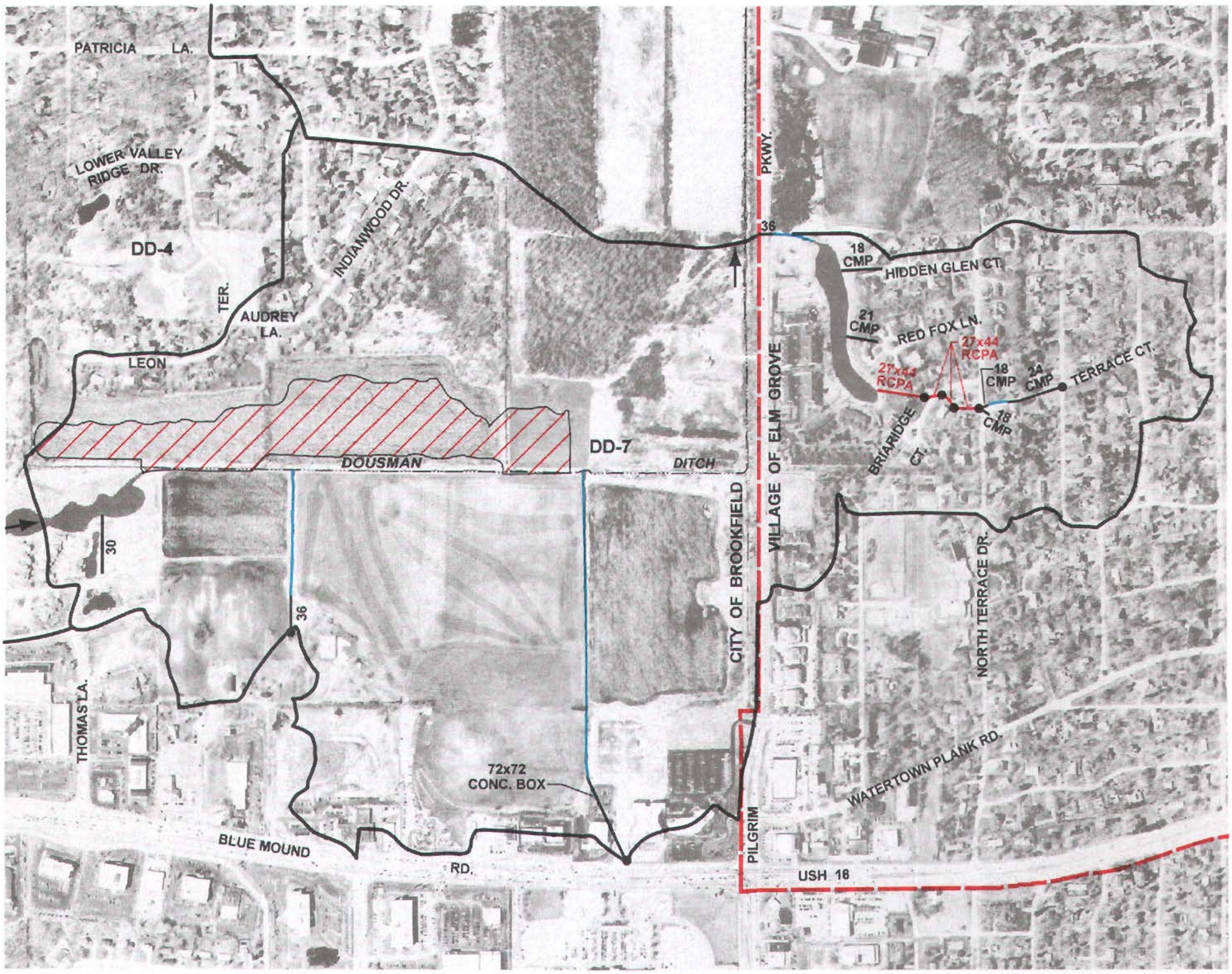
▬	HYDROLOGIC UNIT BOUNDARY
DD-5	HYDROLOGIC UNIT IDENTIFICATION
⟶	HYDROLOGIC UNIT OUTLET
18	EXISTING STORM SEWER OR CULVERT TO BE RETAINED (SIZE IN INCHES)
●	EXISTING MANHOLE OR CATCH BASIN
▬	EXISTING OPEN CHANNEL OR FLOW PATH
18	PROPOSED REPLACEMENT STORM SEWER OR CULVERT (SIZE IN INCHES)
48x96	PROPOSED STORM SEWER OR CULVERT (SIZE IN INCHES)
NOTE:	THIS MAP GENERALLY SHOWS EXISTING STORM SEWERS OF 18-INCH DIAMETER OR LARGER. PIPES ARE CONSTRUCTED OF REINFORCED CONCRETE UNLESS DESIGNATED AS BELOW.
CMP	CORRUGATED METAL PIPE
CMPA	CORRUGATED METAL PIPE ARCH

GRAPHIC SCALE
0 200 400 600 FEET
DATE OF PHOTOGRAPHY: APRIL 1995

Map 53 (continued)

RECOMMENDED STORMWATER MANAGEMENT PLAN FOR THE DOUSMAN DITCH AND UNDERWOOD CREEK SUBWATERSHEDS IN THE CITY OF BROOKFIELD AND THE VILLAGE OF ELM GROVE

HYDROLOGIC UNIT DD-7



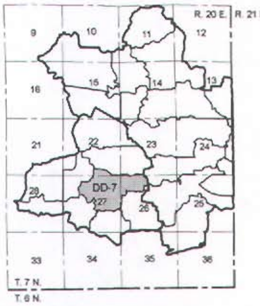
▬	HYDROLOGIC UNIT BOUNDARY
DD-7	HYDROLOGIC UNIT IDENTIFICATION
➔	HYDROLOGIC UNIT OUTLET
18	EXISTING STORM SEWER OR CULVERT TO BE RETAINED (SIZE IN INCHES)
●	EXISTING MANHOLE OR CATCH BASIN
▬	EXISTING OPEN CHANNEL OR FLOW PATH
18	PROPOSED REPLACEMENT STORM SEWER OR CULVERT (SIZE IN INCHES)
▨	PROPOSED DUAL-PURPOSE WET DETENTION BASIN

NOTE: THIS MAP GENERALLY SHOWS EXISTING STORM SEWERS OF 18-INCH DIAMETER OR LARGER. PIPES ARE CONSTRUCTED OF REINFORCED CONCRETE UNLESS DESIGNATED AS BELOW.

CMP	CORRUGATED METAL PIPE
RCPA	REINFORCED CONCRETE PIPE ARCH

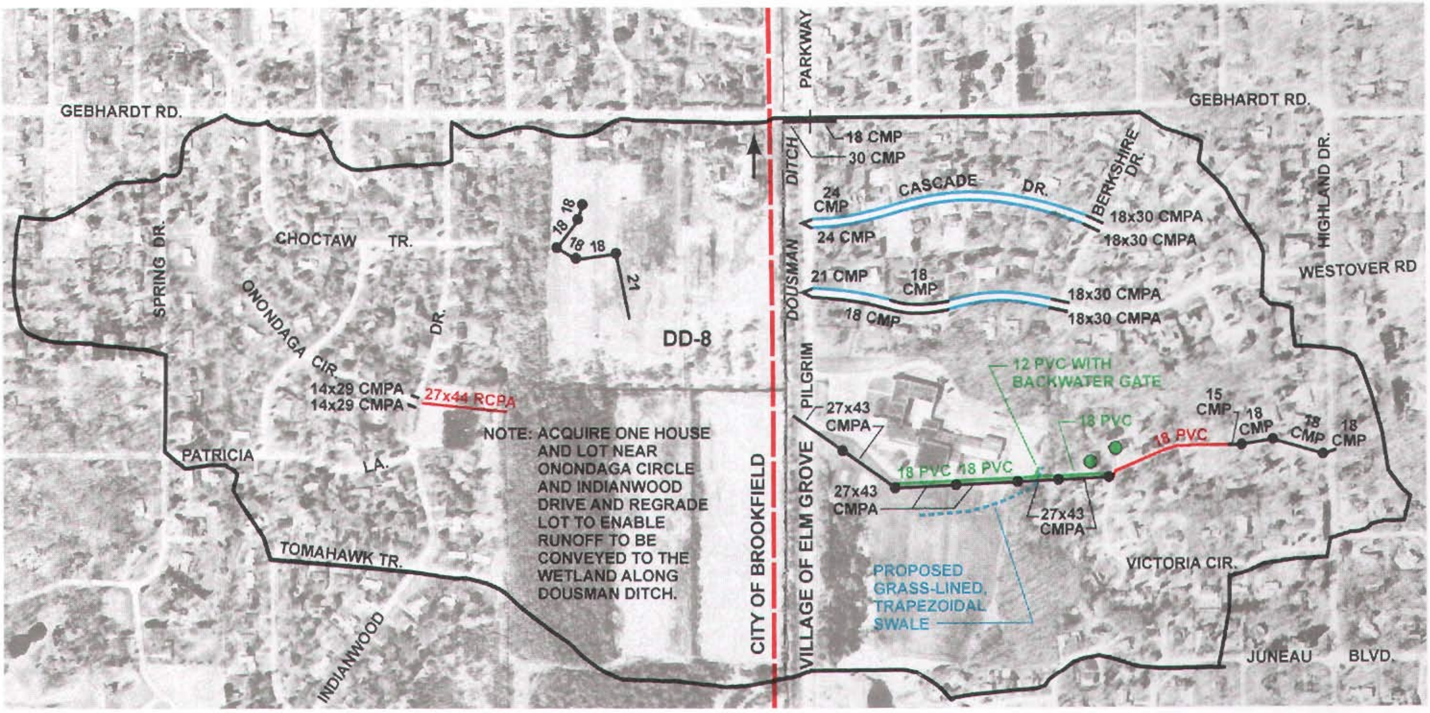
GRAPHIC SCALE
0 200 400 800 FEET
DATE OF PHOTOGRAPHY: APRIL 1995

DOUSMAN DITCH AND UNDERWOOD CREEK SUBWATERSHEDS HYDROLOGIC UNIT LOCATION MAP



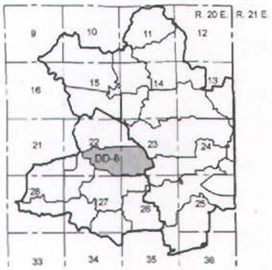
Map 53 (continued)

RECOMMENDED STORMWATER MANAGEMENT PLAN FOR THE DOUSMAN DITCH AND UNDERWOOD CREEK SUBWATERSHEDS IN THE CITY OF BROOKFIELD AND THE VILLAGE OF ELM GROVE
HYDROLOGIC UNIT DD-8



—	HYDROLOGIC UNIT BOUNDARY
DD-8	HYDROLOGIC UNIT IDENTIFICATION
→	HYDROLOGIC UNIT OUTLET
18	EXISTING STORM SEWER OR CULVERT TO BE RETAINED (SIZE IN INCHES)
●	EXISTING MANHOLE OR CATCH BASIN
—	EXISTING OPEN CHANNEL OR FLOW PATH
18	PROPOSED REPLACEMENT STORM SEWER OR CULVERT (SIZE IN INCHES)
18	PROPOSED STORM SEWER OR CULVERT (SIZE IN INCHES)
●	BUILDING PROPOSED TO BE FLOODPROOFED
NOTE:	THIS MAP GENERALLY SHOWS EXISTING STORM SEWERS OF 18-INCH DIAMETER OR LARGER. PIPES ARE CONSTRUCTED OF REINFORCED CONCRETE UNLESS DESIGNATED AS BELOW.
CMP	CORRUGATED METAL PIPE
CMPA	CORRUGATED METAL PIPE ARCH
PVC	POLYVINYL CHLORIDE
RCPA	REINFORCED CONCRETE PIPE ARCH

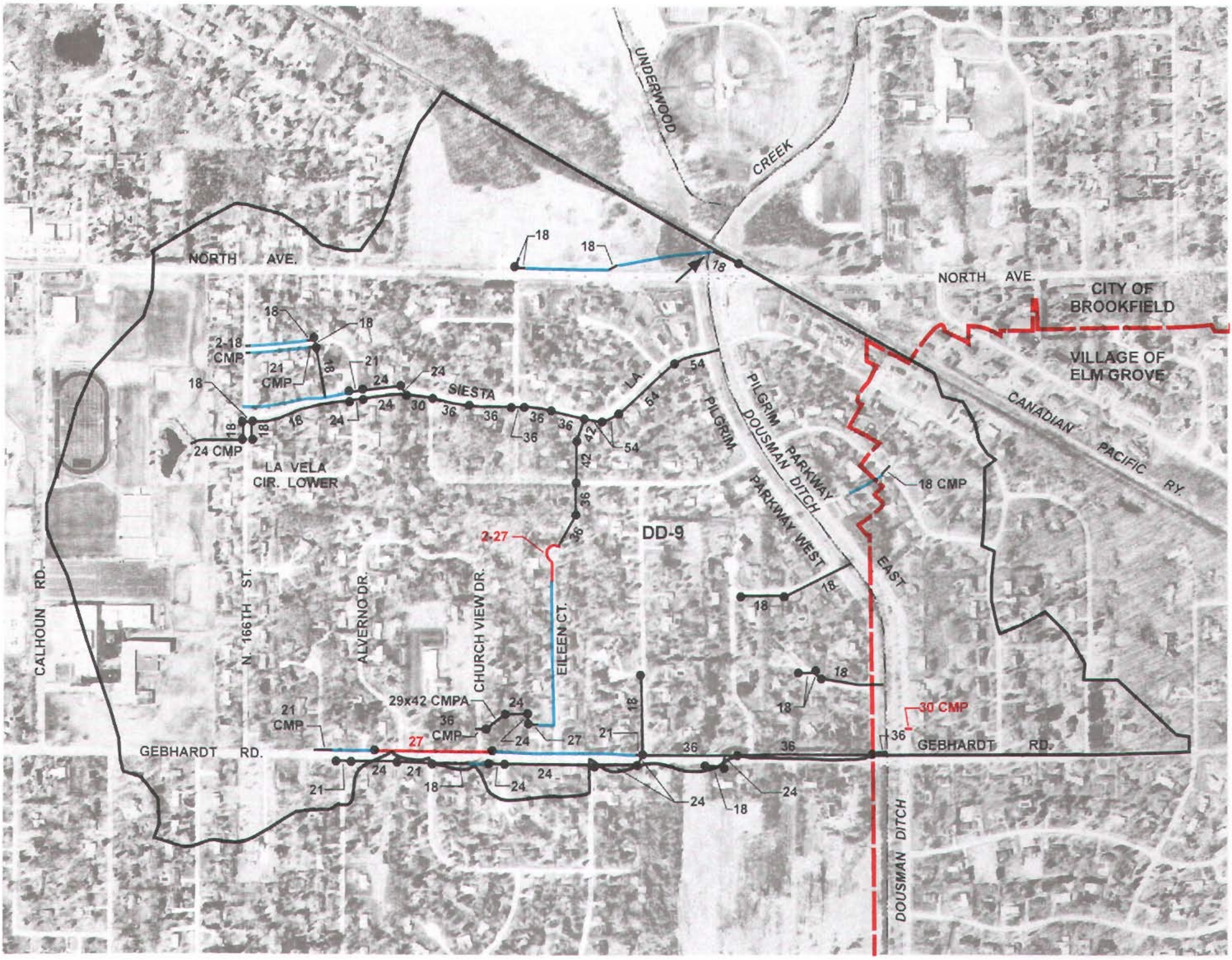
DOUSMAN DITCH AND
UNDERWOOD CREEK SUBWATERSHEDS
HYDROLOGIC UNIT LOCATION MAP



Map 53 (continued)

RECOMMENDED STORMWATER MANAGEMENT PLAN FOR THE DOUSMAN DITCH AND UNDERWOOD CREEK SUBWATERSHEDS IN THE CITY OF BROOKFIELD AND THE VILLAGE OF ELM GROVE

HYDROLOGIC UNIT DD-9



— HYDROLOGIC UNIT BOUNDARY

DD-9 HYDROLOGIC UNIT IDENTIFICATION

→ HYDROLOGIC UNIT OUTLET

18 EXISTING STORM SEWER OR CULVERT TO BE RETAINED (SIZE IN INCHES)

● EXISTING MANHOLE OR CATCH BASIN

— EXISTING OPEN CHANNEL OR FLOW PATH

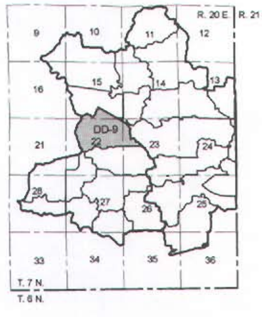
18 PROPOSED REPLACEMENT STORM SEWER OR CULVERT (SIZE IN INCHES)

NOTE: THIS MAP GENERALLY SHOWS EXISTING STORM SEWERS OF 18-INCH DIAMETER OR LARGER. PIPES ARE CONSTRUCTED OF REINFORCED CONCRETE UNLESS DESIGNATED AS BELOW.

CMP CORRUGATED METAL PIPE

CMPA CORRUGATED METAL PIPE ARCH

DOUSMAN DITCH AND UNDERWOOD CREEK SUBWATERSHEDS HYDROLOGIC UNIT LOCATION MAP



Map 53 (continued)

RECOMMENDED STORMWATER MANAGEMENT PLAN FOR THE DOUSMAN DITCH AND UNDERWOOD CREEK SUBWATERSHEDS IN THE CITY OF BROOKFIELD AND THE VILLAGE OF ELM GROVE

HYDROLOGIC UNIT UC-1

HYDROLOGIC UNIT BOUNDARY

UC-1 HYDROLOGIC UNIT IDENTIFICATION

HYDROLOGIC UNIT OUTLET

18 EXISTING STORM SEWER OR CULVERT TO BE RETAINED (SIZE IN INCHES)

● EXISTING MANHOLE OR CATCH BASIN

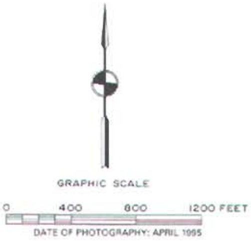
EXISTING OPEN CHANNEL OR FLOW PATH

18 PROPOSED REPLACEMENT STORM SEWER OR CULVERT (SIZE IN INCHES)

NOTE: THIS MAP GENERALLY SHOWS EXISTING STORM SEWERS OF 18-INCH DIAMETER OR LARGER. PIPES ARE CONSTRUCTED OF REINFORCED CONCRETE UNLESS DESIGNATED AS BELOW.

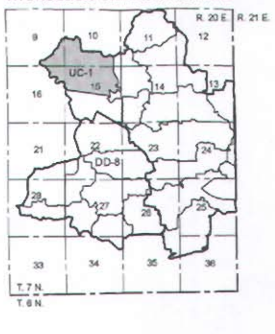
CMP CORRUGATED METAL PIPE

CMPA CORRUGATED METAL PIPE ARCH



DATE OF PHOTOGRAPHY: APRIL 1995

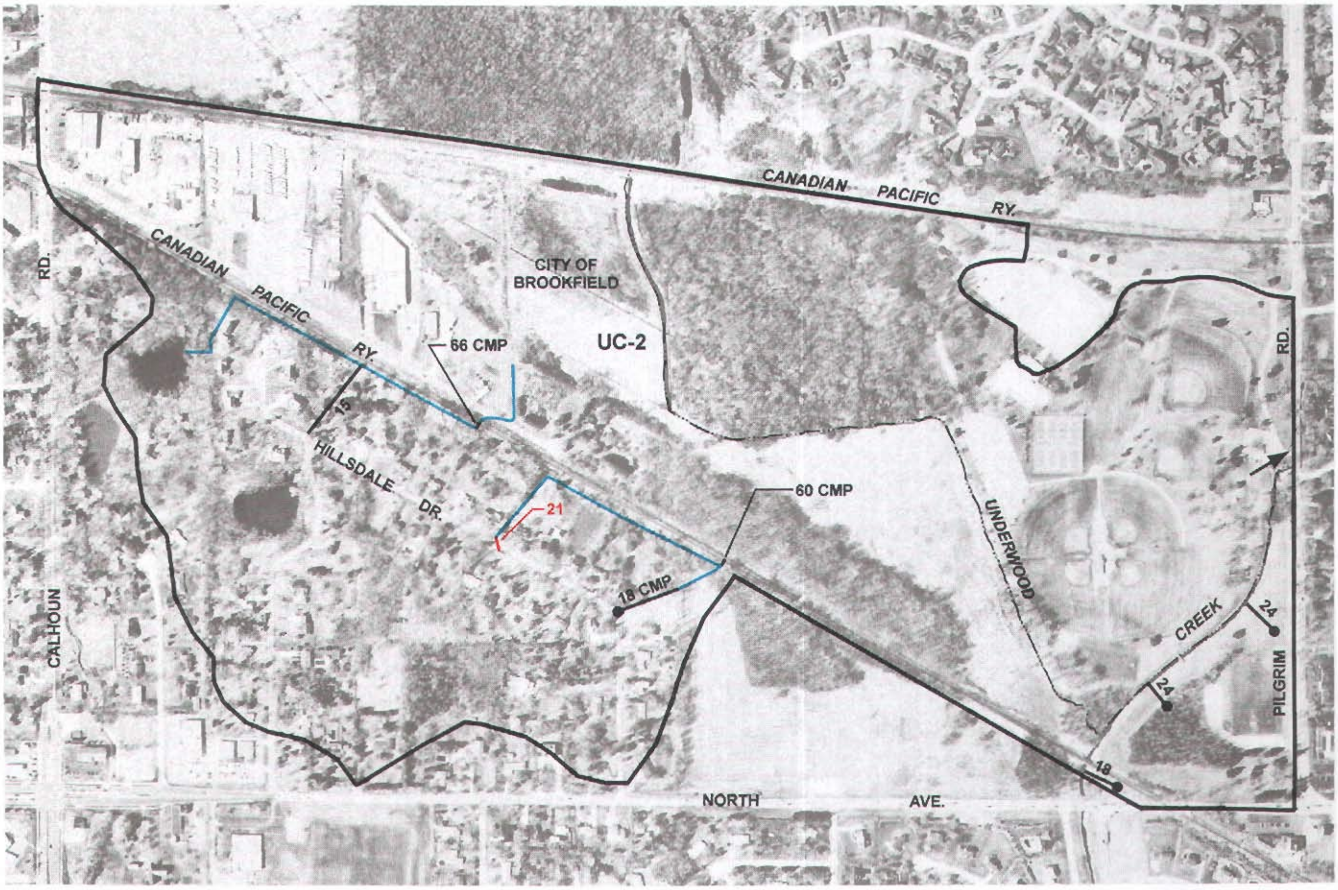
DOUSMAN DITCH AND UNDERWOOD CREEK SUBWATERSHEDS HYDROLOGIC UNIT LOCATION MAP



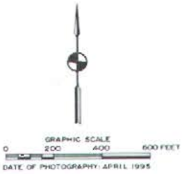
Map 53 (continued)

RECOMMENDED STORMWATER MANAGEMENT PLAN FOR THE DOUSMAN DITCH AND UNDERWOOD CREEK SUBWATERSHEDS IN THE CITY OF BROOKFIELD AND THE VILLAGE OF ELM GROVE

HYDROLOGIC UNIT UC-2

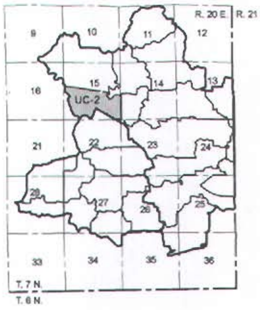


—	HYDROLOGIC UNIT BOUNDARY
UC-2	HYDROLOGIC UNIT IDENTIFICATION
➔	HYDROLOGIC UNIT OUTLET
18	EXISTING STORM SEWER OR CULVERT TO BE RETAINED (SIZE IN INCHES)
●	EXISTING MANHOLE OR CATCH BASIN
—	EXISTING OPEN CHANNEL OR FLOW PATH
21	PROPOSED REPLACEMENT STORM SEWER OR CULVERT (SIZE IN INCHES)
NOTE:	THIS MAP GENERALLY SHOWS EXISTING STORM SEWERS OF 18-INCH DIAMETER OR LARGER. PIPES ARE CONSTRUCTED OF REINFORCED CONCRETE UNLESS DESIGNATED AS BELOW.
CMP	CORRUGATED METAL PIPE



DATE OF PHOTOGRAPHY: APRIL 1995

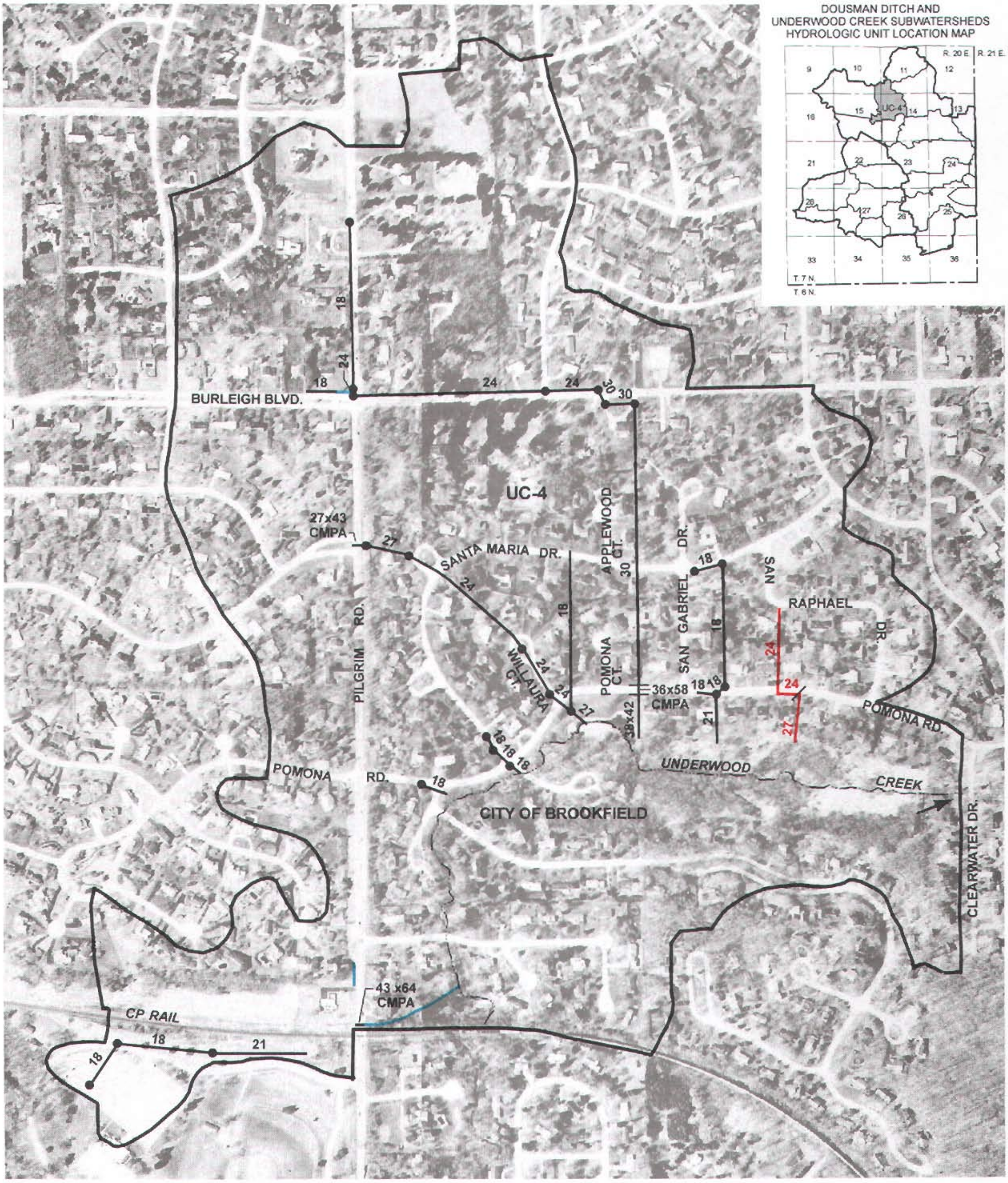
DOUSMAN DITCH AND UNDERWOOD CREEK SUBWATERSHEDS HYDROLOGIC UNIT LOCATION MAP



Map 53 (continued)

RECOMMENDED STORMWATER MANAGEMENT PLAN FOR THE DOUSMAN DITCH AND UNDERWOOD CREEK SUBWATERSHEDS IN THE CITY OF BROOKFIELD AND THE VILLAGE OF ELM GROVE

HYDROLOGIC UNIT UC-4



▬ HYDROLOGIC UNIT BOUNDARY

UC-4 HYDROLOGIC UNIT IDENTIFICATION

→ HYDROLOGIC UNIT OUTLET

18 EXISTING STORM SEWER OR CULVERT TO BE RETAINED (SIZE IN INCHES)

● EXISTING MANHOLE OR CATCH BASIN

— EXISTING OPEN CHANNEL OR FLOW PATH

27 PROPOSED REPLACEMENT STORM SEWER OR CULVERT (SIZE IN INCHES)

NOTE: THIS MAP GENERALLY SHOWS EXISTING STORM SEWERS OF 18-INCH DIAMETER OR LARGER. PIPES ARE CONSTRUCTED OF REINFORCED CONCRETE UNLESS DESIGNATED AS BELOW.

CMP	CORRUGATED METAL PIPE
CMPA	CORRUGATED METAL PIPE ARCH

GRAPHIC SCALE
0 200 400 600 FEET

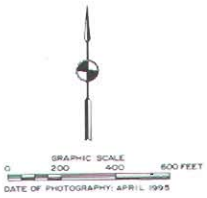
DATE OF PHOTOGRAPHY: APRIL 1995

Map 53 (continued)

RECOMMENDED STORMWATER MANAGEMENT PLAN FOR THE DOUSMAN DITCH AND UNDERWOOD CREEK SUBWATERSHEDS IN THE CITY OF BROOKFIELD AND THE VILLAGE OF ELM GROVE

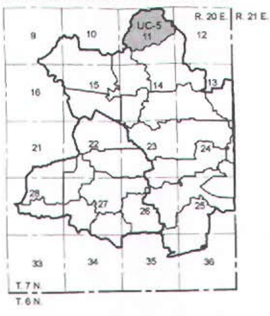
HYDROLOGIC UNIT UC-5

——	HYDROLOGIC UNIT BOUNDARY
UC-5	HYDROLOGIC UNIT IDENTIFICATION
→	HYDROLOGIC UNIT OUTLET
18	EXISTING STORM SEWER OR CULVERT TO BE RETAINED (SIZE IN INCHES)
●	EXISTING MANHOLE OR CATCH BASIN
——	EXISTING OPEN CHANNEL OR FLOW PATH
24x38	PROPOSED REPLACEMENT STORM SEWER OR CULVERT (SIZE IN INCHES)
24	PROPOSED STORM SEWER OR CULVERT (SIZE IN INCHES)
NOTE:	THIS MAP GENERALLY SHOWS EXISTING STORM SEWERS OF 18-INCH DIAMETER OR LARGER. PIPES ARE CONSTRUCTED OF REINFORCED CONCRETE UNLESS DESIGNATED AS BELOW.
CMP	CORRUGATED METAL PIPE



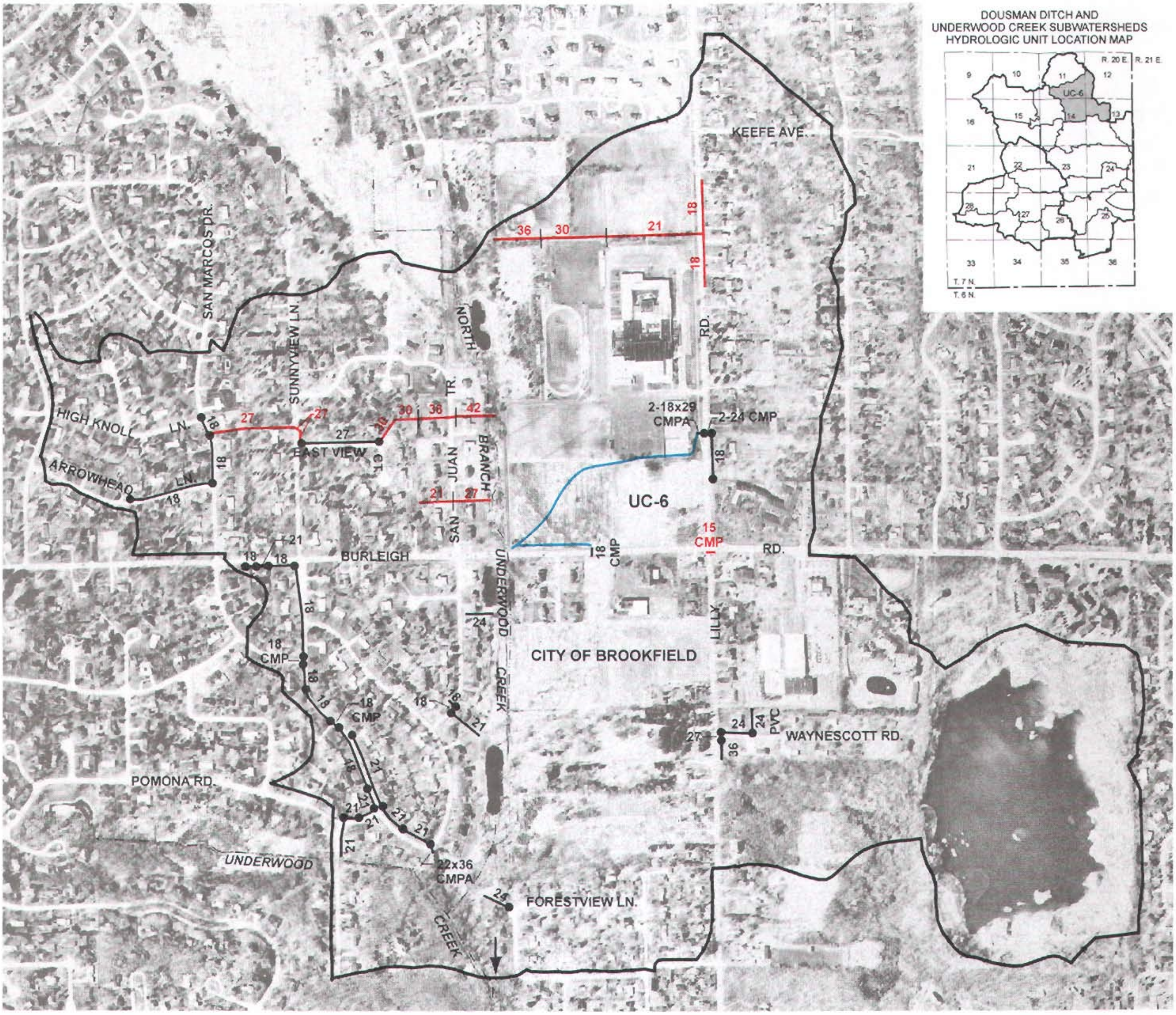
DATE OF PHOTOGRAPHY: APRIL 1995

DOUSMAN DITCH AND UNDERWOOD CREEK SUBWATERSHEDS HYDROLOGIC UNIT LOCATION MAP



Map 53 (continued)

RECOMMENDED STORMWATER MANAGEMENT PLAN FOR THE DOUSMAN DITCH AND UNDERWOOD CREEK SUBWATERSHEDS IN THE CITY OF BROOKFIELD AND THE VILLAGE OF ELM GROVE
HYDROLOGIC UNIT UC-6



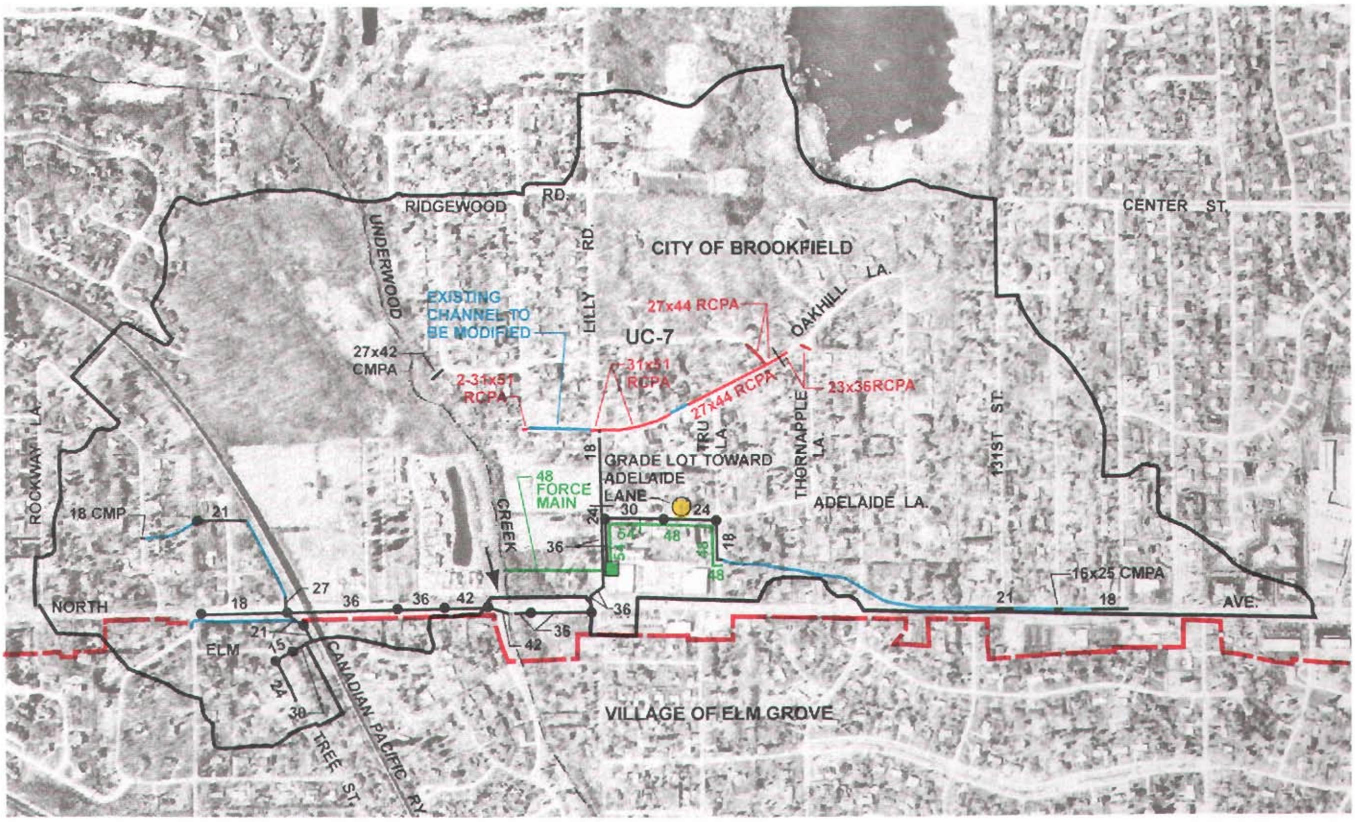
—	HYDROLOGIC UNIT BOUNDARY
UC-6	HYDROLOGIC UNIT IDENTIFICATION
→	HYDROLOGIC UNIT OUTLET
18	EXISTING STORM SEWER OR CULVERT TO BE RETAINED (SIZE IN INCHES)
●	EXISTING MANHOLE OR CATCH BASIN
—	EXISTING OPEN CHANNEL OR FLOW PATH
18	PROPOSED REPLACEMENT STORM SEWER OR CULVERT (SIZE IN INCHES)
NOTE:	THIS MAP GENERALLY SHOWS EXISTING STORM SEWERS OF 18-INCH DIAMETER OR LARGER PIPES ARE CONSTRUCTED OF REINFORCED CONCRETE UNLESS DESIGNATED AS BELOW.
CMP	CORRUGATED METAL PIPE
CMPA	CORRUGATED METAL PIPE ARCH
PVC	POLYVINYL CHLORIDE

DATE OF PHOTOGRAPHY: APRIL 1995

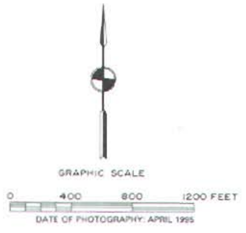
Map 53 (continued)

RECOMMENDED STORMWATER MANAGEMENT PLAN FOR THE DOUSMAN DITCH AND UNDERWOOD CREEK SUBWATERSHEDS IN THE CITY OF BROOKFIELD AND THE VILLAGE OF ELM GROVE

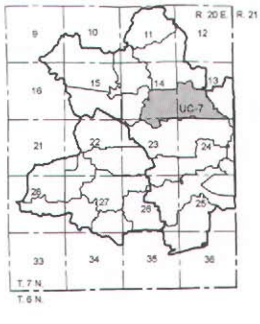
HYDROLOGIC UNIT UC-7



—	HYDROLOGIC UNIT BOUNDARY
UC-7	HYDROLOGIC UNIT IDENTIFICATION
→	HYDROLOGIC UNIT OUTLET
18	EXISTING STORM SEWER OR CULVERT TO BE RETAINED (SIZE IN INCHES)
●	EXISTING MANHOLE OR CATCH BASIN
—	EXISTING OPEN CHANNEL OR FLOW PATH
27x44	PROPOSED REPLACEMENT STORM SEWER OR CULVERT (SIZE IN INCHES)
🟩	PROPOSED STORMWATER PUMPING STATION
54	PROPOSED STORM SEWER OR CULVERT (SIZE IN INCHES)
NOTE:	THIS MAP GENERALLY SHOWS EXISTING STORM SEWERS OF 18-INCH DIAMETER OR LARGER. PIPES ARE CONSTRUCTED OF REINFORCED CONCRETE UNLESS DESIGNATED AS BELOW.
CMP	CORRUGATED METAL PIPE
CMPA	CORRUGATED METAL PIPE ARCH
RCPA	REINFORCED CONCRETE PIPE ARCH



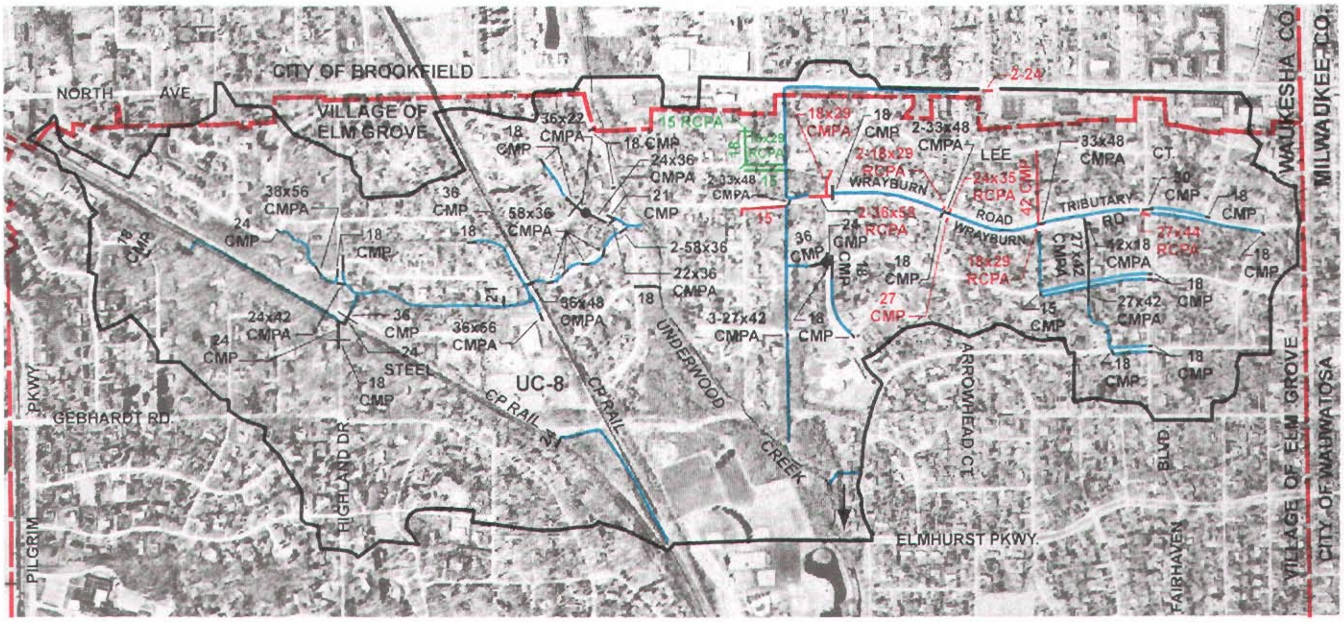
DOUSMAN DITCH AND UNDERWOOD CREEK SUBWATERSHEDS HYDROLOGIC UNIT LOCATION MAP



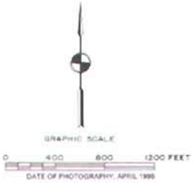
Map 53 (continued)

RECOMMENDED STORMWATER MANAGEMENT PLAN FOR THE DOUSMAN DITCH AND UNDERWOOD CREEK SUBWATERSHEDS IN THE CITY OF BROOKFIELD AND THE VILLAGE OF ELM GROVE

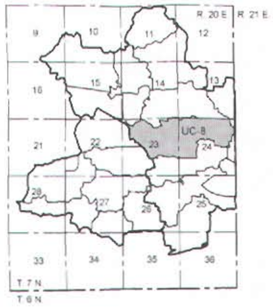
HYDROLOGIC UNIT UC-8



—	HYDROLOGIC UNIT BOUNDARY
UC-8	HYDROLOGIC UNIT IDENTIFICATION
→	HYDROLOGIC UNIT OUTLET
24	EXISTING STORM SEWER OR CULVERT TO BE RETAINED (SIZE IN INCHES)
●	EXISTING MANHOLE OR CATCH BASIN
—	EXISTING OPEN CHANNEL OR FLOW PATH
15	PROPOSED REPLACEMENT STORM SEWER OR CULVERT (SIZE IN INCHES)
18	PROPOSED STORM SEWER OR CULVERT (SIZE IN INCHES)
NOTE	THIS MAP GENERALLY SHOWS EXISTING STORM SEWERS OF 18-INCH DIAMETER OR LARGER. PIPES ARE CONSTRUCTED OF REINFORCED CONCRETE UNLESS DESIGNATED AS BELOW
CMP	CORRUGATED METAL PIPE
CMPA	CORRUGATED METAL PIPE ARCH
RCPA	REINFORCED CONCRETE PIPE ARCH

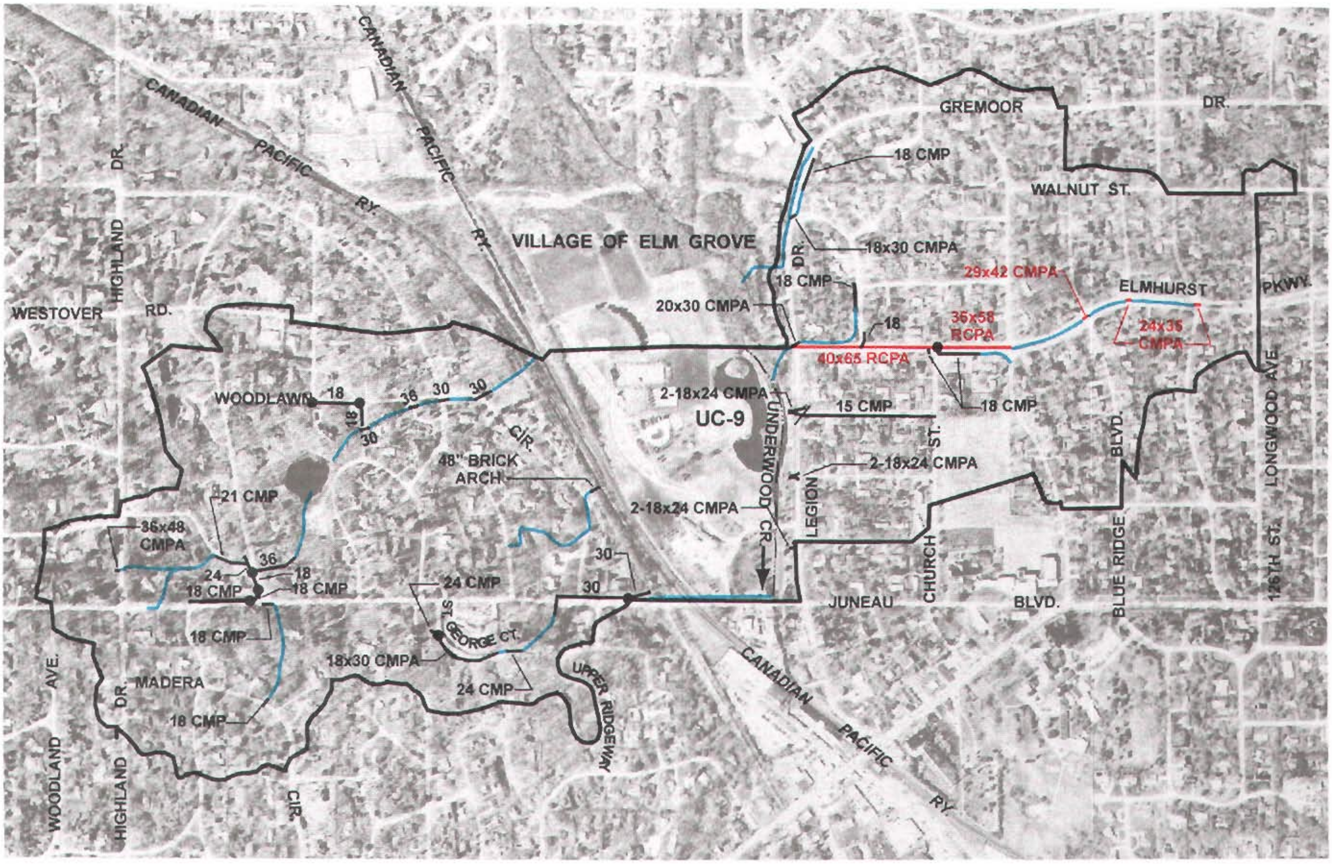


DOUSMAN DITCH AND UNDERWOOD CREEK SUBWATERSHEDS HYDROLOGIC UNIT LOCATION MAP

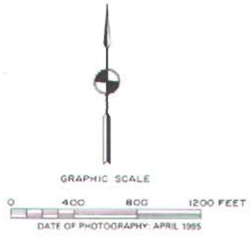


Map 53 (continued)

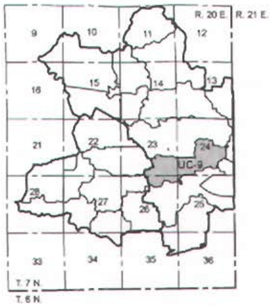
RECOMMENDED STORMWATER MANAGEMENT PLAN FOR THE DOUSMAN DITCH AND UNDERWOOD CREEK SUBWATERSHEDS IN THE CITY OF BROOKFIELD AND THE VILLAGE OF ELM GROVE
HYDROLOGIC UNIT UC-9



—	HYDROLOGIC UNIT BOUNDARY
UC-9	HYDROLOGIC UNIT IDENTIFICATION
→	HYDROLOGIC UNIT OUTLINE
18	EXISTING STORM SEWER OR CULVERT TO BE RETAINED (SIZE IN INCHES)
●	EXISTING MANHOLE OR CATCH BASIN
—	EXISTING OPEN CHANNEL OR FLOW PATH
40x65	PROPOSED REPLACEMENT STORM SEWER OR CULVERT (SIZE IN INCHES)
NOTE:	THIS MAP GENERALLY SHOWS EXISTING STORM SEWERS OF 18-INCH DIAMETER OR LARGER. PIPES ARE CONSTRUCTED OF REINFORCED CONCRETE UNLESS DESIGNATED AS BELOW.
CMP	CORRUGATED METAL PIPE
CMPA	CORRUGATED METAL PIPE ARCH
RCPA	REINFORCED CONCRETE PIPE ARCH



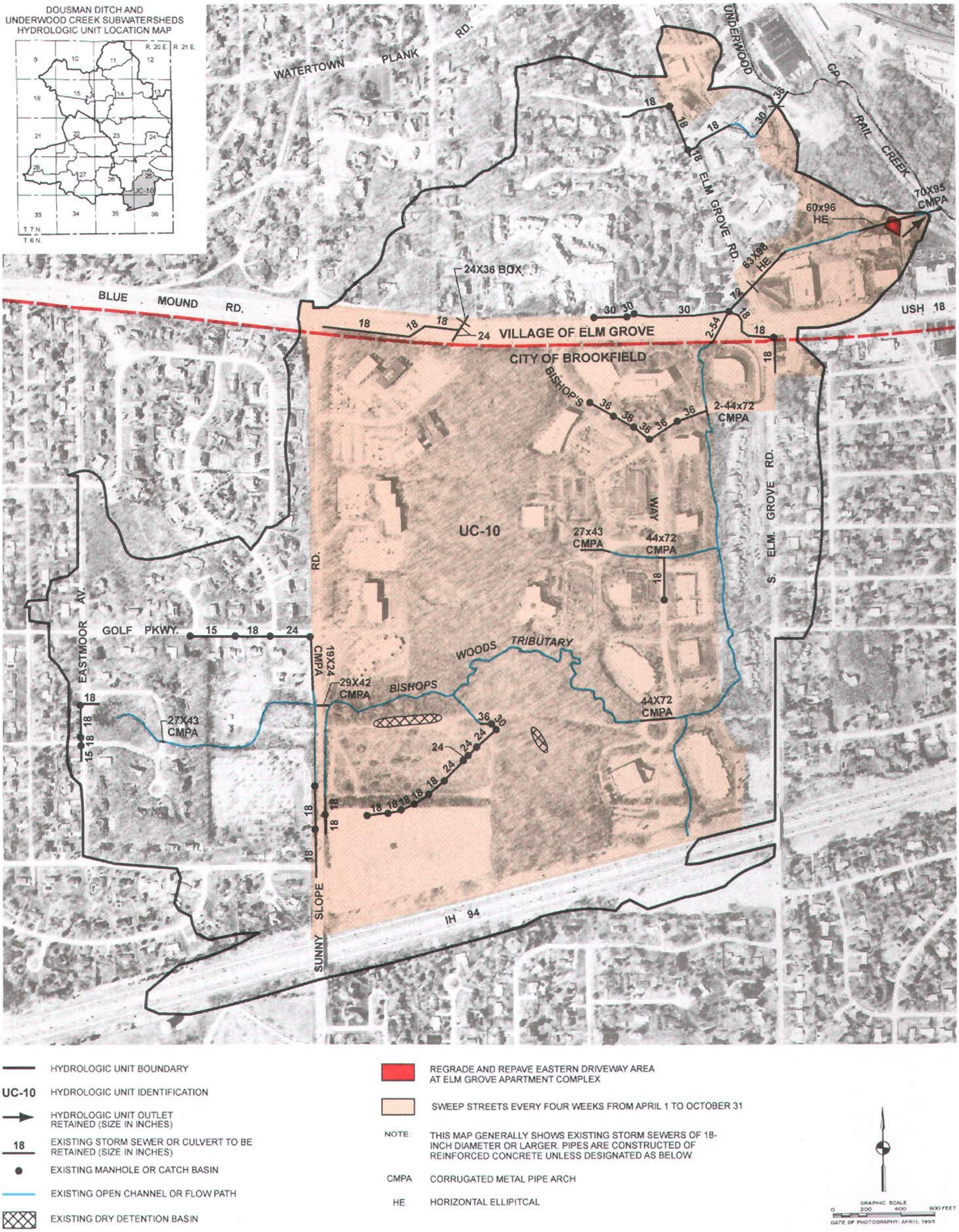
DOUSMAN DITCH AND
UNDERWOOD CREEK SUBWATERSHEDS
HYDROLOGIC UNIT LOCATION MAP



Map 53 (continued)

RECOMMENDED STORMWATER MANAGEMENT PLAN FOR THE DOUSMAN DITCH AND UNDERWOOD CREEK SUBWATERSHEDS IN THE CITY OF BROOKFIELD AND THE VILLAGE OF ELM GROVE

HYDROLOGIC UNIT UC-10



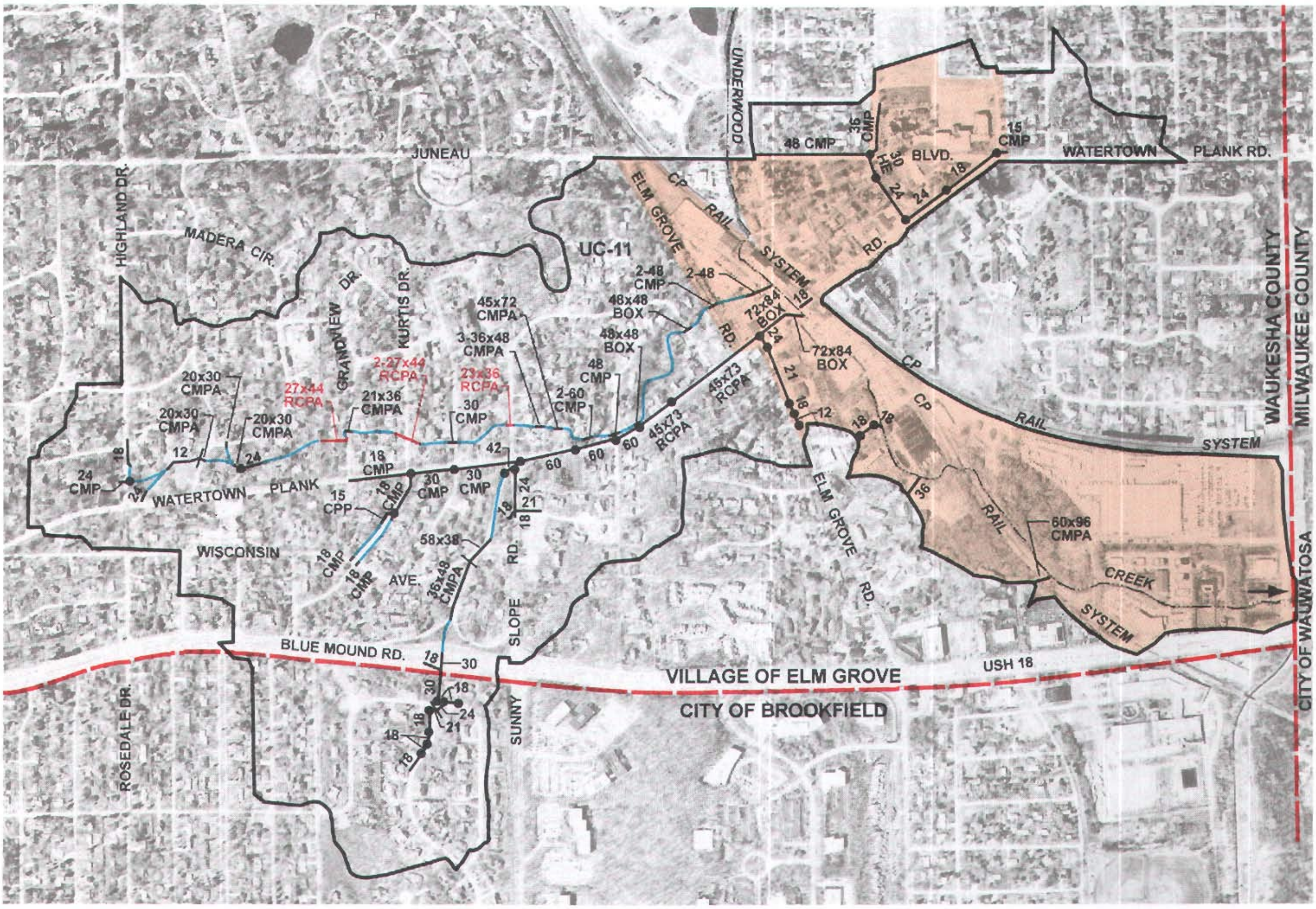
NOTE: THIS MAP GENERALLY SHOWS EXISTING STORM SEWERS OF 18-INCH DIAMETER OR LARGER. PIPES ARE CONSTRUCTED OF REINFORCED CONCRETE UNLESS DESIGNATED AS BELOW.

DATE OF PHOTOGRAPHY: APRIL, 1995

Map 53 (continued)

RECOMMENDED STORMWATER MANAGEMENT PLAN FOR THE DOUSMAN DITCH AND UNDERWOOD CREEK SUBWATERSHEDS IN THE CITY OF BROOKFIELD AND THE VILLAGE OF ELM GROVE

HYDROLOGIC UNIT UC-11



— HYDROLOGIC UNIT BOUNDARY

UC-11 HYDROLOGIC UNIT IDENTIFICATION

→ HYDROLOGIC UNIT OUTLET

18 EXISTING STORM SEWER OR CULVERT TO BE RETAINED (SIZE IN INCHES)

● EXISTING MANHOLE OR CATCH BASIN

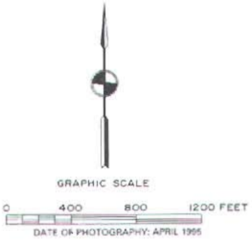
— EXISTING OPEN CHANNEL OR FLOW PATH

27x44 PROPOSED REPLACEMENT STORM SEWER OR CULVERT (SIZE IN INCHES)

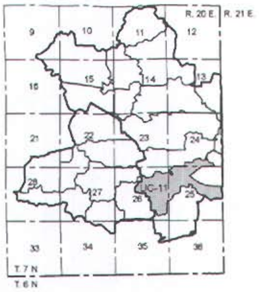
▨ SWEEP STREETS EVERY FOUR WEEKS FROM APRIL 1 TO OCTOBER 31

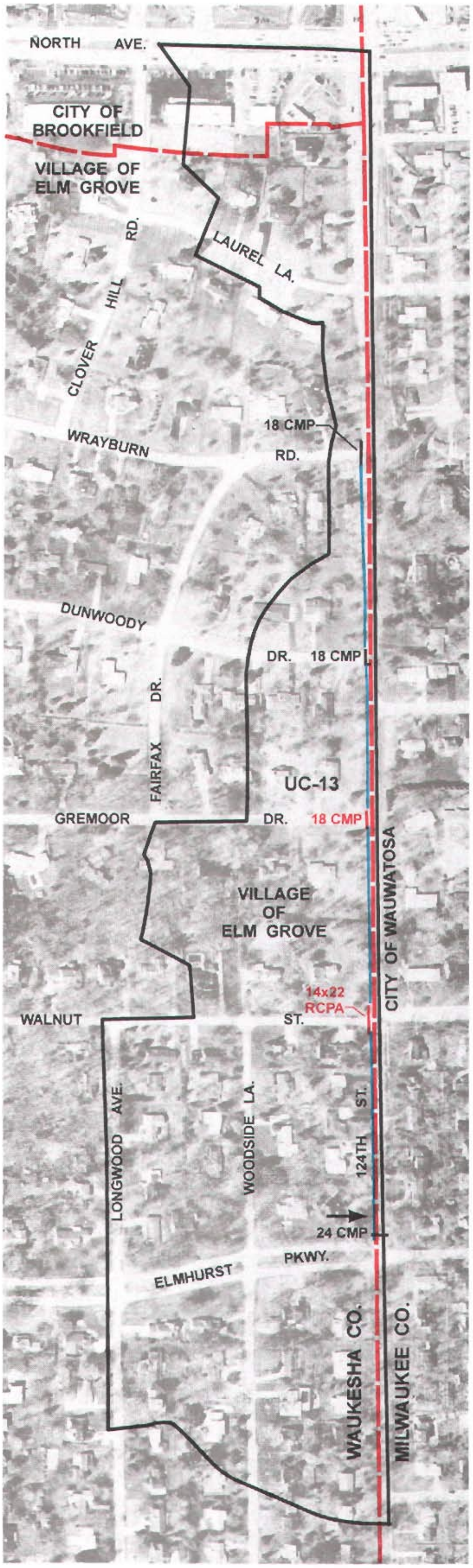
NOTE: THIS MAP GENERALLY SHOWS EXISTING STORM SEWERS OF 18-INCH DIAMETER OR LARGER. PIPES ARE CONSTRUCTED OF REINFORCED CONCRETE UNLESS DESIGNATED AS BELOW.

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



DOUSMAN DITCH AND UNDERWOOD CREEK SUBWATERSHEDS HYDROLOGIC UNIT LOCATION MAP



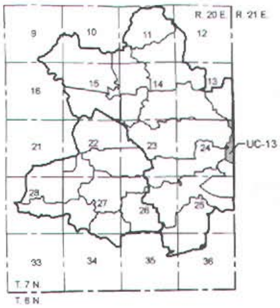


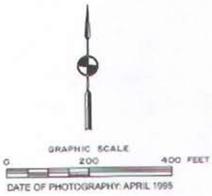
Map 53 (continued)

RECOMMENDED STORMWATER MANAGEMENT PLAN FOR THE DOUSMAN DITCH AND UNDERWOOD CREEK SUBWATERSHEDS IN THE CITY OF BROOKFIELD AND THE VILLAGE OF ELM GROVE HYDROLOGIC UNIT UC-13

▬	HYDROLOGIC UNIT BOUNDARY
UC-13	HYDROLOGIC UNIT IDENTIFICATION
→	HYDROLOGIC UNIT OUTLET
18	EXISTING STORM SEWER OR CULVERT TO BE RETAINED (SIZE IN INCHES)
●	EXISTING MANHOLE OR CATCH BASIN
▬	EXISTING OPEN CHANNEL OR FLOW PATH
18	PROPOSED REPLACEMENT STORM SEWER OR CULVERT (SIZE IN INCHES)
NOTE:	THIS MAP GENERALLY SHOWS EXISTING STORM SEWERS OF 18-INCH DIAMETER OR LARGER. PIPES ARE CONSTRUCTED OF REINFORCED CONCRETE UNLESS DESIGNATED AS BELOW.
CMP	CORRUGATED METAL PIPE
RCPA	REINFORCED CONCRETE PIPE ARCH

DOUSMAN DITCH AND
UNDERWOOD CREEK SUBWATERSHEDS
HYDROLOGIC UNIT LOCATION MAP



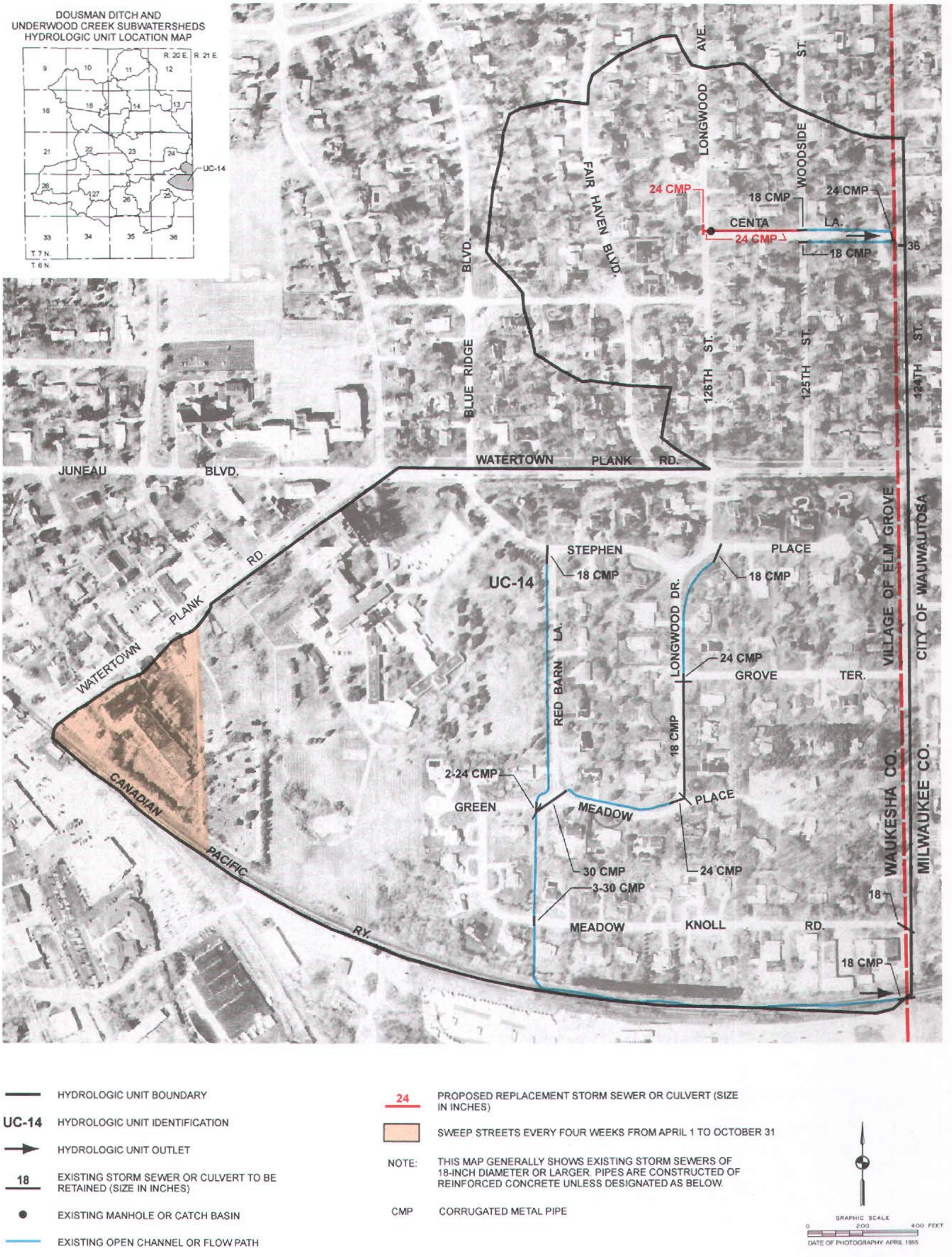


DATE OF PHOTOGRAPHY: APRIL 1995

Map 53 (continued)

RECOMMENDED STORMWATER MANAGEMENT PLAN FOR THE DOUSMAN DITCH AND UNDERWOOD CREEK SUBWATERSHEDS IN THE CITY OF BROOKFIELD AND THE VILLAGE OF ELM GROVE

HYDROLOGIC UNIT UC-14



Source: SEWRPC.

cent, and total zinc loads by 37 percent, relative to 1990 conditions.

Appurtenant facilities required for the proper functioning of the wet detention basin include about 1,900 lineal feet of access roads/baffles and an 1,800-foot-long open channel along the south side of the access road, as shown on Map 20. The access road/baffle would provide access to the Underwood trunk sewer manholes which would be located within the permanent pond, would divert runoff into the wet basin, and would provide an adequate travel distance for that runoff. The provision of that travel distance would maximize the settling time for removal of particulate pollutants.

Construction of the open channel would require reversing the existing slope of a portion of Dousman Ditch to enable flow to occur from east to west along the baffle and into the permanent pond. The eastern 500 feet of the channel would be excavated beginning at the existing south to north channel and extending west to the existing Dousman Ditch channel. From that point, the streambed slope of Dousman Ditch would be reversed for a distance of 1,300 feet. The open channel would essentially be an extension of the pond. The channel would be from five to six feet deep and could be parabolic in shape, with a top width of 35 to 40 feet.

A sediment forebay would be provided in the wet detention basin to trap the coarser particulates in a localized area, reducing sediment removal costs.

Additional Measures for the Control of Nonpoint Source Pollution

In addition to the control of runoff from areas of planned development that would be provided by the recommended wet detention basin, the recommended plan calls for the control of nonpoint source pollution from all remaining areas to be developed, or from areas of redevelopment. Such control would be achieved through 1) construction of the recommended Dousman Ditch detention basin, 2) construction site erosion control measures, and 3) site-specific best management practices to reduce the washoff of pollutants.

The plan also calls for 1) maintenance of the existing 15 ponds in the study area; 2) increasing the frequency of street sweeping in areas with urban street cross-sections and curb and gutter to once every four weeks between April 1 and October 31; 3) reduced application of sand on streets in the winter; 4) localized bank protection projects, using natural bioengineering techniques wherever practical; and 5) public information and education efforts to promote good urban "housekeeping" practices that reduce nonpoint source pollution.

Implementation of the recommended plan would provide controls on runoff from about 73 percent of the critical land uses in the study area and all areas of new development or redevelopment. As seen from Table 20, construction of the Dousman Ditch wet detention basin and the recommended increased street sweeping would result in pollutant loading reductions relative to 1990 land use conditions in the study area of 3 percent for total solids, 18 percent for particulate solids, 5 percent for phosphorus, 16 percent for copper, 20 percent for lead, and 3 percent for zinc. Relative to planned buildout conditions, the expected reductions due to implementation of those measures would be 8 percent for total solids, 25 percent for particulate solids, 15 percent for phosphorus, 21 percent for copper, 28 percent for lead, and 15 percent for zinc. Implementation of the additional measures as recommended above would be expected to significantly increase the loading reductions.

Recommended Stormwater Drainage Measures

The recommended stormwater drainage measures are summarized in graphic form on Map 53. Detailed descriptions of the recommended stormwater drainage components for each of the hydrologic units in the study area are provided in Chapter V.

In addition to providing control of nonpoint source pollution, the Dousman Ditch detention basin also serves as an important component of the stormwater drainage plan element. This basin would provide storage to offset the effects of new tributary development on peak flows. The basin would reduce the 100-year flood stage along Dousman Ditch upstream of the detention basin outlet structure from 0.4 to 1.9 feet compared to the existing 100-year flood stage. Along Dousman Ditch between the basin outlet and Gebhardt Road, the 100-year flood stage would be decreased by about 0.1 foot. That reduction would marginally improve drainage of adjacent developed areas where significant major system stormwater drainage problems exist in the City of Brookfield and the Village of Elm Grove. Those areas include the Indianwood Drive/Onondaga Circle area, the Cascade Drive/Westover Road/Pilgrim Parkway Middle School area, and the Victoria Circle North area.

Full implementation of the recommended stormwater drainage measures would provide a minor stormwater drainage system adequate to convey and/or store runoff from storms with recurrence intervals up to, and including 10 years and to generally provide an acceptable level of traffic service and access to property during such storms. Implementation of the recommended drainage measures would also avoid direct flooding of inhabited buildings during storms with recurrence intervals up to, and including 100 years. The recommended measures would help to mitigate, but not eliminate, flooding of basements due to sanitary sewer backup. Other measures directed toward reduction of infiltration and inflow to sanitary sewers would be required to fully alleviate sanitary sewer backup problems.

Stormwater Management Plan Costs

As set forth in Table 53, the estimated capital cost of the recommended water quality management plan element is $4,096,000 and the estimated capital cost of the recommended stormwater drainage plan element is $5,388,000. Thus, the estimated cost of the stormwater management plan component of the recommended plan is $9,484,000.

Local Action on Stormwater Drainage Recommendations

Following review of the recommended stormwater management plan by the City of Brookfield and the Village of Elm Grove, several local initiatives were undertaken relative to implementation and/or refinement of the recommended plan. These include:

- Design and construction of the recommended stormwater drainage facilities in the vicinity of Verdant Drive and Pilgrim Parkway in Hydrologic Unit DD-5 in the Village of Elm Grove.
- Design and construction of some of the recommended stormwater drainage facilities in the vicinity of Victoria Circle North in Hydrologic Unit DD-8 in the Village of Elm Grove.
- Initiation by the City of Brookfield of analyses to explore the possibility of purchasing buildings and constructing an expanded floodwater storage facility in the vicinity of Tru and Adelaide Lanes northeast of the intersection of W. North Avenue and Lilly Road in Hydrologic Unit UC-7. That approach was put forth as an alternative to constructing a stormwater pump station and appurtenances to alleviate flooding problems.

At the time of publication of this report, the feasibility of the City's refinement to the plan had not been established.

RECOMMENDED FLOODLAND MANAGEMENT PLAN

The components of the recommended floodland management plan and their estimated capital and annual operation and maintenance costs are summarized in Table 53. The recommended plan components are shown in detail on Map 54 and in summary form in the context of the overall recommended plan on Map 53. The recommended floodland management plan is a refinement of Alternative Plan No. 11, which is described in Chapter V.

Reduction in Flooding Resulting from Implementation of the Recommended Plan

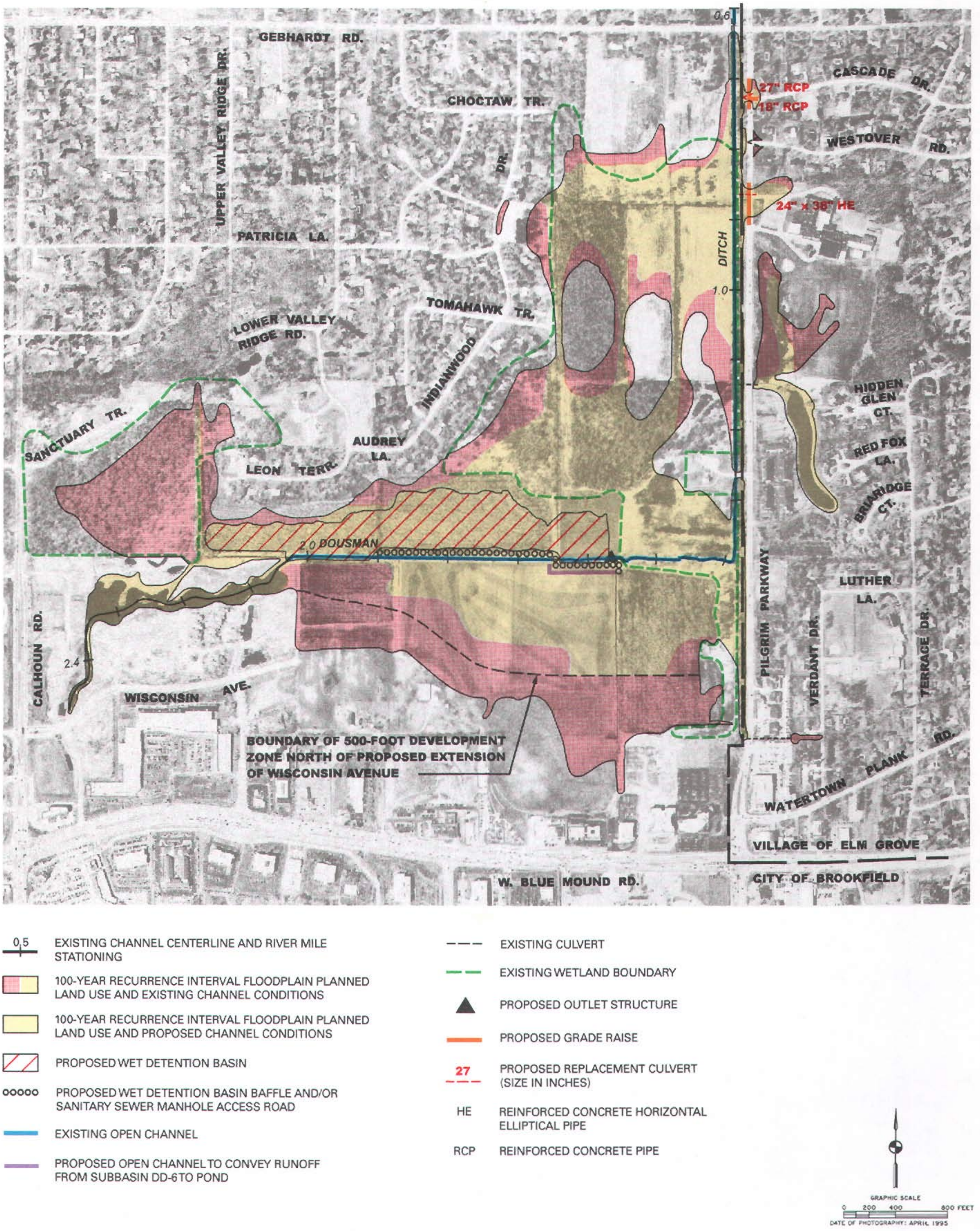
Full implementation of the recommended floodland management plan would eliminate structure flood damages due to direct overland flooding along Underwood Creek for floods up to and including the 100-year recurrence interval flood event under planned land use and channel conditions. Damages due to street flooding and sanitary sewer basement backup problems would be reduced, but not eliminated by implementation of this plan. Other measures directed toward reduction of infiltration and inflow to sanitary sewers would be required to fully alleviate sanitary sewer backup problems.

The 100-year flood stage along Dousman Ditch in the City of Brookfield upstream of the detention basin outlet structure would be reduced from 0.4 to 1.9 feet compared to the existing 100-year flood stage. Along Dousman Ditch between the basin outlet and Gebhardt Road in the City of Brookfield and the Village of Elm Grove, the 100-year flood stage would be decreased by about 0.1 foot. As previously described, that reduction would marginally improve drainage of adjacent developed lands in the City and the Village, including the Indianwood and Onondaga area where significant stormwater drainage problems exist.

Implementation of the plan would reduce the 100-year flood stage from 0.7 to 3.5 feet in the reach in the

Map 54

RECOMMENDED MANAGEMENT PLAN ALONG DOUSMAN DITCH—LIMITED DOUSMAN DITCH DETENTION STORAGE, UNDERWOOD CREEK OVERFLOW CHANNEL AND DIVERSION, AND COMPENSATING STORAGE WITH STRUCTURE FLOODPROOFING AND REMOVAL



Source: SEWRPC.

Village of Elm Grove extending from the Milwaukee-Waukesha County line to W. North Avenue and from 0.2 to 0.3 foot in the City of Brookfield in the 0.5-mile-long reach upstream from W. North Avenue. The provision of floodwater storage volume as described below would avoid flood flow and stage increases in the City of Wauwatosa downstream of the Village of Elm Grove during floods with recurrence intervals ranging from two through 100 years.

The number of buildings located in the 100-year floodplain of Underwood Creek would be reduced from 57 to 22 due to implementation of the plan. As shown in Tables 54 and 55, 50 of those buildings are located in the Village of Elm Grove and seven are located in the City of Brookfield.

Components of the Recommended Floodland Management Plan

As shown on Maps 53, 54, and 55 the components of the recommended plan include: 1) a dual-purpose, 23-acre-foot detention basin along Dousman Ditch west of Pilgrim Parkway; 2) about 14 acre-feet of floodwater storage volume in the east overbank of Underwood Creek in the City of Brookfield immediately northwest of the intersection of W. North Avenue and Lilly Road; 3) purchase of six houses and lots located east of Underwood Creek in the City to enable construction of the detention storage area described under Item 2; 4) about 35 acre-feet of floodwater storage volume in the northern portion of the Village Park; 5) a 4,100-foot-long overflow channel along the west overbank of Underwood Creek from near the intersection of Mt. Kisco Drive and Underwood River Parkway to Juneau Boulevard;[2] 6) three parallel 31-foot-long, four-foot-high by 10-foot-wide reinforced concrete box culverts at the Marcella Avenue crossing of the overflow channel; 7) two parallel 28-foot-long, five-foot-high by 10-foot-wide reinforced concrete box culverts at the Village Hall Drive crossing of the overflow channel; 8) a 5,400-foot-long double six-foot-high by seven-foot-wide reinforced concrete box culvert diversion from Juneau Boulevard through the downtown portion of the Village of Elm Grove to a location about 450 feet east of the Milwaukee-Waukesha County line; 9) floodproofing of one single-family residence in Brookfield and two in Elm Grove, three apartment buildings in Elm Grove, and one commercial building in Brookfield and eight in Elm Grove (Tables 56 and 57); 10) replacement of the existing Clearwater Drive culverts with four parallel, 40-foot-long, 48-inch-high by 76-inch-wide reinforced concrete HE culverts; 11) raising the grade of Clearwater Drive; and 12) provision of one acre-foot of floodwater storage volume near Clearwater Drive.[3] Typical cross-sections of the proposed overflow channel are shown on Figures 10 through 13.

Additional measures associated with the recommended Dousman Ditch detention basin include 1) acquiring about 115 acres of land in the vicinity of the detention basin; 2) raising about 360 feet of Pilgrim Parkway south of Gebhardt Road an average of about 0.9 foot to avoid inundation of the roadway during a 100-year flood; and 3) replacing the existing northern 24-inch-diameter corrugated metal pipe (CMP) culvert under Pilgrim Parkway at Cascade Drive with a 50-foot-long, 27-inch-diameter RCP culvert, replacing the southern CMP culvert with a 53-foot-long, 18-inch-diameter RCP culvert, and replacing the existing 27-inch-high by 43-inch-wide corrugated metal pipe arch (CMPA) culvert under Pilgrim Parkway at the northern entrance to Pilgrim Park Middle School with a 60-foot-long, 24-inch-high by 38-inch-wide reinforced concrete horizontal elliptical (HE) pipe culvert.[4]

As part of the detailed design of the flood control channel project, it is recommended that consideration be given to lowering one or both of the existing

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[2] *In general the overflow channel would be from two to 4.5 feet deep, with a 40- to 300-foot-wide bottom and 70- to 330-foot-wide top. Channel side slopes would be one vertical on three horizontal, or flatter. The channel would flow into, and out of, the existing pond in the Village Park.*

[3] *See the later section of this chapter which describes the recommended measures in the vicinity of Clearwater Drive.*

[4] *As described in Appendix D, under this plan, which has the same effects relative to the Bluemound Road Golf Range site as floodland management Alternative Plan Nos. 3, 10, and 11, the frequency and duration of flooding of the golf range site would be reduced in comparison with existing conditions. Interruptions in the use of the range due to flooding would be infrequent.*

Table 54

BUILDINGS ALONG UNDERWOOD CREEK THAT ARE WITHIN THE 100-YEAR RECURRENCE INTERVAL FLOODPLAIN IN THE VILLAGE OF ELM GROVE[a]

Building Number	Type of Building
602	Single-family residence
603	Commercial
604a	Apartments
604b	Apartments
604c	Apartments
604d	Apartments
604e	Apartments
604f	Apartments
606	Commercial
607	Commercial
607a	Commercial
608	Commercial
611	Commercial
612	Commercial
613	Commercial
614	Commercial
615	Single-family residence
616	Commercial
617	Commercial
618	Commercial
619	Commercial
620	Single-family residence
621	Single-family residence
622	Single-family residence
623	Single-family residence
624	Commercial
625	Commercial
626	Commercial
626a	Commercial
628	Single-family residence
629	Single-family residence
630	Single-family residence
632	Single-family residence
633	Single-family residence
634	Single-family residence
635	Single-family residence

Table 54 (continued)

Building Number	Type of Building
636	Single-family residence
637	Single-family residence
638	Single-family residence
640	Single-family residence
641	Single-family residence
642	Single-family residence
644	Single-family residence
649	Single-family residence
650	Single-family residence
650a	Single-family residence
653	Single-family residence
654	Single-family residence
655	Single-family residence
656	Single-family residence
700	Single-family residence

[a] *Under planned land use and existing channel conditions.*

Source: SEWRPC.

Table 55

BUILDINGS ALONG UNDERWOOD CREEK THAT ARE WITHIN THE 100-YEAR RECURRENCE INTERVAL FLOODPLAIN IN THE CITY OF BROOKFIELD[a]

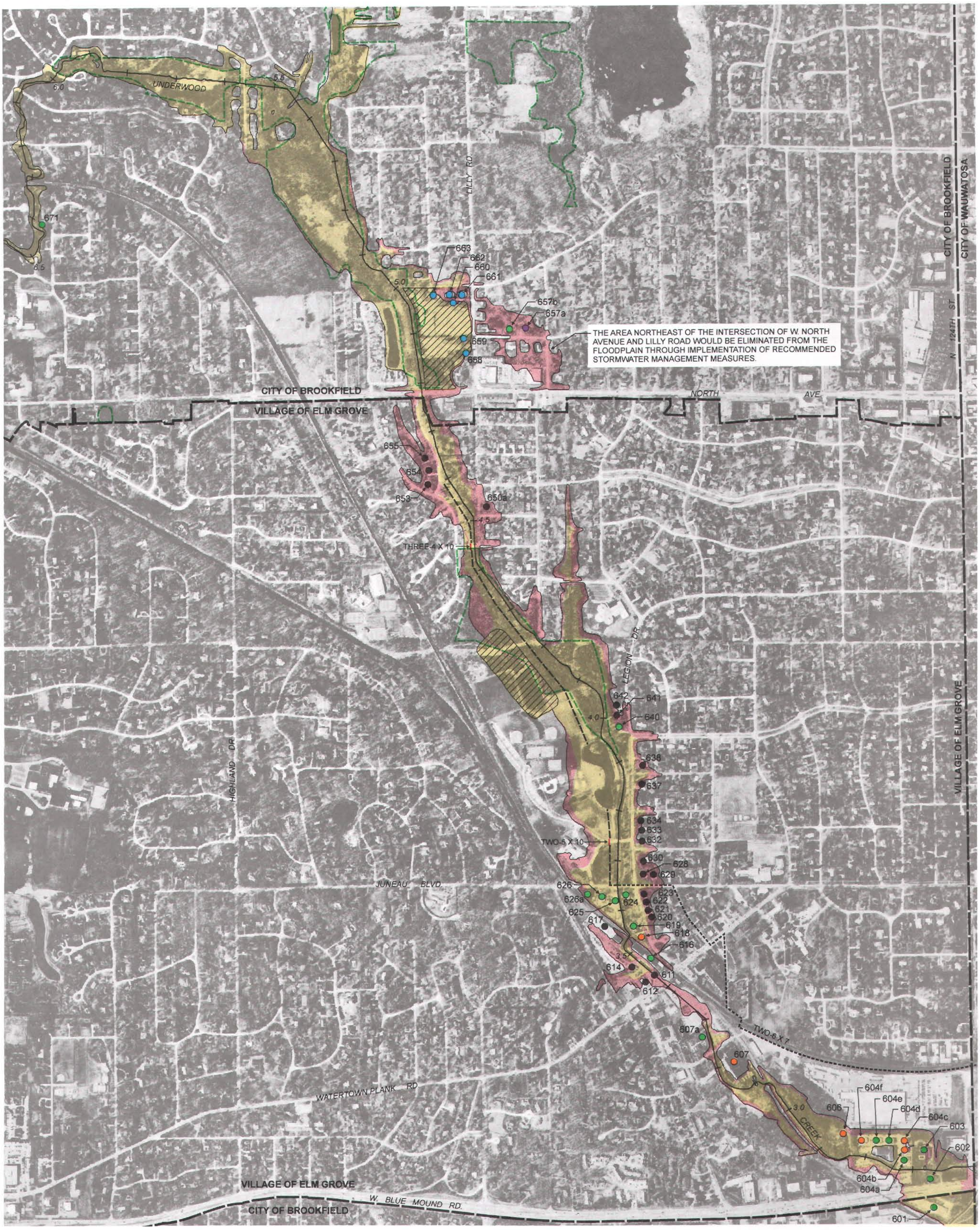
Building Number	Type of Building
601	Commercial
657b	Single-family residence
658	Single-family residence
659	Single-family residence
660	Single-family residence
663	Single-family residence
671	Single-family residence

[a] *Under planned land use and existing channel conditions.*

Source: SEWRPC.

Map 55

RECOMMENDED FLOODLAND MANAGEMENT PLAN ALONG UNDERWOOD CREEK—LIMITED DOUSMAN DITCH DETENTION STORAGE, UNDERWOOD CREEK OVERFLOW CHANNEL, AND DIVERSION, AND COMPENSATING STORAGE WITH STRUCTURE FLOODPROOFING AND REMOVAL



0.5 EXISTING CHANNEL CENTERLINE AND RIVER MILE STATIONING

🟥 100-YEAR RECURRENCE INTERVAL FLOODPLAIN—PLANNED LAND USE AND EXISTING CHANNEL CONDITIONS

🟨 100-YEAR RECURRENCE INTERVAL FLOODPLAIN—PLANNED LAND USE AND PROPOSED CHANNEL CONDITIONS

- - - EXISTING WETLAND BOUNDARY

607a BUILDING DESIGNATION

● BUILDING PROPOSED TO BE FLOODPROOFED

● BUILDING PROPOSED TO BE REMOVED

● BUILDING PROPOSED TO BE PURCHASED FOR CONSTRUCTION OF FLOODWATER STORAGE AREA

● BUILDING NO LONGER IN FLOODPLAIN DUE TO IMPLEMENTATION OF RECOMMENDED FLOOD CONTROL MEASURES

● BUILDING NEAR EDGE OF FLOODPLAIN, FLOODPROOFING MAY NOT BE REQUIRED

— PROPOSED BOX CULVERT (SIZE IN FEET)

- - - - - PROPOSED DIVERSION BOX CULVERT (SIZE IN FEET)

— — — PROPOSED OVERFLOW CHANNEL

▨ PROPOSED COMPENSATING STORAGE AREA

NOTE: IF IT IS DETERMINED DURING THE FINAL DESIGN STAGE THAT CERTAIN BUILDINGS CANNOT BE FLOODPROOFED, IT IS RECOMMENDED THAT THOSE BUILDINGS BE ACQUIRED AND REMOVED.

GRAPHIC SCALE
0 200 400 800 FEET
DATE OF PHOTOGRAPHY: APRIL 1995

Source: SEWRPC.

Table 56

BUILDINGS IN THE VILLAGE OF ELM GROVE TO BE FLOODPROOFED UNDER THE RECOMMENDED FLOOD CONTROL PLAN

Building Number	Type of Building
602	Single-family residence
603	Commercial
604a	Apartments
604d	Apartments
604e	Apartments
607a	Commercial
616	Commercial
619	Commercial
624	Commercial
625	Commercial
626	Commercial
626a	Commercial
640	Single-family residence

Source: SEWRPC.

Table 57

BUILDINGS IN THE CITY OF BROOKFIELD TO BE FLOODPROOFED UNDER THE RECOMMENDED FLOOD CONTROL PLAN[a,b]

Building Number	Type of Building	Type of Mitigation
601	Commercial	Floodproof
671	Single-family residence	Floodproof

[a] *Building 657b at 13860 Adelaide Lane would be removed from the floodplain through implementation of recommended stormwater management measures.*

[b] *Buildings 658, 659, 660, and 663 would be purchased for construction of the floodwater storage area north of W. North Avenue*

Source: SEWRPC.

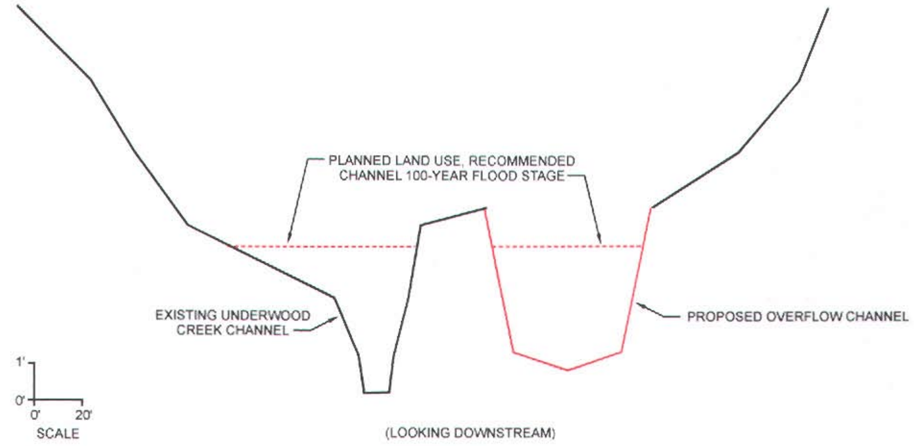
channel overbanks as an option in all or portions of the area where additional capacity is needed. In addition, it is recommended that consideration be given to removing the existing low-flow concrete cunette in the bed of Underwood Creek between the Village Hall Drive and Juneau Boulevard.

Potential Wetland Impacts

This recommended plan was developed to minimize the number of buildings in the 100-year floodplain and to avoid disturbance and modification of the existing Underwood Creek stream channel. The upstream 2,900-foot-long reach of the overflow

Figure 10

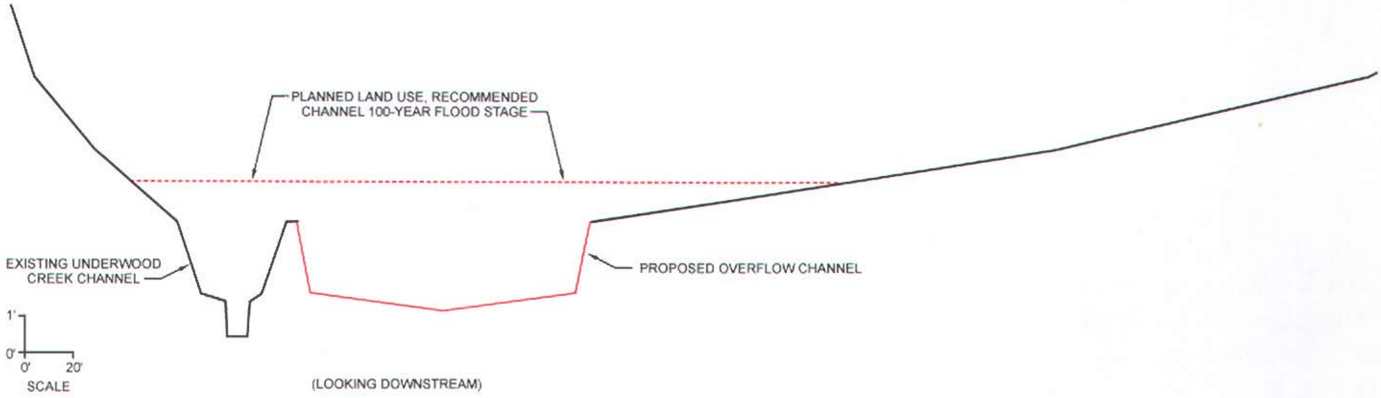
TYPICAL CROSS-SECTION OF EXISTING UNDERWOOD CREEK CHANNEL AND PROPOSED OVERFLOW CHANNEL FROM RIVER MILE 4.42 TO 4.64



Source: SEWRPC.

Figure 11

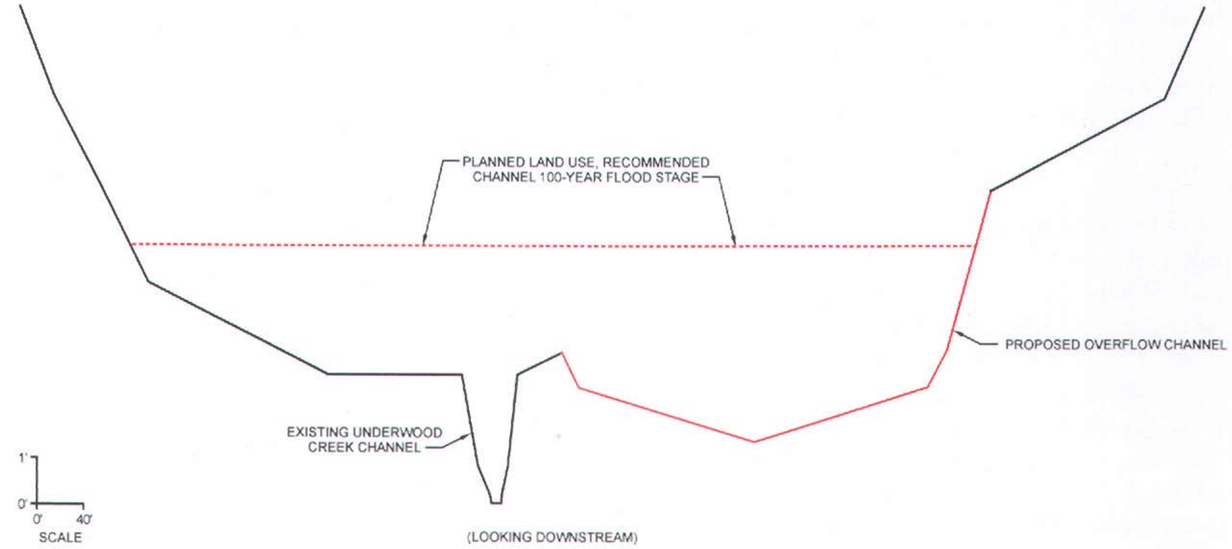
TYPICAL CROSS-SECTION OF EXISTING UNDERWOOD CREEK CHANNEL AND PROPOSED OVERFLOW CHANNEL FROM RIVER MILE 4.26 TO 4.42



Source: SEWRPC.

Figure 12

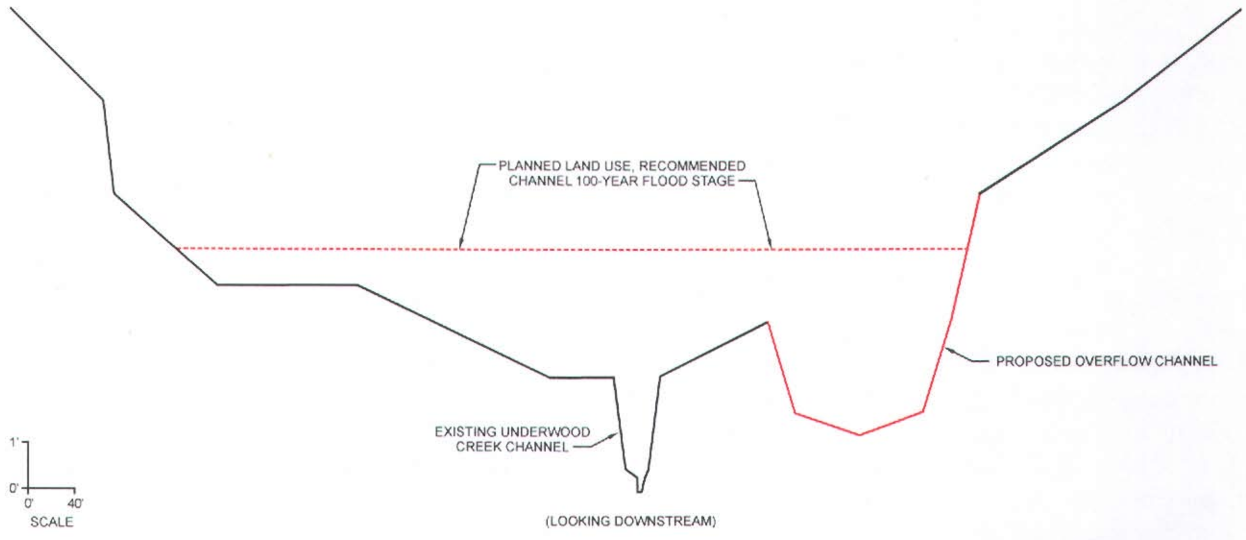
TYPICAL CROSS-SECTION OF EXISTING UNDERWOOD CREEK CHANNEL AND PROPOSED OVERFLOW CHANNEL FROM RIVER MILE 3.68 TO 3.82 AND 4.16 TO 4.26



Source: SEWRPC.

Figure 13

TYPICAL CROSS-SECTION OF EXISTING UNDERWOOD CREEK CHANNEL AND PROPOSED OVERFLOW CHANNEL FROM RIVER MILE 3.97 TO 4.16



Source: SEWRPC.

channel from Marcella Street to the north end of the pond in the Village Park would be located in a wetland. Within the Village Park, the channel top width would range from about 160 feet to 330 feet. In the reach extending from the northern boundary of the Village Park to Marcella Street, the channel top width would range from 120 to 135 feet. The top width would narrow to 70 feet near Marcella Street. In general, it would not be possible to construct the overflow channel without some wetland disturbance and removal of mature trees; however, it may be possible to minimize the degree of disturbance and tree removal by refining the channel alignment during the final design stage. Also, the channel design could include restoration of wetland conditions in disturbed areas. Construction of the proposed floodwater storage areas upstream of W. North Avenue and in the Elm Grove Village Park and the downstream portion of the diversion culvert might also involve some wetland disturbance, but, once again, the degree of disturbance could be minimized during the final design of the project. Also, wetland conditions could be reestablished following construction, since the land would remain in open space uses. The final overflow channel alignment and floodwater storage area configurations would involve consideration of 1) the concerns of property owners along the route of the channel in the area north of the Village Park, 2) the impacts to the recreational features of the Village Park, 3) the degree of disturbance of wetlands, and 4) the monetary costs of alternative alignments and configurations.

Cost of the Recommended Floodland Management Element

As set forth in Table 53, the total capital cost of the floodland management element of the recommended plan is estimated to be $14,755,000, assuming it would be possible to floodproof all of the buildings remaining in the floodplain. This cost includes $260,000 for land acquisition; $50,000 for raising the grade of Pilgrim Parkway and installing larger culverts under the roadway; $1,625,000 for construction of the overflow channel and associated culverts; $9,400,000 for construction of the diversion box culvert and associated easements; $1,540,000 for the provision of floodwater storage volume along Underwood Creek upstream of W. North Avenue, including the purchase of buildings and lots; $1,500,000 for the provision of floodwater storage volume in the Elm Grove Village Park; $260,000 for floodproofing or removal of structures; and $120,000 for culvert replacement, a road grade raise, and creation of floodwater storage volume at Clearwater Drive. Assuming an annual interest rate of 6 percent, a project life and amortization period of 50 years, and annual operation and maintenance costs of $36,000 per year, the average annual cost of the recommended plan is $973,000. The average annual flood damage abatement benefit is estimated to be $135,000, yielding a benefit-cost ratio of 0.14.

If, during the final design stage, it were determined that all of the buildings that are recommended to be floodproofed could not be floodproofed, those buildings would be purchased and removed. If all of the buildings were purchased and removed, the estimated cost of the recommended plan could increase to $22,205,000. Therefore, it would be realistic to expect that the cost of implementing the recommended plan to be in the range from $14,755,000 to $22,205,000.

Local Action on Floodland Management Recommendations

Following review of the recommended floodland management plan by the Village of Elm Grove, a local initiative was undertaken to refine that plan. The Village initiated analyses to explore the possibility of purchasing several buildings in or near the Underwood Creek floodplain, removing private bridges, and rerouting the recommended double box diversion culverts so that they would discharge to a floodwater storage facility that would be constructed along Underwood Creek in the Village just east of the Milwaukee/Waukesha County line. That floodwater storage facility would be located at the site of the buildings to be purchased under the Village scenario. The storage facility was intended to reduce the amount of storage volume to be provided in the Village Park, or to eliminate the need for the Village Park storage area. As was the case for the recommended plan, the scenario proposed by the Village was to be developed in such a manner that flood flows and stages would not be increased downstream of the County line. At the time of publication of this report, the feasibility of the Village's refinement to the plan had not been established.

100-Year Recurrence Interval Flood Profile

Tables 58 and 59 present estimated 100-year recurrence interval flood flows at selected locations along Dousman Ditch and Underwood Creek under planned land use and existing channel conditions and under planned land use and recommended channel conditions.

Table 58

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

Location	River Mile	Planned Land Use and Existing Channel Conditions (cfs)[a]	Planned Land Use and Recommended Channel Conditions (cfs)[a]	Federal Flood Insurance Study (cfs)
At Canadian Pacific Railway	7.68	74	74	165[b]
Above Confluence with Dousman Ditch	7.08	158	158	165[b]
At Canadian Pacific Railway	6.32	727	715	1,175[b]
At Santa Maria Drive	5.85	847	831	1,430[b]
About 930 Feet Downstream of Clearwater Drive	5.41	847	831	1,680[b]
At North Avenue	4.82	1,040	1,020	1,540[b]
At Juneau Boulevard	3.67	1,170	1,170	1,950[c]
Above Confluence with the South Branch of Underwood Creek	2.56	1,550	1,120[d]	1,950[c]
Just Downstream of Confluence with the South Branch of Underwood Creek	2.50	3,460	3,470	- -
About 90 Feet Upstream of W. Watertown Plank Road	1.53	4,410	4,390	5,400[e]
Just Upstream of USH 45	0.76	5,190	5,170	5,400[e]
Above Confluence with the Menomonee River	0.06	6,040	6,010	5,400[e]

[a] *Based on simulated record from 1940 through 1997.*

[b] *Flow based on 1986 Federal Emergency Management Agency (FEMA) Federal Flood Insurance Study for the City of Brookfield.*

[c] *Flow based on 1982 FEMA Federal Flood Insurance Study for the Village of Elm Grove.*

[d] *Flow in existing stream only. 550 cfs would be conveyed in the concrete box diversion.*

[e] *Flow based on 1978 FEMA Federal Flood Insurance Study for the City of Wauwatosa.*

Source: SEWRPC.

Table 59

COMPARISON OF 100-YEAR RECURRENCE INTERVAL FLOOD FLOWS FOR DOUSMAN DITCH

Location	River Mile	Planned Land Use and Existing Channel Conditions (cfs)[a]	Planned Land Use and Recommended Channel Conditions (cfs)[a]	1986 Federal Flood Insurance Study for the City of Brookfield (cfs)
About 1,080 Feet Upstream of Private Drive Entrance to Dunkel Inn	1.48	452	384	715
At Private Drive Entrance to Dunkel Inn	1.26	356	334	715
About 490 Feet Upstream of Gebhardt Road	0.72	356	334	900
Above Confluence with Underwood Creek	0.02	543	528	900

[a] *Based on simulated record from 1940 through 1997.*

Source: SEWRPC.

The 100-year recurrence interval flood profiles for Dousman Ditch and Underwood Creek, computed using peak flow rates for planned land use and existing channel conditions and for planned land use and recommended channel conditions, was used to delineate the 100-year recurrence interval floodplain areas along the streams as shown on Maps 53, 54, and 55. The floodplain delineation was accomplished using one-inch-equals-200-feet scale, two-foot contour interval topographic maps prepared to Regional Planning Commission standards.

Comparison to the Federal Flood Insurance Study

The hydrologic and hydraulic analyses performed under this planning effort for the determination of 100-year recurrence interval flood stages along Dousman Ditch and Underwood Creek refine the corresponding analyses performed under the 1982 Federal Emergency Management Agency (FEMA) flood insurance study (FIS) for the Village of Elm Grove and the 1986 FEMA FIS for the City of Brookfield.

As may be seen from an examination of Tables 58 and 59, the Commission flood flows developed for planned land use and existing channel conditions are somewhat lower than the FIS flood flows for each stream. The differences are due to a better accounting for the existing wetland/floodplain storage and extension of the simulation modeling period of record.

TOTAL COST OF THE RECOMMENDED PLAN

The total capital cost of the recommended stormwater and floodland management plan as set forth in Table 53 is estimated to be between $24,239,000 and $31,689,000. The lower cost would apply if all buildings remaining in the floodplain could be floodproofed. The higher cost would apply if those buildings could not be floodproofed and they were purchased and removed. The annual operation and maintenance cost increase relative to existing conditions is estimated to be $64,280. The costs of the plan are apportioned between the City of Brookfield, the Village of Elm Grove, and the private sector in Chapter VII, "Plan Implementation."

AUXILIARY PLAN RECOMMENDATIONS

Natural Resources and Open Space Preservation

The adopted park and open space plan for the City of Brookfield and the regional land use plan provide for the preservation of the primary environmental corridor lands within the City and the Village of Elm Grove and environs, including associated floodlands and wetlands, in essentially natural, open uses.[5] The protection of floodlands and wetlands from the intrusion of urban land uses has important implications for stormwater management, since these lands can provide needed capacity for the storage, infiltration, and transport of stormwater runoff. The recommended plan would enhance the storage function of two wetlands.

Surveys of Buildings in and Near the 100-Year Floodplain

This system plan utilized large-scale topographic maps compiled in 1986 at a scale of one inch equals 200 feet and in 1998 at a scale of one inch equals 100 feet. Those maps are valuable resources for the preparation of the hydrologic and hydraulic models and the delineation of floodplain boundaries. However, the building grade elevations determined from those maps are only approximate. Therefore, it is recommended that the City and Village survey the low grade elevations adjacent to buildings and the first floor elevations of buildings in and near the 100-year floodplain of Underwood Creek and Dousman Ditch prior to proceeding with implementation of the recommended plan. The buildings listed in Tables 54 and 55 should be surveyed, along with other nearby, lower-lying buildings near the floodplain.

Floodplain Map Revisions

As already noted, the 100-year recurrence interval flood profiles determined for Dousman Ditch and Underwood Creek under this study are based on more detailed analyses than were used in the 1982 and 1986 FEMA FIS, and they utilize more current information on the hydraulic structures located along the streams. Thus, upon adoption of this system plan,

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[5] *See SEWRPC Community Assistance Planning Report No. 108,* A Park and Open Space Plan for the City of Brookfield, Waukesha County, Wisconsin, *August 1991.*

the City and Village should amend their floodplain zoning ordinances to reflect the 100-year recurrence interval water surface profiles developed under this planning effort. At that time, the City and Village should also submit their proposed floodplain revisions and additions to the Wisconsin Department of Natural Resources, requesting revision of the Flood Insurance Rate Maps by the FEMA Federal Insurance Administration. of the Federal Emergency Management Agency.[6]

Maintenance of Stormwater Management Facilities

The effectiveness of the stormwater management conveyance and detention facilities, can be sustained only if proper operation, repair and maintenance procedures are carefully followed.

Important additional maintenance procedures include the periodic repair of storm sewers, clearing sewer obstructions, maintenance of open channel vegetation lining, clearing debris and sediment from open channels, maintenance of detention facilities inlets and outlets, maintenance of detention basin vegetative cover, and periodic removal of sediment accumulated in detention basins. These maintenance activities are recommended to be carried out on a continuing basis to maximize the effectiveness of the stormwater management facilities and measures and to protect the capital investment in the facilities.

CONSIDERATION OF FLOODING CONDITIONS IN THE VICINITY OF CLEARWATER DRIVE AND POMONA ROAD IN THE CITY OF BROOKFIELD

Clearwater Drive crosses Underwood Creek about 0.75 mile upstream from W. North Avenue. Four 54-inch-diameter CMP culverts convey the flow in the Creek under Clearwater Drive. During floods with recurrence intervals of 10 years and greater, Clearwater Drive would be overtopped. Based on available topographic information and reports from residents during the floods in June 1997 and August 1998, none of the houses along Clearwater Drive south of Underwood Creek would be expected to receive direct overland flooding during a 100-year flood. Although none of the other houses in this area are in the 100-year floodplain, floodwaters have surrounded several of the homes during recent floods. In addition, vehicular access to the 10 houses south of Underwood Creek on Clearwater Drive has been blocked and sanitary sewer backup into basements has occurred. In June of 1999, residents of the area wrote to the City, requesting that consideration be given to the problems that they have experienced.

Because the floodland management element of this plan is directed primarily toward the solution of problems of direct overland flooding of inhabited buildings, specific measures were not initially developed to address reduction of flood stages upstream of Clearwater Drive. However, Clearwater Drive does not meet the collector street overtopping standard set forth in Chapter III of this report. That standard calls for the hydraulic structures associated with collector streets to convey the peak flow during a 10-year flood without overtopping the associated roadway. For this reason, and because of the other related problems, analyses were made under this study to determine what measures would be required to reduce the degree of flooding in the vicinity of Clearwater Drive during both the 10-year flood and the 100-year flood.

Measures to Reduce Flooding During a 100-Year Event

It was found that removal of the existing culverts and construction of a 27-foot-long clear span bridge could reduce the 100-year flood stage by about 0.6 foot immediately upstream from the bridge. To avoid overtopping of Clearwater Drive during a 100-year flood, the existing road grade would have to be raised a maximum of about two feet along the entire 980-foot length of Clearwater Drive and Pomona Road would also be raised slightly at the intersection with Clearwater Drive.

Some reduction in the stage would be expected to occur for a distance of about 0.25 mile upstream from the dam and a loss in floodplain storage volume of about four acre-feet during a 100-year flood would occur as a result of the stage decrease. The loss of floodplain storage volume could result in an increase in 100-year flood flows that would either have to be eliminated through the provision of compensating

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[6] *The Commission staff has begun computation of updated or revised flood profiles where warranted throughout the City and Village under a map updating program undertaken by the communities.*

storage, or would have to be legally agreed to by all affected property owners and municipalities.

The areal extent of the 100-year floodplain upstream of Clearwater Drive would not be greatly reduced relative to existing channel conditions. The houses west of Clearwater Drive would experience some reduction in the degree of yard flooding, but the houses on the east side would see no change in the flood stage, or an increase in stage, depending on where the compensating storage was located. The elimination of road flooding could help mitigate sanitary sewer backups, but additional action directed to reducing infiltration and inflow would also be required to fully resolve that problem.

The estimated capital cost of this alternative would be $350,000. Because it would provide a higher degree of flood protection than is consistent with the standards adopted for this plan, it is not recommended to be implemented under this plan.

Measures to Reduce Flooding During a 10-Year Event

It was found that removal of the existing culverts and replacement with four 40-foot-long, 48-inch-high by 76-inch-wide reinforced concrete HE culverts could reduce the 10-year flood stage by about 0.4 foot immediately upstream from the bridge. To avoid complete overtopping of Clearwater Drive, and to keep one lane of traffic open during a 10-year flood, the existing road grade would have to be raised a maximum of about 0.7 foot feet along a 650-foot length of Clearwater Drive south of Underwood Creek.

The 100-year flood stage immediately upstream of Clearwater Drive would be decreased by 0.1 foot and about one acre-foot of floodplain storage volume would occur as a result of the stage decrease. The loss of floodplain storage volume could result in an increase in 100-year flood flows that would either have to be eliminated through the provision of compensating storage, or would have to be legally agreed to by all affected property owners and municipalities.

The change in the areal extent of the 100-year floodplain upstream of Clearwater Drive would be insignificant. The reduction in the frequency of road flooding might help mitigate sanitary sewer backups, but additional action directed to reducing infiltration and inflow would be required to fully resolve that problem.

The estimated capital cost of this alternative would be $120,000. This project is recommended to be implemented under this plan; however, it should be noted that it may be difficult to find suitable compensatory storage sites in the vicinity of the project because wetlands comprise most of the open land in, and adjacent to, the floodplain.

PUBLIC REVIEW AND COMMENT ON THE PLAN

The Commission staff, assisted by the staffs of the City of Brookfield, the Village of Elm Grove, the Wisconsin Department of Natural Resources (WDNR), and Ruekert & Mielke Engineers began preparation of this plan in 1997 prior to the June 21, 1997, and the August 6, 1998, floods. The occurrence of those floods heightened public awareness of stormwater management and flooding problems in the Dousman Ditch and Underwood Creek subwatersheds and the Menomonee River watershed as a whole. As a result, the Commission staff, the City, the Village, WDNR, and Ruekert & Mielke Engineers in their role as Village engineer for Elm Grove had numerous opportunities to obtain public comments regarding problems that were experienced and to provide the public information developed under this plan regarding solutions to problems.

Public Meetings

The main forums through which information was obtained from the public and the plan was discussed during its development were the regular meetings of the joint City of Brookfield/Village of Elm Grove Underwood Creek Flooding Task Force and the Brookfield City-wide Task Force. Those two bodies were formed following the flood of August 1998. Presentations were also made at several informational meetings for City and Village officials and the public. The public meetings include:

- An April 28, 1997, public meeting of the City of Brookfield Board of Public Works.
- A June 18, 1997, public meeting the Village of Elm Grove Sewer Commission.
- A July 21, 1997, public informational meeting at the Village of Elm Grove.

- A September 8, 1997, special meeting of the City of Brookfield Common Council called to provide and obtain information regarding stormwater management, flooding, and sanitary sewer backup problems.

- A January 26, 1998, public meeting of the City of Brookfield Board of Public Works.

- A September 21, 1998, public informational meeting of the Village of Elm Grove Board of Trustees, Sewer Commission, and Underwood Sewer Committee.

- An October 1, 1998, public informational meeting of the Village of Elm Grove Board of Trustees, Sewer Commission, and Underwood Sewer Committee.

- Public meetings of the Underwood Creek Flooding Task Force on November 2, 1998; November 24, 1998; December 15, 1998; January 18, 1999; February 17, 1999; March 24, 1999; April 21, 1999; and September 15, 1999.

- Meetings of the Elm Grove subcommittee of the Underwood Creek Task Force on March 2, 1999, and September 24, 1999.

- An October 13, 1999, public informational meeting sponsored by the Elm Grove subcommittee of the Underwood Task Force.

- A November 29, 1999, public meeting of the City of Wauwatosa Joint Committee on the Preparation of the Comprehensive City Plan.

Task Force Consideration of the Preliminary Draft Plan

The preliminary draft stormwater and floodland management plan was presented by the Commission staff to the entire Underwood Creek Task Force and the public at the September 15, 1999, meeting of the entire Underwood Creek Task Force. Prior to that meeting, copies of the preliminary draft plan were distributed to the Task Force members; the staffs and officials of the City of Brookfield and the Village of Elm Grove; the WDNR; the Milwaukee County Department of Parks, Recreation, and Culture; the Milwaukee Metropolitan Sewerage District (MMSD); and the City of Wauwatosa. The Task Force voted to accept the preliminary draft report at the meeting. Following that meeting, the Commission staff provided the City and the Village electronic copies of the report. These copies, were made available for public review along with the printed reports copies provided to the communities prior to the meeting. The minutes of the meeting are included in this report as Appendix E.

The preliminary draft plan was considered at a September 23, 1999, meeting of the Brookfield subcommittee of the Underwood Creek Task Force. The subcommittee 1) accepted the preliminary draft plan as a guide in the future design and implementation of stormwater management measures in the City, 2) supported the provision of water quality measures, and 3) requested that the City Board of Public Works give a high priority to consideration of acquiring the six homes that the plan recommends be purchased and removed in the area northwest of the intersection of W. North Avenue and Lilly Road. The minutes of the meeting are included in this report as Appendix F.

The preliminary draft plan was also presented by the Commission staff at the October 13, 1999, public informational meeting sponsored by the Elm Grove subcommittee of the Underwood Task Force. The Task Force approved the plan at the meeting and forwarded it to the Village Board with a recommendation for adoption by the Board. The minutes of the meeting are included in this report as Appendix G.

Agency Review of the Preliminary Draft Plan

The WDNR commented on the preliminary draft report in a December 20, 1999, letter to the Village of Elm Grove (Appendix H). The Commission staff responded to the WDNR comments in a January 5, 2000, letter which is also included in Appendix H.

Supporting data relative to the hydrologic and hydraulic analyses on which the floodland management plan element are based were provided to the MMSD for review. Based on discussions with MMSD staff, it is our understanding that the District concurs with the conclusion of this report that implementation of the recommended plan will not increase flood flows and stages along Underwood Creek in Milwaukee County, downstream of the Village of Elm Grove.

The City of Wauwatosa requested additional evaluation of specific issues related to the potential downstream effects on flood flows and stages resulting from implementation of the recommended plan. That evaluation is set forth in the December 22, 1999, letter included in this report as Appendix I.

Public Comments on the Preliminary Draft Plan

Following the Task Force meeting at which the preliminary draft plan was presented, the City of Brookfield received letters from residents of four of the six homes that are recommended to be purchased in the area northwest of the intersection of W. North Avenue and Lilly Road. Each of those residents supported the recommendation to purchase and remove those homes.

The Village of Elm Grove received letters from two residents along Underwood River Parkway providing comments on the recommended plan. Those letters make important points regarding the degree of disturbance of wetlands and removal of mature trees that might be associated with construction of the overflow channel. The issues raised were considered at the systems level in the preliminary draft report and the discussion has been expanded to reflect the comments received. Although those issues are addressed at a systems planning level in this report, they must be given further consideration during the detailed design of the project. At that time, modifications to the extent and alignment of the proposed overflow channel, and/or the overbank adjacent to the existing channel, which minimize impacts on wetlands and mature trees can be evaluated to determine their effects on the level of flood control that would be provided. Such an evaluation will be an integral part of the State permitting process as described in Appendix H.

Local Adoption of the Preliminary Draft Plan

The Elm Grove Village Board of Trustees adopted the preliminary draft plan on March 13, 2000. The resolution of adoption is included as Appendix J.

Chapter VII

PLAN IMPLEMENTATION

INTRODUCTION

The recommended stormwater and floodland management plan described in this report is designed to attain, to the maximum extent practicable, the stormwater and floodland management objectives and standards set forth in Chapter III. In a practical sense, however, the plan is not complete until the steps to implement it, that is to convert the plan into action policies and programs, have been specified. Following formal adoption of the plan by the City of Brookfield, and the Village of Elm Grove, realization of the plan will require a long-term commitment to the objectives of the plan and a high degree of coordination and cooperation among City and Village officials and staff, Wisconsin Department of Natural Resources staff, developers, and concerned citizens in undertaking the substantial investments and series of actions needed to implement the plan in the Dousman Ditch and Underwood Creek subwatersheds in the City and the Village.

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

RELATION TO FUTURE LAND USE DEVELOPMENT

Coordination with land use development and redevelopment is fundamental to successful implementation of a sound stormwater and floodland management plan. Planned buildout land use conditions in the study area, as presented in Chapter II of this report, have almost been achieved. The estimated rates and volumes of runoff and nonpoint source pollutant loadings which were used in the development of the alternatives set forth here were determined based on the buildout land use condition. Although buildout land use conditions have been attained in almost all of the study area, in limited areas the effectiveness of the recommended stormwater and floodland management measures will depend upon the degree to which future land use development and redevelopment and the plan properly complement each other.

It should be noted that under planned buildout conditions, about 15 percent of the study area would remain in open space uses, including environmental corridors and other open space lands. This system plan identifies those areas in the subwatershed that should be preserved in open, natural uses. Such preservation would provide major economies in stormwater and floodland management, thus maximizing the use of natural stormwater conveyance and storage and allowing such conveyance and storage to be incorporated in the plan. If the preservation of these areas is greatly compromised, problems, such as localized flooding, poor drainage, and water pollution, may be expected to result.

RELATION OF DETAILED ENGINEERING DESIGN TO SYSTEM PLANNING

The systems-level stormwater and floodland management plan presented in this report is intended to serve as a guide to the future design and construction of stormwater and floodland management facilities. Detailed engineering design should begin as the systems-planning phase is completed. The detailed engineering design should examine in greater depth and detail potential variations in the technical, economic, and environmental features of the recommended solutions to problems identified in the system plan in order to determine the best means of carrying out the plan. The resulting facility development plans should be fully consistent with the recommendations presented in this report.

Chapter III of this report presented the engineering design criteria and analytic procedures used in the preparation and evaluation of the alternative stormwater and floodland management plans. These criteria and procedures, firmly based in current engineering practice, provided the means for quantitatively sizing and analyzing the performance of both the minor and major stormwater drainage system components and the flooding characteristics of the streams in the subwatersheds. These criteria and procedures should also serve as a basis for the more detailed design of system components in the implementation of the recommended plan. It is important that such criteria and procedures be applied uniformly and consistently in all phases of implementation of the plan if the resulting system is to function as envisioned in the plan. Accordingly, Table 60 presents the design criteria and analytic procedures recommended to be followed in the detailed engineering design of the recommended plan components. Criteria and procedures presented in the table are for estimating rates of runoff, calculating hydraulic capacities of conveyance components, designing street cross-sections and related site grading, locating and designing storm sewer inlets, designing storm sewers, designing roadside swales, open channels, and culverts, designing detention facilities, and designing water quality control facilities. In this respect, it is recognized that over time new design procedures may be developed and become available for use in the design of stormwater and floodland management components. Before adoption, such techniques should, however, be carefully reviewed for consistency with the criteria and procedures set forth in the plan.

PLAN IMPLEMENTATION

Plan Adoption

An important first step in plan implementation is the formal adoption of the recommended stormwater and floodland management plan, as documented herein, by the Underwood Creek Task Force; the Brookfield City-Wide Flooding Task Force; the Board of Public Works, Plan Commission, and Common Council of the City; and the Finance Committee and Board of Trustees of the Village of Elm Grove.[1] In addition, the plan should be endorsed by the Wisconsin Department of Natural Resources (WDNR). Upon such adoption, the plan becomes the official guide to making of stormwater and floodland management decisions by City and Village officials. Such formal adoption serves to signify agreement with, and official support of, the recommendations contained in the plan and enables the City and Village staffs to begin integrating the plan recommendations into the ongoing land use control, public works development planning and programming, and subdivision plat review processes of the City and the Village.

Implementation Procedures

It is recommended that the plan be implemented by using the existing City and Village procedures for land subdivision plat approval; capital improvement programming; and public works construction, operation, and maintenance. Funding for capital improvements and operation and maintenance can be obtained through the creation of a stormwater utility, the property tax levy, special assessments, issuance of general obligation bonds, reserve funds, private developer contributions, and grants from the State of Wisconsin and/or the Federal government.

In reviewing subdivision plats and land development or redevelopment proposals, the City and Village Plan Commissions should determine the compatibility of the plats or the proposals with the land use recommendations set forth in the adopted regional land use plan, described in detail in Chapter II of this report, and used in preparation of the stormwater management plan. Any proposed departures from those recommendations should be carefully considered in light of the stormwater and/or floodland management needs of the proposed development or redevelopment and the impacts on upstream and downstream areas. The plat review function can, and should, under Wisconsin law, be exercised extraterritorially. Implementation of the plan through the City and Village zoning maps and ordinances would be another means of ensuring that land use development takes place in accordance with the assumptions underlying the stormwater and floodland management plan.

Stormwater facility maintenance is an important part of plan implementation. It is recommended that the public works programs of the City and Village continue to provide for the maintenance, as well as the construction, of the stormwater management facilities, including periodic inspection of conveyance and detention facilities; timely repair of facilities; cleaning

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[1] *The Village of Elm Grove Board of Trustees adopted the preliminary draft stormwater and floodland management plan on March 13, 2000.*

Table 60

DESIGN CRITERIA AND PROCEDURES RECOMMENDED TO BE FOLLOWED IN DETAILED ENGINEERING DESIGN OF THE RECOMMENDED STORMWATER AND FLOODLAND MANAGEMENT COMPONENTS

Design Function	Recommended Criteria and Procedures
Storm Runoff Flows	Minor system components should be designed to accommodate flows expected from a 10-year recurrence interval storm event. Major system components should be designed to accommodate flows expected from a 100-year recurrence interval storm event. The effects of refinements to the plan recommendations should be analyzed using the base XP-SWMM stormwater management models developed for this system plan
Conveyance and On-Line Storage Components, Including Storm Sewers, Culverts, and Stream Channels	The sizes of recommended conveyance facilities are set forth in Table 53 of Chapter VI of this report. Design criteria for such facilities are provided in Chapter III of this report. Stormwater conveyance facilities should be designed using the base XP-SWMM models developed for this system plan. The XP-SWMM model may be supplemented as necessary by the use of appropriate culvert nomographs or the application of standard procedures for computation of hydraulic capacities of pipes. Refinements to the components of the floodland management system should be analyzed using the HSPF continuous simulation hydrologic model and the HEC-RAS hydraulic models developed for this system plan
Site Grading	Slopes away from all buildings, as well as the slopes of interior drainage swales, should be at one-quarter inch per foot to provide positive drainage
Storm Sewer Inlets	Storm sewer inlet location and capacity should be dictated by the allowable stormwater spread and depth of flow in streets. Combination inlets should be used in most instances. Uncontrolled flow across streets should not be allowed when the streets are functioning as part of the minor stormwater drainage system. At locations where storm sewers function as part of the major drainage system and are sized to convey design flows resulting from storms with recurrence intervals greater than 10 years, and at locations where a storm sewer is intended to divert a specific design flow to an off-line detention basin, sufficient inlet hydraulic capacity should be provided to permit the design capacity of the storm sewer to be developed
Storage Facilities	The recommended storage facilities are listed in Table 53. The effects of storage facilities on the frequency and magnitude of downstream flows under planned conditions as compared to existing conditions should be carefully examined using the HSPF and HEC-RAS models developed for this system plan
Water Quality Control Measures	The following references provide criteria for the design of water quality control measures: 1. SEWRPC Technical Report No 31, *Costs of Urban Nonpoint Source Water Pollution Control Measures,* June 1991 2. Schueler, Thomas R., *Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban BMPs,* Metropolitan Washington Council of Governments, July 1987

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

Source: SEWRPC.

of storm sewers, culverts, open channels, and detention facility inlets and outlets; repair of erosion along open channels; and periodic removal of accumulated sediment from conveyance, retention, and detention facilities.

Financing

Several means of financing stormwater management components are available to local government agencies that are not available to the private sector. Although these means offer flexibility, certain constraints and limitations are imposed on these financing methods by State law; in some cases approval by the electorate is required. Therefore, successful public financing of the recommended plan will require a thorough study of costs and available revenues, careful financial planning, public information programs, and a timely approach to securing public support and approvals.

Financing of the construction, operation, and maintenance of stormwater and floodland management facilities may be accomplished through the establishment of a stormwater utility; tax incremental financing districts; local property taxes; reserve funds; general obligation bonds; private developer contributions, including paying fees to be applied toward construction of regional stormwater management facilities in lieu of providing onsite facilities; and State or Federal grants or loans. Appendix K provides a brief description of the possible features and functions of a stormwater utility.

It is recommended that the City and Village study public financing options, considering each of the financing methods listed in the following section of this report and in Appendix L.

Possible Funding through the State and Federal Programs

Funds may be available from the State of Wisconsin for the installation of best management practices that meet the nonpoint source pollution reduction objectives set forth in Menomonee River Priority Watershed Study. The current policy of the WDNR regarding the provision of funds under the Wisconsin Fund Nonpoint Source Pollution Abatement Program allows State funding of up to 70 percent of the capital cost of wet detention basins to serve areas of existing urban development, up to 50 percent of land acquisition costs, up to 50 percent of the cost of the conveyance components required to divert runoff into treatment facilities, and up to 100 percent of the design and engineering costs for structural best management practices which serve existing urban development.

Chapter NR 120 of the *Wisconsin Administrative Code*, which details the administrative procedures of the State nonpoint source water pollution abatement program, forbids provision of State funds for stormwater management practices to serve new urban development and for construction site erosion control measures. However, State funds may be available to pay the entire cost of local staff to enforce a construction erosion control ordinance over a maximum period of five years. State funds may also be provided for accelerated street sweeping above the current levels practiced by the City and the Village. The funds would cover the costs of accelerated sweeping, for a five-year period, after which the City and the Village would be required to maintain the accelerated sweeping schedule for 10 years. On the basis of current State cost-sharing policy, it is estimated that a maximum of $2,828,000 in State nonpoint source grant funds could be provided for components of the water quality management plan.[2]

Under current conditions, in order for urban best management practice in the Menomonee River watershed to be eligible for State funds provided under the nonpoint source program, funds must be applied for by the end of December 2000.[3] In addition to funds provided by the WDNR, it is also possible that the cost of certain recommended components of the stormwater drainage system may be shared between the City or Village and the Wisconsin Department of Transportation as a part of future highway construction or reconstruction projects. Funding may also be available through the Federal Emergency Management Agency (FEMA) Hazard Mitigation Grant (HMG) or Public Assistance Grant programs or the U.S. Department of Housing and Urban Development Community Development Block Grant program, but all such funds are only available in fixed amounts following a Presidential disaster declaration.[4] Because the division of costs for such measures is presently unknown, this plan assigns all such costs to the City or Village.

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[2] *The State of Wisconsin is in the process of redesigning the nonpoint source pollution control program. As an outcome of that redesign, it is likely that current State programs for funding nonpoint source pollution control projects will be restructured and/or augmented with new programs operating under different rules.*

[3] *It is possible that the State may extend that deadline.*

[4] *The City and Village have obtained FEMA HMG program funds for purchase and removal of three structures in the study area.*

It may be possible to obtain funds for certain elements of the recommended plan through the Urban Green Space (UGS) program, which is a component of the State of Wisconsin Stewardship Grant Program. Public acquisition of land in the vicinity of the recommended wet detention basin along Dousman Ditch, which is recommended under both this plan and the adopted park and open space plan for the City of Brookfield, may be a candidate for funding. The UGS program provides cost-share funding for up to 50 percent of the purchase price with a maximum State share of $100,000 per parcel. Funding for recommended localized streambank protection projects may also be available through the Stewardship Program.

Details on State and Federal programs that may be sources of funding are provided in Appendix L.

SCHEDULE FOR FINANCING AND IMPLEMENTATION OF THE PLAN

Possible Apportionment of Costs between the City of Brookfield, the Village of Elm Grove, and the Private Sector

With the exception of the costs of floodproofing, the costs of the plan were assumed to be borne by the public sector. Floodproofing costs are usually borne by the individual building owner; however, if the City or Village provided financial assistance to those individuals, it would be more the likely that floodproofing measures would be implemented. If it were found that floodproofing was not feasible for certain structures and acquisition and removal of those structures was necessary, the cost of acquisition and removal would be a public sector cost. Tables 61 and 62 provide possible allocations of costs between the City, the Village, and the private sector.

The recommended individual stormwater drainage projects are generally intended to solve drainage problems due to stormwater runoff from the community in which the project would be constructed. In addition, in most cases, all of the tributary runoff to the problem areas are from the same community as the problem location. Thus, stormwater drainage capital and operation and maintenance costs were assigned to the municipality in which the project would be located.

The capital costs of the recommended floodland and water quality management projects cannot be as easily assigned to the City or the Village because they provide benefits to each community and the problems they are intended to solve are related to conditions in each community. Thus, the following three possible approaches to apportionment of those costs were developed:

1. Apportion capital costs based on the approximate runoff volume contribution to Underwood Creek of each community. It was estimated that about 70 percent of the runoff volume from the portion of the study area that is tributary to Underwood Creek at the Milwaukee-Waukesha county line comes from the City of Brookfield and about 30 percent comes from the Village of Elm Grove. Thus, under this approach, 70 percent of the costs would be assigned to the City and 30 percent to the Village.

2. Apportion capital costs based on the approximate flood damage reduction benefits realized from construction of the project. It was estimated that about 7 percent of the flood damage reduction benefits for floods with recurrence intervals up to, and including, 100 years would accrue to the City and about 93 percent to the Village of Elm Grove. Thus, under this approach, 7 percent of the costs would be assigned to the City and 93 percent to the Village.

3. Have each community pay for those floodland and water quality management projects located within that community. Under this approach, 30 percent of the costs would be assigned to the City and 70 percent to the Village.

Each of the above approaches represents a single aspect of the cost apportionment process. The most equitable way to apportion costs would be to consider the relative merits of each approach and synthesize a composite. In this respect, the first approach enables consideration of the possible causes of the floodland and water quality problems; the second approach enables consideration of the benefits of implementing the plan; and the third approach enables consideration of the administrative structure for accomplishing the projects, in that the simplest administrative arrangement would be for each community to construct project components within its boundaries.

Table 61

ASSIGNMENT OF LOCAL PUBLIC-SECTOR AND PRIVATE-SECTOR CAPITAL COSTS OF THE RECOMMENDED PLAN FOR THE DOUSMAN DITCH AND UNDERWOOD CREEK SUBWATERSHEDS

Plan Element	Capital Cost[a]		
	Local Public Sector	Private Sector	Total
Stormwater Drainage	$5,320,000	$68,000	$5,388,000
Water Quality Management	$4,096,000[b]	$ 0	$4,096,000
Floodland Management[c, d]	$14,495,000 to $22,205,000	$0 to $260,000[e]	$14,755,000 to $22,205,000
Total	$23,911,000 to $31,621,000	$68,000 to $328,000	$24,239,000 to $31,689,000

[a] *Includes 35 percent for engineering, administration, and contingencies. Costs are for year 1998 with Engineering News-Record Construction Cost Index = 6,740.*

[b] *State of Wisconsin nonpoint source grant program funds may be available for up to $2,828,000 of this amount. That cost assumes 70 percent State cost sharing for wet detention basin construction and 50 percent State cost sharing for the channel to convey runoff to the wet basin, land acquisition, and accelerated street sweeping.*

[c] *There may be some funds available from the Wisconsin Department of Transportation to pay for limited portions of this plan element as part of future highway construction or reconstruction projects. Also, following a Presidential disaster declaration, FEMA Flood Hazard Mitigation Grant and Public Assistance Grant funds and U.S. Department of Housing and Urban Development Community Development Block Grant funds may be available. It is also possible that new State funding for flood mitigation projects may be available.*

[d] *These costs include $120,000 for the flood control measures recommended along Underwood Creek in the vicinity of Clearwater Drive and Pomona Road in the City of Brookfield.*

[e] *If the buildings to be floodproofed were purchased and demolished, the cost of this component would be eliminated.*

Source: SEWRPC.

To base the apportionment on Approach 1 alone would not adequately account for other factors which contribute to, or serve to mitigate, the flooding problem, but which cannot be readily quantified. Such contributing factors include: 1) the occurrence of development in low-lying riparian areas that were subsequently identified as floodplains and 2) backwater that is caused by hydraulic structures in and near flood hazard areas and that affects the extent of the floodplain. Mitigating factors include the reduction in flood flows due to the preservation of large wetland storage areas in the City. When these additional factors are considered, it can be concluded that the City share of the costs based on Approach 1 could be reduced and the Village share could be increased.

Similarly, to base the apportionment on Approach 2 alone would not adequately account for other factors which contribute to the flooding problem. A significant contributing factor to the flooding is the relatively larger amount of runoff volume contributed by the City as described under Approach 1. Thus, when consideration is given to the City's contribution to flood volumes it can be concluded that the City share of the costs based on Approach 2 could be increased and the Village share could be decreased.

Approach 3 does not account for factors that contribute to the flooding problem, or factors that mitigate the flooding problem.

Based on consideration of the possible approaches and qualifying factors set forth above, it was concluded that a reasonable cost apportionment for the water quality and floodland management plan elements would be to assign the costs of the plan based upon the approximate average of the three approaches noted above, thereby blending consideration of all three approaches. This results in an approximated

Table 62

POSSIBLE APPORTIONMENT OF TOTAL CITY OF BROOKFIELD AND VILLAGE OF ELM GROVE COSTS FOR THE RECOMMENDED STORMWATER AND FLOODLAND MANAGEMENT PLAN FOR THE DOUSMAN DITCH AND UNDERWOOD CREEK SUBWATERSHEDS

	City of Brookfield		Village of Elm Grove		Local Total	
Plan Element	Capital Cost[a]	Annual Operation and Maintenance[b]	Capital Cost[a]	Annual Operation and Maintenance[b]	Capital Cost[a]	Annual Operation and Maintenance
Stormwater Drainage	$3,782,000	$10,160	$1,538,000	$ 2,120	$5,320,000[c]	$12,280[c]
Water Quality Management	$1,641,000	$15,000	$2,455,000	$ 1,000	$4,096,000[d]	$16,000
Floodland Management	$5,870,000 to $8,954,000	$ 4,000	$8,505,000 to $13,131,000	$32,000	$14,495,000[e] to $22,205,000	$36,000
Total	$11,293,000 to $14,377,000	$29,160	$12,498,000 to $17,124,000	$35,120	$23,911,000 to $31,621,000	$64,280

[a] *Includes 35 percent for engineering, administration, and contingencies. Costs are for year 1998 with* Engineering News-Record *Construction Cost Index = 6,740. As described in this chapter, 40 percent of the capital cost for water quality and floodland management measures is assigned to the City of Brookfield and 60 percent is assigned to the Village of Elm Grove.*

[b] *Operation and maintenance costs are assigned to the community in which the facility is located.*

[c] *An additional capital cost of $68,000 and an annual operation and maintenance cost of $200 for floodproofing were assigned to the private sector.*

[d] *Up to $2,828,000 in WDNR cost-share funds could be provided as described in a footnote to Table 61. If only part of that amount were provided, the difference would be divided between the City (40 percent) and the Village (60 percent).*

[e] *An additional capital cost of $260,000 for floodproofing was assigned to the private sector.*

Source: SEWRPC.

assignment of 40 percent of the costs to the City of Brookfield and 60 percent to the Village.[5]

As set forth in Table 61, the total capital cost of the recommended plan could range from $24.2 million to $31.7 million, with the higher cost being applicable if it were necessary to purchase and remove all structures that are recommended to be floodproofed. The local public sector share of the capital costs could range from $23.9 million to $31.6 million and the private-sector share could range from $68,000 to $328,000. As set forth in Table 62, of that public sector share, from $11.3 to $14.4 million, depending on the amount of floodproofing, is assigned to the City of Brookfield and from $12.6 to $17.2 million is assigned to the Village of Elm Grove.

In order to simplify the operation and maintenance of the recommended facilities, it was assumed that the municipality in which a facility is located would be responsible for the operation and maintenance of that facility. The estimated annual operation and maintenance cost assigned to the City is $29,160 and the annual operation and maintenance cost assigned to the Village is $35,120.

Possible institutional frameworks for implementing the plan based on the recommended apportionment include 1) the establishment of a joint stormwater commission, including members from both the City and the Village or 2) intercommunity coordination through intergovernmental agreements as provided for under Section 66.30 of the *Wisconsin Statutes*

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[5] *The only exception to this cost apportionment rule for the floodland and water quality management plan elements is that the total capital cost of the Clearwater Drive culvert replacement, road grade raise, and compensatory storage project is assigned to the City, since it would solely benefit City residents.*

Prioritization of Capital Improvements

A preliminary prioritization of the recommended capital improvements is given in Table 63. For this prioritization, a project is defined as a set of stormwater or floodland management components that should be constructed in concert in order for the set to function properly by itself and within the context of the larger system of which it is a part.

The projects are classified as of high, intermediate, or low priority. The high-priority projects are those that address the most significant existing problems, including direct flooding of structures. The intermediate-priority projects are predominantly those that are required to upgrade the minor system to meet the plan standards and which are of somewhat greater extent than the low-priority projects, but which do not relate to the prevention of direct flooding of buildings. The low-priority projects are those that are required to upgrade the minor system to meet the plan standards and to address localized problems.

The sequence in which projects are actually implemented and the time at which they are implemented will ultimately depend on a number of factors not related solely to stormwater and floodland management considerations. Such factors include budgetary constraints, the need to implement other projects in the City and Village capital improvements programs, and variations in future development and redevelopment patterns as determined by the urban land market.

Critical Implementation Sequences

In general, projects which call for upgrading the existing stormwater conveyance system should proceed from downstream to upstream to insure that the downstream portions of the system are not overloaded when the hydraulic capacities of the upstream portions are increased. The recommended sequence for constructing the water quality and floodland management plan elements is described below.

Project Nos. 1 and 2 in Table 63—Dual Purpose Wet Detention Basin Along Dousman Ditch, Underwood Creek Overflow Channel and Diversion, Compensating Storage, and Structure Floodproofing or Removal should be coordinated. The three floodwater storage components-along Dousman Ditch, upstream of W. North Avenue, and in the Village Park-should be constructed first. If they are to be constructed individually at different times, the best sequence would be to proceed from upstream to downstream. After completing construction of the storage areas, the overflow channel should be constructed, followed by the diversion culvert. The recommended construction sequence would ensure that downstream flood flows and stages would not be increased during any phases of the project.

REGULATORY CONSIDERATIONS

Implementation of some of the measures recommended in this system plan may require the prior approval of certain regulatory agencies other than the City and Village, including the Wisconsin Department of Natural Resources, and the U.S. Army Corps of Engineers. The regulatory process involved is complex, therefore, the City and Village should seek legal counsel prior to proceeding with any stormwater and floodland management measures that involve the construction or modification of artificial waterways connecting to navigable waters, the alteration or enclosure of navigable watercourses, the removal of material from the beds of navigable watercourses, or the disturbance of wetlands.

Federal regulatory authority relating to the disturbance of wetlands is granted under Section 404 of the Federal Water Pollution Control Act of 1972 as amended. The administering agency is the U.S. Army Corps of Engineers.

State regulatory authority relates to the construction or modification of artificial waterways, canals, or ponds connecting to, or located within 500 feet of, a navigable waterway, the alteration of navigable waterways, the placement of deposits or structures in the bed of navigable waterways or the enclosure of navigable waterways, the removal of material from navigable waterways, and also to activities affecting the water quality of wetlands. This authority is contained in sections 30.12, 30.195, 30.20, and 144.025 of the *Wisconsin Statutes*. The administering agency is the Wisconsin Department of Natural Resources.

Chapters of the *Wisconsin Administrative Code* which are pertinent to activities called for under the recommended plan include Chapter NR 103, "Water Quality Standards for Wetlands"; Chapter NR 116, "Wisconsin's Floodplain Management Program"; and Chapter NR 117, "Wisconsin's City and Village Shoreland-Wetland Protection Program." Implementation of the recommended floodland management plan could involve disturbance of wetlands during construction followed by restoration of the wetlands

Table 63

PRIORITIZATION OF RECOMMENDED PROJECTS FOR THE DOUSMAN DITCH AND UNDERWOOD CREEK SUBWATERSHEDS

Project Designation	Location of Component	Hydrologic Unit (H.U.)	Plan Components As Listed In Table 53	Capital Cost[a]			
				City of Brookfield	Village of Elm Grove	Private Sector	Total
			High-Priority Projects[a]				
Floodland Management/Water Quality Management							
1. Dual-Purpose Wet Detention Basin Along Dousman Ditch	City of Brookfield	DD-7	Water quality plan element Items 1 through 4. Floodland management plan element Item 2	$ 1,740,000[b]	$ 2,610,000[b]	$ 0	$ 4,350,000[b]
2. Underwood Creek Overflow Channel and Diversion, Compensating Storage, and Structure Floodproofing or Removal	City of Brookfield Village of Elm Grove	- -	Floodland management plan element Items 3 through 14	5,646,000[c]	8,469,000[c]	260,000[c]	14,375,000[c]
Stormwater Drainage/Water Quality Management							
3. Verdant Drive	Village of Elm Grove	DD-5	H.U. DD-5 Items 1 through 4	$ 0	$ 305,000	$ 0	$ 305,000
4. Victoria Circle North	Village of Elm Grove	DD-8	H.U. DD-8 Victoria Circle North Items 1 through 3	0	147,000	23,000	170,000
5. Wrayburn Road	Village of Elm Grove	UC-8	H.U. UC-8 Items 1 through 8	0	231,000	0	231,000
6. Elmhurst Parkway	Village of Elm Grove	UC-9	H.U. UC-9 Items 1 through 5	0	409,000	0	409,000
7. Briaridge Court/ Squires Grove	Village of Elm Grove	DD-7	H.U. DD-7 Items 1 and 2	0	106,000	0	106,000
8. Bishops Woods Tributary	Village of Elm Grove	UC-10	H.U. UC-10 Item 1	0	0	45,000	45,000
9. Grandview/Kurtis	Village of Elm Grove	UC-11	H.U. UC-11 Items 1 through 3	0	119,000	0	119,000
10. Downtown Street Sweeping	Village of Elm Grove	UC-11	Water quality plan element Item 5	0	1,000	0	1,000
11.	City of Brookfield	DD-8	H.U. DD-8 Indianwood/ Onondaga Items 1 through 3	355,000	0	0	355,000
12. Tru/Adelaide	City of Brookfield	UC-7	H.U. UC-7 Items 1 through 14	2,565,000	0	0	2,565,000
13. San Juan Trail	City of Brookfield	UC-6	H.U. UC-6 Items 1 through 7	234,000	0	0	234,000
14. Pomona Road	City of Brookfield	UC-4	H.U. UC-4 Items 1 and 2	79,000	0	0	79,000
15. Clearwater Drive	City of Brookfield	UC-4	Four replacement culverts, road grade raise, compensating storage	120,000	0	0	120,000
16. Westwood Drive	City of Brookfield	UC-5	H.U. UC-5 Items 1 through 5	108,000	0	0	108,000
17. Street Sweeping	City of Brookfield	UC-10	Water quality plan element Item 5	5,000	0	0	5,000

after construction. As stated in Chapter VI, the degree of wetland disturbance could be minimized during the final design of the project.

As a result of the detailed hydrologic and hydraulic modeling conducted under the planning effort, updated 100-year recurrence interval flood profiles were computed for Dousman Ditch and Underwood Creek in the City of Brookfield and the Village of Elm Grove. Those profiles and the substantiating analyses used in their development can be submitted by the City and the Village to the WDNR and FEMA with a request to revise the City and Village floodplain boundary maps.[6]

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[6] *The currently adopted 100-year recurrence interval flood profiles are based on the FEMA FIS prepared in 1986 for the City and 1982 for the Village. Those profiles must be used for zoning and regulatory purposes until the 100-year flood profiles determined under this stormwater and floodland management plan are formally approved by the State of Wisconsin and FEMA and adopted by the City and the Village.*

Table 63 (continued)

Project Designation	Location of Component	Hydrologic Unit (H.U.)	Plan Components as Listed in Table 53	Capital Cost[a]			
				City of Brookfield	Village of Elm Grove	Private Sector	Total
Medium-Priority Projects							
1. San Fernando Drive	Village of Elm Grove	UC-8	H.U. UC-8 Items 9 through 12	$ 0	$ 165,000	$ 0	$ 165,000
2. N. 124th Street	Village of Elm Grove	UC-13	H.U. UC-13 Items 1 and 2	0	19,000	0	19,000
3. Centa Lane	Village of Elm Grove	UC-14	H.U. UC-14 Items 1 through 3	0	33,000	0	33,000
4. Mt. Vernon Avenue	City of Brookfield	DD-7	H.U. DD-5 Item 5	2,000	0	0	2,000
5. Gebhardt Road	City of Brookfield	DD-9	H.U. DD-9 Items 1 and 2	128,000	0	0	128,000
6. Brookfield East High School	City of Brookfield	UC-6	H.U. UC-6 Items 8 through 13	206,000	0	0	206,000
Low-Priority Projects							
Stormwater Drainage							
1. Pilgrim Parkway	Village of Elm Grove	DD-9	H.U. DD-9 Item 3	$ 0	$ 4,000	$ 0	$ 4,000
2. Patricia Lane/Lucy Circle	City of Brookfield	DD-2	H.U. DD-2 Items 1 and 2	14,000	0	0	14,000
3. Burleigh Boulevard/ Luella Drive	City of Brookfield	UC-1	H.U. UC-1 Items 1 through 5	76,000	0	0	76,000
4. Hillside Drive	City of Brookfield	UC-2	H.U. UC-2 Item 1	4,000	0	0	4,000
5. N. 131st Street	City of Brookfield	UC-7 and 8	H.U. UC-8 Item 13	11,000	0	0	11,000
Total	--	--	--	$11,293,000	$12,618,000	$328,000	$24,239,000[d]

[a] *Includes 35 percent for engineering, administration, and contingencies. Costs are for year 1998 with* Engineering News-Record *Construction Cost Index = 6,740.*

[b] *A maximum of $2,828,000 in State of Wisconsin nonpoint source grant funds may be available for this wet detention basin. $1,131,000 of that would be applied against the City of Brookfield share and $1,697,000 against the Village of Elm Grove share.*

[c] *If structures had to be purchased and removed, rather than floodproofed, the private-sector cost would be eliminated and the $7,710,000 purchase and removal cost would be apportioned with $3,084,000 assigned to the City of Brookfield and $4,626,000 assigned to the Village of Elm Grove.*

[d] *This cost could be increased by up to $7,450,000 if it were necessary to purchase and remove all structures for which floodproofing is recommended.*

Source: SEWRPC.

PLAN REEVALUATION AND UPDATING

The recommended plan components should be reevaluated at 10-year intervals, considering the degree to which the recommendations have been implemented and incorporating any changes in the available rainfall-duration-frequency data and in the state-of-the-art of stormwater and floodland management. The plan components, including the need for certain facilities and the location, size and capacity of facilities, should be revised as necessary to reflect changing conditions and stormwater management needs.

Chapter VIII

SUMMARY

DESCRIPTION OF THE RECOMMENDED PLAN

The recommended stormwater and floodland management plan for the Dousman Ditch and Underwood Creek subwatersheds consists of three elements: a water quality management element, a stormwater drainage element, and a floodland management element. A graphical summary of the recommended plan components is set forth on Map 56.

The components of the recommended stormwater management plan, including the water quality and stormwater drainage elements, and their estimated capital and annual operation and maintenance costs are summarized in Table 53. The recommended stormwater management plan is summarized in graphic form on Map 54. The recommended stormwater management plan calls for 1) the construction of a dual-purpose wet detention basin with a permanent pond area of 19 acres along the upper reach of Dousman Ditch west of Pilgrim Parkway and north of Wisconsin Avenue extended; 2) the provision of new or replacement culverts and storm sewers at potential problem areas throughout the study area; 3) limited swale modification; 4) acquisition of one house and lot and floodproofing of two houses; 5) floodproofing of basement garages at two apartment buildings along the Bishops Woods Tributary in Elm Grove; 6) the construction of a stormwater pumping station along the east side of Lilly Road, north of W. North Avenue; 7) increased sweeping of about 23 curb-miles of streets in critical land use areas in both Brookfield and Elm Grove; 8) continued enforcement of the existing construction site erosion control ordinances; 9) site specific best management practices to reduce the washoff of pollutants from new development, or redevelopment, sites; 10) maintenance of the existing 15 ponds in the study area; 11) reduced application of sand on streets in the winter; 12) localized bank protection projects, using natural bioengineering techniques wherever practical; and 13) public information and education efforts to promote good urban "housekeeping" practices that reduce nonpoint source pollution.

The estimated capital cost of the recommended water quality management plan element is $4,096,000 and the estimated capital cost of the recommended stormwater drainage plan element is $5,388,000. Thus, the estimated cost of the stormwater management plan component of the recommended plan is $9,484,000.

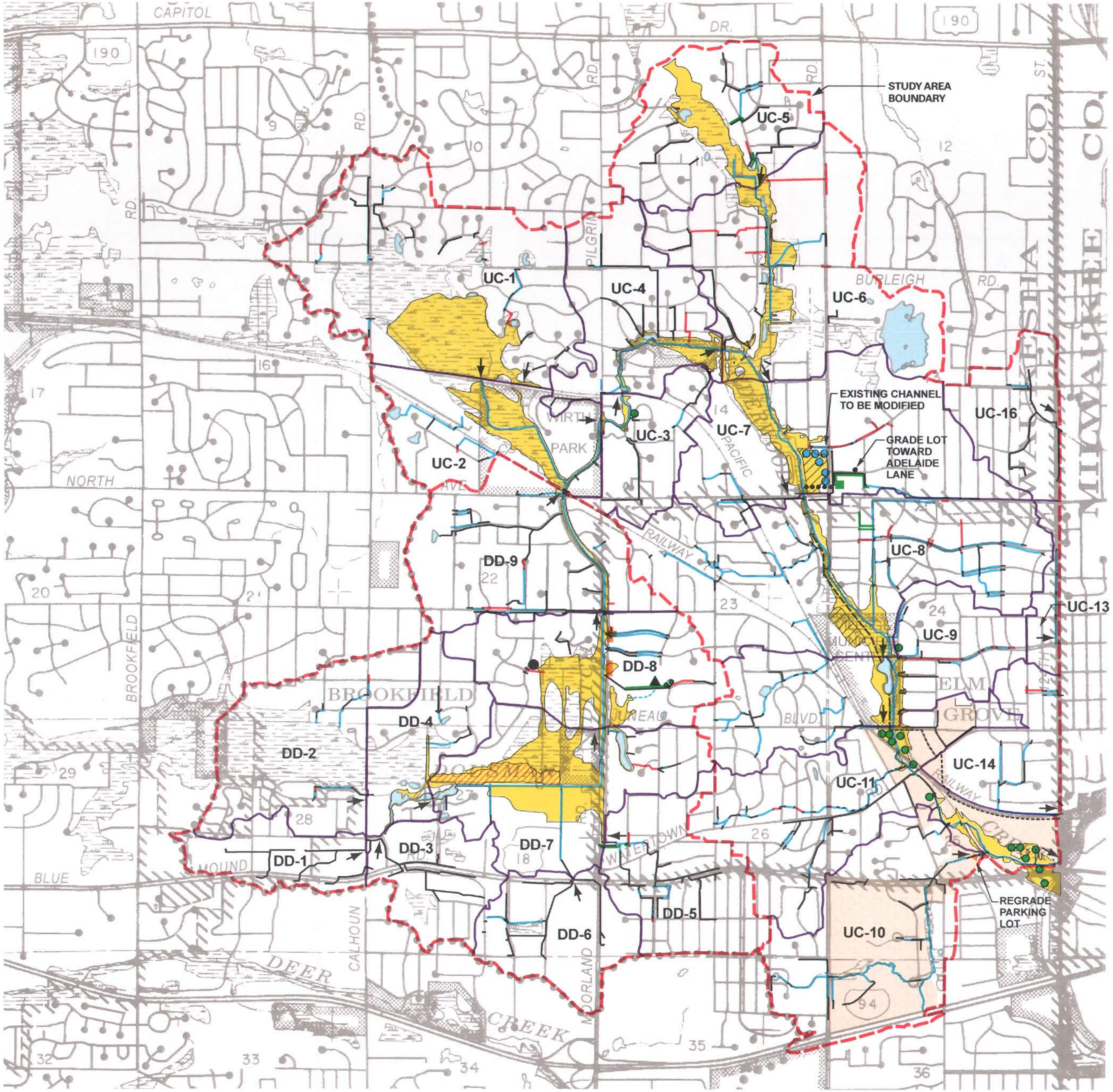
Implementation of the recommended water quality management plan would provide controls on runoff from about 73 percent of the critical land uses in the study area and all areas of new development or redevelopment. As seen from Table 20, construction of the Dousman Ditch wet detention basin and the recommended increased street sweeping would result in pollutant loading reductions relative to 1990 land use conditions in the study area of 3 percent for total solids, 18 percent for particulate solids, 5 percent for phosphorus, 16 percent for copper, 20 percent for lead, and 3 percent for zinc. Relative to planned buildout conditions, the expected reductions due to implementation of those measures would be 8 percent for total solids, 25 percent for particulate solids, 15 percent for phosphorus, 21 percent for copper, 28 percent for lead, and 15 percent for zinc. Implementation of the additional measures as recommended above would be expected to significantly increase the loading reductions.

Full implementation of the recommended stormwater drainage measures would provide a minor stormwater drainage system adequate to convey and/or store runoff from storms with recurrence intervals up to, and including 10 years and to generally provide an acceptable level of traffic service and access to property during such storms. Implementation of the recommended drainage measures would also avoid direct flooding of inhabited buildings during storms with recurrence intervals up to, and including 100 years. The recommended measures would help to mitigate, but not eliminate, flooding of basements due to sanitary sewer backup. Other measures directed toward reduction of infiltration and inflow to sanitary sewers would be required to fully alleviate sanitary sewer backup problems.

The components of the recommended floodland management plan, as summarized in graphic form on Map 54, include: 1) the dual-purpose wet detention basin with a permanent pond area of 19 acres along

Map 56

RECOMMENDED STORMWATER AND FLOODLAND MANAGEMENT PLAN FOR THE DOUSMAN DITCH AND UNDERWOOD CREEK SUBWATERSHEDS



⫽⫽	CORPORATE LIMIT BOUNDARY
—	HYDROLOGIC UNIT BOUNDARY
DD-1	HYDROLOGIC UNIT IDENTIFICATION
➤	HYDROLOGIC UNIT OUTLET
🟨	100-YEAR RECURRENCE INTERVAL FLOODPLAIN PLANNED LAND USE AND PROPOSED CHANNEL CONDITIONS
▨	PROPOSED DUAL-PURPOSE WET DETENTION BASIN
—	EXISTING STORM SEWER OR CULVERT
—	EXISTING OPEN CHANNEL OR FLOW PATH
—	PROPOSED REPLACEMENT STORM SEWER OR CULVERT
—	PROPOSED STORM SEWER OR CULVERT
------	PROPOSED GRASS-LINED TRAPEZOIDAL SWALE
▲	PROPOSED BACKWATER GATE
•••••	PROPOSED 48-INCH FORCE MAIN
— — —	PROPOSED OVERFLOW CHANNEL
--------	PROPOSED DIVERSION BOX CULVERT
▬	PROPOSED ROAD GRADE RAISE
▩	EXISTING DRY DETENTION BASIN
▨	PROPOSED COMPENSATING STORAGE AREA
▭	SWEEP STREETS EVERY FOUR WEEKS FROM APRIL 1 TO OCTOBER 31
🟢	BUILDING PROPOSED TO BE FLOODPROOFED
🔵	BUILDING PROPOSED TO BE PURCHASED FOR CONSTRUCTION OF FLOODWATER STORAGE AREA
●	ACQUIRE ONE HOUSE AND LOT NEAR ONONDAGA CIRCLE AND INDIANWOOD DRIVE AND REGRADE LOT TO ENABLE RUNOFF TO BE CONVEYED TO THE WETLAND ALONG DOUSMAN DITCH
🟩	PROPOSED STORMWATER PUMPING STATION
▭	SURFACE WATER

NOTE THE STUDY AREA CONSISTS OF THE ENTIRE DOUSMAN DITCH SUBWATERSHED AND THE WAUKESHA COUNTY PORTION OF THE UNDERWOOD CREEK SUBWATERSHED.

Source: SEWRPC.

the upper reach of Dousman Ditch; 2) about 14 acre-feet of floodwater storage volume in the east overbank of Underwood Creek in the City of Brookfield northwest of the intersection of W. North Avenue and Lilly Road; 3) purchase and removal of six houses located east of Underwood Creek in the City to enable construction of the detention storage area described under Item 2; 4) about 35 acre-feet of floodwater storage volume in the northern portion of the Village Park; 5) a 4,100-foot-long overflow channel along the west overbank of Underwood Creek, or possibly channel overbank lowering, from near the intersection of Mt. Kisco Drive and Underwood River Parkway to Juneau Boulevard and associated culverts at Marcella Avenue and the Village Hall Drive; 6) a 5,400-foot-long double six-foot-high by seven-foot-wide reinforced concrete box culvert diversion from Juneau Boulevard through the downtown portion of the Village of Elm Grove to a location about 450 feet east of the Milwaukee-Waukesha County line; 7) floodproofing, or purchase and removal, of one house in Brookfield, two houses in Elm Grove, three apartment buildings in Elm Grove, one commercial building in Brookfield, and seven commercial buildings in Elm Grove; 8) replacement culverts and a road grade raise at Clearwater Drive; 9) about one acre-foot of floodwater storage volume near Clearwater Drive; and 10) raising about 360 feet of Pilgrim Parkway south of Gebhardt Road an average of about 0.9 foot, and replacement of associated culverts, to avoid inundation of the roadway during a 100-year flood.

Implementation of the plan would reduce the 100-year flood stage from 0.7 to 3.5 feet in the reach in the Village of Elm Grove extending from the Milwaukee-Waukesha County line to W. North Avenue and from 0.2 to 0.3 foot in the City of Brookfield in the 0.5-mile-long reach upstream from W. North Avenue. The provision of a total of about 72 acre-feet of floodwater storage volume would avoid flood flow and stage increases in the City of Wauwatosa downstream of the Village of Elm Grove during floods with recurrence intervals ranging from two through 100 years.

Full implementation of the recommended floodland management plan would eliminate structure flood damages due to direct overland flooding along Underwood Creek for floods up to and including the 100-year recurrence interval flood event under planned land use and channel conditions. Damages due to street flooding would be reduced, but not eliminated by implementation of this plan in the absence of other measures directed toward reduction of infiltration and inflow to sanitary sewers.

The total capital cost of the floodland management element of the recommended plan is estimated to be $14,755,000, assuming it would be possible to floodproof all of the buildings remaining in the floodplain. Assuming an annual interest rate of 6 percent, a project life and amortization period of 50 years, and annual operation and maintenance costs of $36,000 per year, the average annual cost of the recommended plan is $973,000. The average annual flood damage abatement benefit is estimated to be $135,000, yielding a benefit-cost ratio of 0.14.

If, during the final design stage, it were determined that all of the buildings that are recommended to be floodproofed could not be floodproofed, those buildings would be purchased and removed. If all of the buildings were purchased and removed, the estimated cost of the recommended floodland management plan element could increase to $22,205,000. Therefore, it would be realistic to expect that the cost of implementing that plan element to be in the range from $14,755,000 to $22,205,000.

Table 64 lists the major identified stormwater drainage and flooding problems in the study area and the recommended solutions to those problems.

TOTAL COST OF THE RECOMMENDED PLAN

The total capital cost of the recommended stormwater and floodland management plan as set forth in Table 61 is estimated to be between $24.2 million and $31.7 million. The lower cost would apply if all buildings remaining in the floodplain could be floodproofed. The higher cost would apply if those buildings could not be floodproofed and they were purchased and removed. The annual operation and maintenance cost increase relative to existing conditions is estimated to be $64,280. Based on the cost apportionment approach described in Chapter VII, the City of Brookfield share of the estimated plan capital costs would be from $11.3 million to $14.4 million, the Village of Elm Grove share would be from $12.6 million to $17.2 million, and the private sector share would be from $68,000 to $320,000. The City share of the estimated annual operation and maintenance costs would be $29,160 and the Village share would be $35,120.

Table 64 (continued)

Problem	Solution	Related Measures
11. Street flooding and sanitary sewer backup in the vicinity of Briaridge Court in the Squires Grove subdivision—Village of Elm Grove	a. Storm sewer replacement	Dousman Ditch detention basin would lower the 100-year flood stage by about 0.1 foot, marginally improving the effectiveness of the recommended major stormwater drainage system
12. Street flooding and sanitary sewer backup in the vicinity of Westwood Drive and Crestview Circle—City of Brookfield	a. Storm sewer addition and replacement	- -
13. Flooding of basement garages of two apartment buildings along the Bishops Woods Tributary—Village of Elm Grove	a. Floodproof through regrading and repairing driveway	- -
14. Potential flooding of houses along drainageway in the vicinity of Grandview and Kurtis Drives in the Village	a. Culvert replacement	- -
15. Inadequate Minor Stormwater Drainage System—San Fernando Drive—Village of Elm Grove	a. New storm sewers b. Storm sewer replacement	- -
16. Inadequate Minor Stormwater Drainage System—N. 124th Street—Village of Elm Grove	a. Culvert replacement	- -
17. Inadequate Minor Stormwater Drainage System—Centa Lane—Village of Elm Grove	a. Culvert replacement	- -
18. Inadequate Minor Stormwater Drainage System—Mt. Vernon Avenue—City of Brookfield	a. Culvert replacement	- -
19. Inadequate Minor Stormwater Drainage System—Gebhardt Road—City of Brookfield	a. Storm sewer replacement	- -
20. Inadequate Minor Stormwater Drainage System—Brookfield East High School—City of Brookfield	a. Storm sewer replacement	- -
21. Inadequate Minor Stormwater Drainage System—Pilgrim Parkway—Village of Elm Grove	a. Culvert replacement	- -
22. Inadequate Minor Stormwater Drainage System—Patricia Lane/Lucy Circle—City of Brookfield	a. Culvert and storm sewer replacement	- -
23. Inadequate Minor Stormwater Drainage System—Burleigh Boulevard/Luella Drive—City of Brookfield	a. Culvert and storm sewer replacement	- -
24. Inadequate Minor Stormwater Drainage System—Hillside Drive—City of Brookfield	a. Storm sewer replacement	- -
25. Inadequate Minor Stormwater Drainage System—N. 131st Street—City of Brookfield	a. Culvert replacement	- -

Source: SEWRPC.

Table 64 (continued)

Problem	Solution	Related Measures
11. Street flooding and sanitary sewer backup in the vicinity of Briaridge Court in the Squires Grove subdivision—Village of Elm Grove	a. Storm sewer replacement	Dousman Ditch detention basin would lower the 100-year flood stage by about 0.1 foot, marginally improving the effectiveness of the recommended major stormwater drainage system
12. Street flooding and sanitary sewer backup in the vicinity of Westwood Drive and Crestview Circle—City of Brookfield	a. Storm sewer addition and replacement	- -
13. Flooding of basement garages of two apartment buildings along the Bishops Woods Tributary—Village of Elm Grove	a. Floodproof through regrading and repairing driveway	- -
14. Potential flooding of houses along drainageway in the vicinity of Grandview and Kurtis Drives in the Village	a. Culvert replacement	- -
15. Inadequate Minor Stormwater Drainage System—San Fernando Drive—Village of Elm Grove	a. New storm sewers b. Storm sewer replacement	- -
16. Inadequate Minor Stormwater Drainage System—N. 124th Street—Village of Elm Grove	a. Culvert replacement	- -
17. Inadequate Minor Stormwater Drainage System—Centa Lane—Village of Elm Grove	a. Culvert replacement	- -
18. Inadequate Minor Stormwater Drainage System—Mt. Vernon Avenue—City of Brookfield	a. Culvert replacement	- -
19. Inadequate Minor Stormwater Drainage System—Gebhardt Road—City of Brookfield	a. Storm sewer replacement	- -
20. Inadequate Minor Stormwater Drainage System—Brookfield East High School—City of Brookfield	a. Storm sewer replacement	- -
21. Inadequate Minor Stormwater Drainage System—Pilgrim Parkway—Village of Elm Grove	a. Culvert replacement	- -
22. Inadequate Minor Stormwater Drainage System—Patricia Lane/ Lucy Circle—City of Brookfield	a. Culvert and storm sewer replacement	- -
23. Inadequate Minor Stormwater Drainage System—Burleigh Boulevard/Luella Drive—City of Brookfield	a. Culvert and storm sewer replacement	- -
24. Inadequate Minor Stormwater Drainage System—Hillside Drive—City of Brookfield	a. Storm sewer replacement	- -
25. Inadequate Minor Stormwater Drainage System—N. 131st Street—City of Brookfield	a. Culvert replacement	- -

Source: SEWRPC.

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APPENDICES

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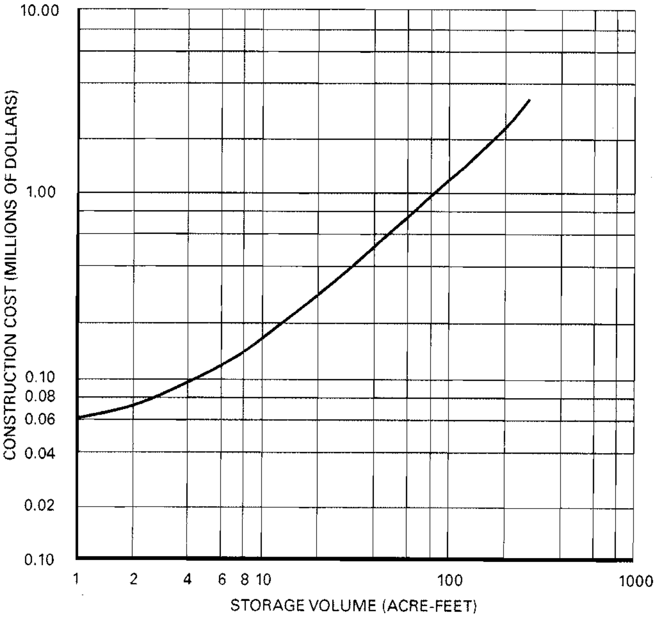
Appendix A

COST DATA FOR STORMWATER MANAGEMENT MEASURES FOR THE DOUSMAN DITCH AND UNDERWOOD CREEK SUBWATERSHEDS IN THE CITY OF BROOKFIELD AND THE VILLAGE OF ELM GROVE

Figure A-1

DRY DETENTION BASIN COST CURVE[a]

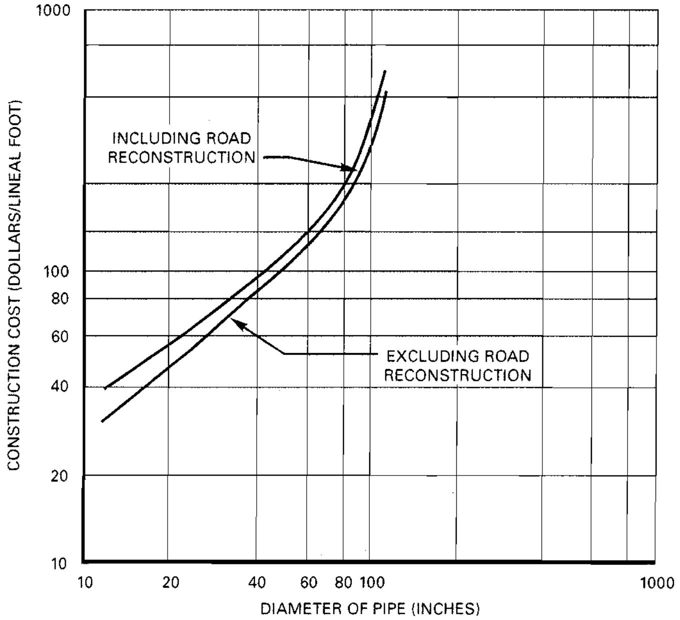


[a]*ENR CCI = 6,740 (1998). Does not include land acquisition, engineering, administration, and contingencies. For capital costs of wet basins and dual-purpose basins and for operation and maintenance costs, see SEWRPC Technical Report No. 31,* Costs of Urban Nonpoint Source Water Pollution Control Measures, *June 1991.*

Source: SEWRPC.

Figure A-2

REINFORCED CONCRETE PIPE COST CURVES[a]

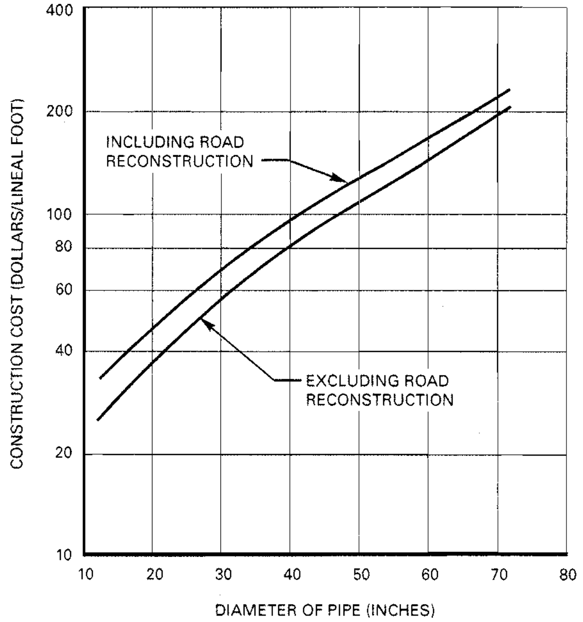


[a]*ENR CCI = 6,740 (1998). Does not include easements, engineering, administration, and contingencies.*

Source: SEWRPC.

Figure A-3

CORRUGATED METAL PIPE COST CURVES[a]

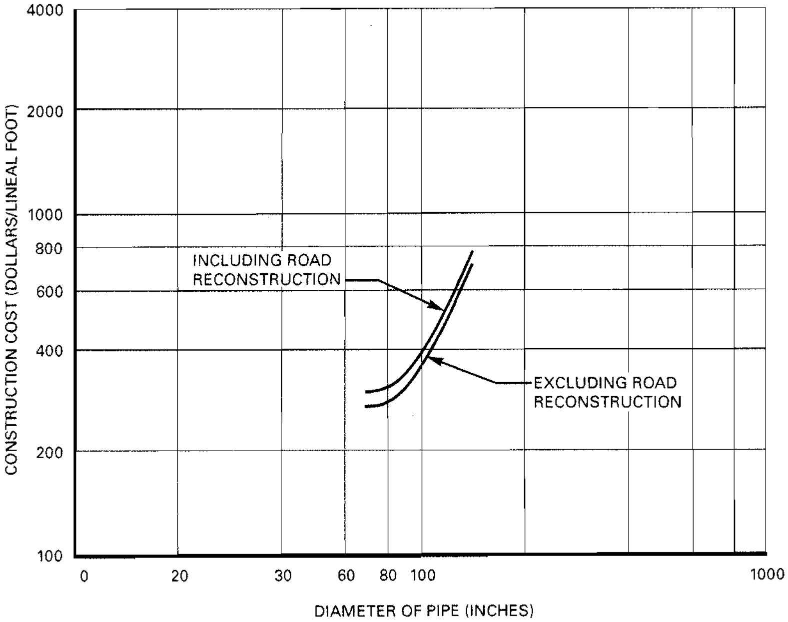


[a]*ENR CCI = 6,740 (1998). Does not include easements, engineering, administration, and contingencies.*

Source: SEWRPC.

Figure A-4

STRUCTURAL PLATE PIPE COST CURVES[a]

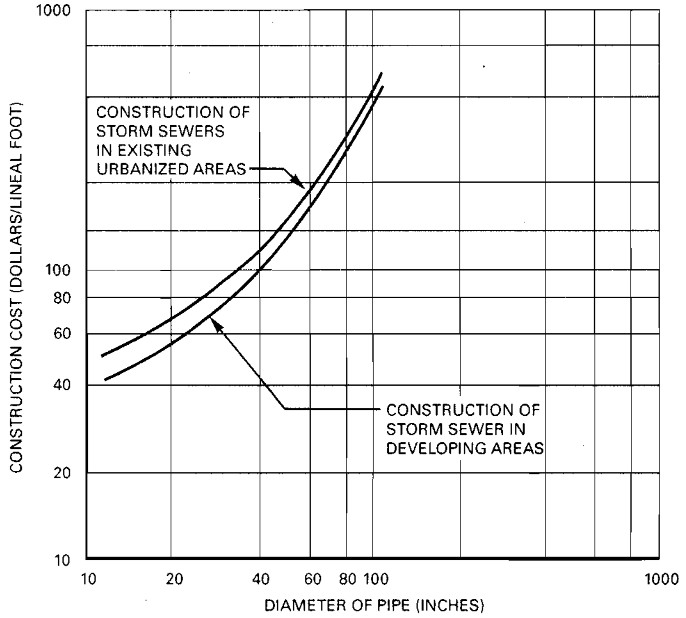


[a]*ENR CCI = 6,740 (1998). Does not include easements, engineering, administration, and contingencies.*

Source: SEWRPC.

Figure A-5

REINFORCED CONCRETE PIPE STORM SEWER COST CURVES[a,b]



[a] *ENR CCI = 6,740 (1998). Does not include easements, engineering, administration, and contingencies. Annual operation and maintenance costs equal $1,400 per mile for diameter greater than or equal to 36 inches and $3,000 per mile for diameter less than 36 inches..*

[b] *These curves are applicable for pipe invert depths of up to 12 feet. For depths greater than 12 feet, site-specific cost adjustments should be made.*

Source: SEWRPC.

Table A-1

MISCELLANEOUS UNIT COSTS

Component	Unit Cost[a]
Clearing and Grubbing	$5,300 per acre
Excavation	$4 to $30 per cubic yard[b]
Concrete	$240 per cubic yard
Riprap	$60 per cubic yard
Gabions	$150 per cubic yard
Landscaping	$5,100 per acre

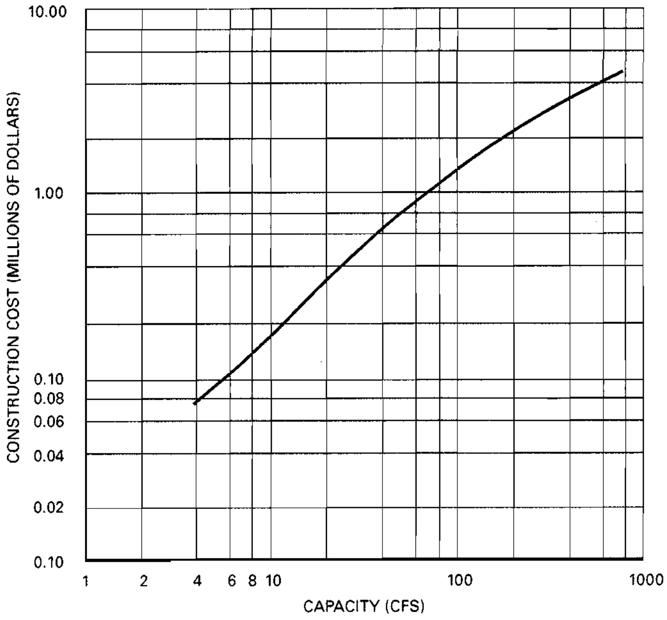
[a] *ENR CCI = $6,740 (1998). Annual channel maintenance cost = $3,000 per mile.*

[b] *Cost dependent on haul distance to disposal site, disposal site tipping fees, and whether excavated material includes toxic substances requiring special disposal methods.*

Source: SEWRPC.

Figure A-6

PUMPING STATION COST CURVES[a]



[a] *ENR CCI = 6,740 (1998). Does not include land acquisition, engineering, administration, and contingencies. Annual operation and maintenance costs equals $9,000 per year.*

Source: SEWRPC.

Table A-2

UNIT COSTS FOR CONCRETE BOX CULVERTS

Culvert Size (feet)	Unit Cost[a,b] (per lineal foot)
4 x 2	$ 190
5 x 3	270
7 x 3	470
8 x 4	560
8 x 6	600
8 x 8	680
10 x 3	530
10 x 4	660
10x 6	730
10 x 8	870
10 x 10	980
12 x 6	960
12 x 8	1,000
12 x 10	1,230
12 x 12	1,340
16 x 6	900

[a] *ENR CCI = 6,740 (1998).*

[b] *Add $30 per lineal foot of pipe to account for road reconstruction.*

Source: SEWRPC.

Table A-3

UNIT COSTS FOR CORRUGATED METAL PIPE ARCHES

Pipe Size, Span x Rise (inches)	Unit Cost[a] (per lineal foot)	
	Excluding Road Reconstruction	Including Road Reconstruction
36 x 22	$ 77	$ 91
43 x 27	90	104
50 x 31	98	113
58 x 36	118	133
65 x 40	148	163
72 x 44	157	171

[a] *ENR CCI = 6,740 (1998).*

Source: SEWRPC.

Table A-4

UNIT COSTS FOR STRUCTURAL PLATE PIPE ARCHES

Pipe Size, Span x Rise (inches)	Unit Cost[a] (per lineal foot)	
	Excluding Road Reconstruction	Including Road Reconstruction
73 X 55	$ 400	$ 410
84 X 61	430	440
98 X 69	480	500
114 X 77	580	600
131 X 85	710	730
148 X 93	770	800
161 X 101	860	880
178 X 109	910	940
190 X 118	1,000	1,040
199 X 121	1,030	1,070

[a] *ENR CCI = 6,740 (1998).*

Source: Dodge Guide and SEWRPC.

Table A-5

UNIT COSTS FOR REINFORCED CONCRETE PIPE ARCH (RCPA) AND HORIZONTAL ELLIPTICAL (HE) STORM SEWERS

Pipe Size, Span x Rose (inches)		Unit Cost[a] (per lineal foot)	
RCPA	HE	Replacement of Existing Storm Sewers in Urbanized Areas	Construction of New Storm Sewers in Developing Areas
22 x 14	23 x 14	$ 81	$ 71
29 x 18	30 x 19	93	82
36 x 23	38 x 24	120	109
44 x 27	45 x 29	142	129
51 x 31	53 x 34	164	150
58 x 36	60 x 38	187	173
65 x 40	68 x 43	219	202
73 x 45	76 x 48	257	240
- -	83 x 53	333	311
88 x 54	91 x 58	365	348

[a] *ENR CCI = $6,740 (1998).*

Source: SEWRPC.

Table A-6

UNIT COSTS FOR ROADWAY BRIDGE REMOVAL AND REPLACEMENT

Removal Unit Cost[a,b] (per square foot)	Replacement Unit Cost[a,b,c] (per square foot)
$14	$100

[a] *ENR CCI = 6,740 (1998).*

[b] *Based on bridge deck area, including street, curbs, sidewalks, and parapets.*

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

Source: SEWRPC.

Table A-7

UNIT COSTS FOR RAILWAY BRIDGE REMOVAL AND REPLACEMENT

Number of Tracks	Removal Unit Cost[a,b] (per square foot)	Replacement Unit Cost[a,b] (per lineal foot of span)
2	$14	$17,000

[a] *ENR CCI = 6,740 (1998).*

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

Source: SEWRPC.

Table A-8

STRUCTURE FLOODPROOFING COSTS[a]

Structure Type	Cost per Structure
Single-Family Home	$11,500
Industrial/Commercial/ Apartment Building with Basement	Fair Market Value x (0.07 + 0.05 x height, in feet, of floodproofing above first floor

[a] *ENR CCI = 6,740 (1998). Costs include administration and contingencies.*

[b] *If there is no basement, the factor 0.07 is eliminated.*

Source: SEWRPC.

Table 9

SINGLE-FAMILY HOME ELEVATION COSTS[a]

Cost = $60,000 per House

[a] *ENR CCI = $6,740 (1998). Costs include administration and contingencies.*

Source: SEWRPC.

Table A-10

BUILDING DEMOLITION AND REMOVAL COSTS[a]

Single-Family Home Cost = $40,000 + Fair Market Value of Structure and Land
Commercial Building Cost = $70,000 + 1.1 x Building Fair Market Value
Apartment Building Cost = $10,000 x Number of Apartments per Building + 1.1 x Building Fair Market Value

[a] *Costs include building demolition and relocation expenses as set forth under State of Wisconsin laws.*

Source: SEWRPC.

Appendix B

CONSIDERATION OF THE EFFECT OF THE VILLAGE PARK BERM ON FLOOD STAGE ELEVATIONS ALONG LEGION DRIVE

At the request of the Village of Elm Grove, the Commission staff performed hydraulic analyses to determine the effect that the berm in the Village Park has on flood stages of Underwood Creek. That analysis was requested by the Village staff in response to inquiries from Village residents. The berm, which was constructed about 30 years ago when the adjacent pond was deepened, is located between the pond and Underwood Creek and it runs parallel to Underwood Creek, as shown on Map B-1.

There are 11 buildings located along Legion Drive between Lindhurst Drive and Nicolet Avenue that are within the 100-year floodplain. Only one building would be expected to be flooded during a the 50-year flood and no buildings would be expected to be flooded during floods with recurrence intervals up to 10 years. Residents of the vicinity inquired as to whether the berm might redirect floodwaters and constrict flood flows, thereby increasing the potential for flooding of buildings along Legion Drive.

The Commission staff performed a hydraulic analysis of the subject reach of Underwood Creek using the U.S. Army Corps of Engineers HEC-RAS River Analysis Systems computer model developed under the ongoing floodland mapping update program for the City of Brookfield and the Village of Elm Grove and also used for the flood control alternatives analyses presented in Chapter V of this report. Water surface profiles were computed for the two-, five-, 10-, 50-, and 100-year recurrence interval floods occurring under planned land use conditions. Profiles were computed for existing channel conditions with and without the berm. A comparison of the flood profiles is given in Table B-1.

The data in the table indicate that during large floods with recurrence intervals of 10 through 100 years, the increase in flood stage due to the berm would range from 0.00 to 0.02 foot. Thus, during such large floods, the effect of the berm on flood stage elevations is insignificant.

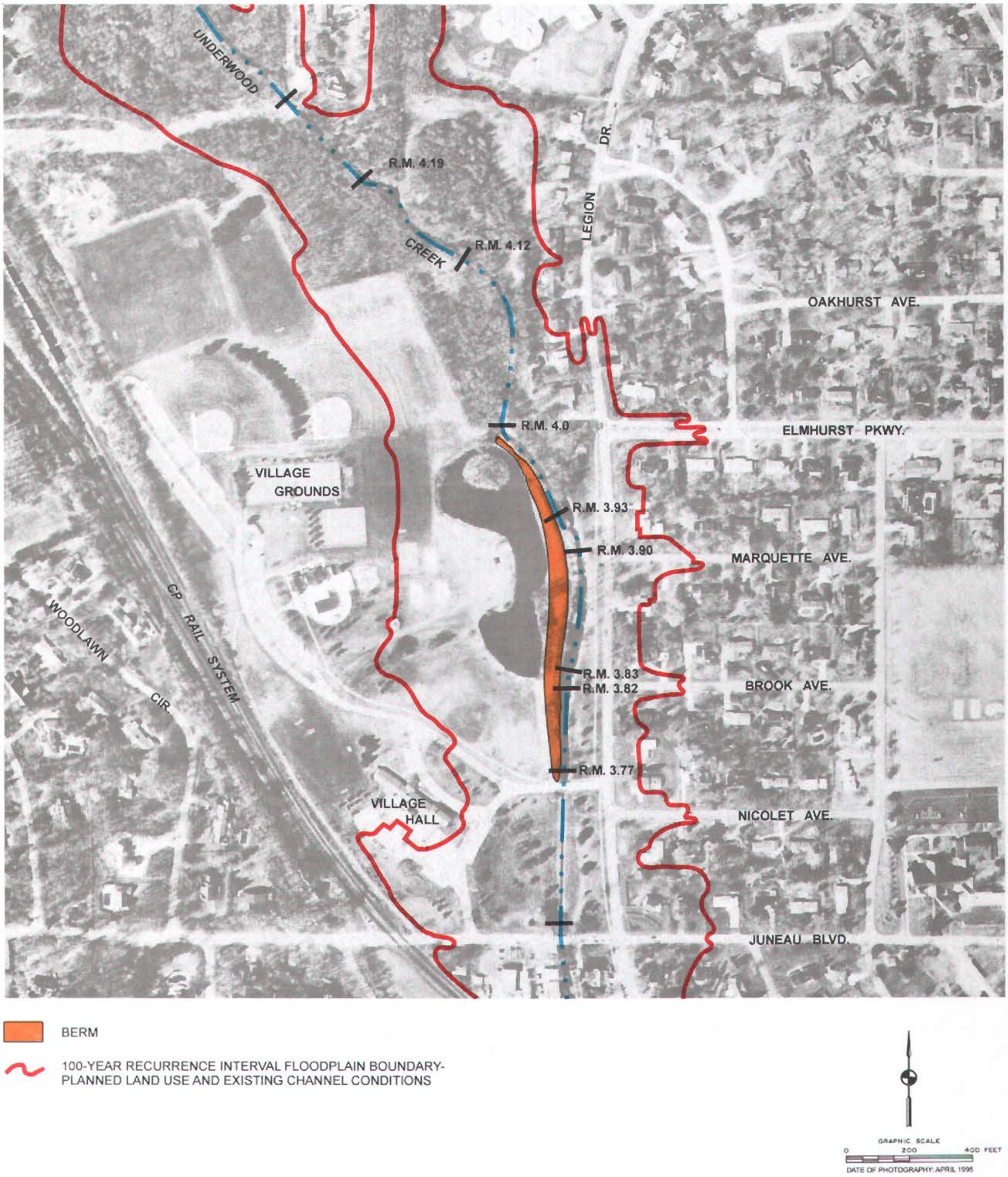
During a five-year recurrence interval flood, the increase in stage due to the berm would range from 0.00 to 0.05 foot. That increase is small, and no buildings would experience greater flooding as a result of the increases in stage since there are no buildings within the limits of the area that would be flooded during a five-year event.

During a two-year recurrence interval flood, the increase in stage due to the berm would generally range from 0.00 to 0.15 foot, but could be as much as 0.49 foot at River Mile 4.00, just upstream of the northern limit of the berm. Once again, no buildings would experience greater flooding as a result of the increases in stage since there are no buildings within the limits of the area that would be flooded during a two-year event.

Based on the results of the analyses as summarized above and in Table B-1, it can be concluded that the berm in the Village Park along Underwood Creek does not cause any significant increase in flooding along the Creek.

Map B-1

LOCATION OF BERM IN ELM GROVE VILLAGE PARK



Source: SEWRPC.

Table B-1

COMPARISON OF FLOOD STAGES WITH AND WITHOUT THE EXISTING BERM ALONG UNDERWOOD CREEK IN THE ELM GROVE VILLAGE PARK

		Two-Year Flood Stage (feet NGVD29)			Five-Year Flood Stage (feet NGVD29)			10-Year Flood Stage (feet NGVD29)			50-Year Flood Stage" (feet NGVD29)			100-Year Flood Stage (feet NGVD29)		
River Mile	Location	Without Berm	With Berm	Change Due to Berm	Without Berm	With Berm	Change Due to Berm	Without Berm	With Berm	Change Due to Berm	Without Berm	With Berm	Change Due to Berm	Without Berm	With Berm	Change Due to Berm
3.77	Upstream of park entrance road and north of Nicolet Avenue	740.18	740.18	0.00	742.08	742.08	0.00	743.24	743.24	0.00	744.58	744.57	-0.01	746.06	746.06	0.00
3.82	- -	740.41	740.39	-0.02	742.17	742.18	0.01	743.28	743.28	0.00	744.60	744.60	0.00	746.07	746.07	0.00
3.83	- -	740.44	740.41	-0.03	742.18	742.20	0.02	743.28	743.29	0.01	744.60	744.61	0.01	746.07	746.07	0.00
3.90	Marquette Avenue	740.57	740.64	0.07	742.20	742.22	0.02	743.29	743.30	0.01	744.61	744.62	0.01	746.08	746.08	0.00
3.93	- -	740.65	740.80	0.15	742.22	742.24	0.02	743.30	743.32	0.02	744.63	744.64	0.01	746.08	746.09	0.01
4.0	North of Elmhurst Parkway	740.90	741.39	0.49	742.26	742.31	0.05	743.33	743.35	0.02	744.65	744.67	0.02	746.10	746.11	0.01
4.12	Lindhurst Drive	742.74	742.72	-0.02	743.22	743.23	0.01	743.79	743.80	0.01	744.90	744.92	0.02	746.19	746.20	0.01
4.19	- -	743.58	743.58	0.00	744.00	744.00	0.00	744.32	744.32	0.00	745.17	745.18	0.01	746.29	746.29	0.00

Source: SEWRPC.

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Appendix C

LOCAL OFFICIALS AND UNDERWOOD CREEK FLOODING TASK FORCE MEMBERS

CITY OF BROOKFIELD

Kathryn C. Bloomberg, Mayor
Dean R. Marquardt, Director of Administrative Services
Thomas M. Grisa, P.E., Director of Public Works
William Muth, P.E., former Director of Public Works
Steven D. Loth, P.E., and Mary Jo Lange, P.E., former Engineering Administrators
Carrie Bristoll-Groll, P.E., Project Engineer
Thomas J. Hafner, P.E., Project Engineer

TASK FORCE MEMBERS

Chris Blackburn, Co-Chairman
Rob Buikema
Dawn Carson
James J. McGavock
Jack Shaw
Jerry Unruh

VILLAGE OF ELM GROVE

James W. Nortman, President
Andrea Steen Crawford, Village Manager
Charles D. Armao, Director of Public Works

TASK FORCE MEMBERS

Gerald Fellows, Co-Chairman
John Bunce (ex officio)
Paul Freedy (ex officio)
James Keyes
Neil Palmer
Richard Reinders
John Schlosser
James Schwai

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Appendix D

CONSIDERATION OF FREQUENCY AND DURATION OF FLOODING AT PROPOSED BLUEMOUND ROAD GOLF RANGE DEVELOPMENT

At the request of the City of Brookfield, the Commission staff performed hydrologic analyses to determine the potential for flooding of the proposed Bluemound Road Golf Range development under the alternative flood and nonpoint source pollution control plans described in Chapter V of this report. This appendix sets forth the findings of the analyses.

The golf range is proposed to be located just north of the future extension of Wisconsin Avenue in the northeast one-quarter of U.S. Public Land Survey Section 27, Township 7 North, Range 20 East, City of Brookfield, as shown on Map D-1. Much of the proposed range would be located in the Dousman Ditch floodplain and within the recommended areawide flood detention facility to be located along Dousman Ditch about 500 feet north of the planned extension of Wisconsin Avenue.

Under the analysis presented herein, daily peak flood flows and stages for the recommended detention basin were simulated using the Hydrological Simulation Program-Fortran (HSPF) model that was developed for the Underwood Creek/Dousman Ditch subwatershed under the Underwood Creek and Dousman Ditch stormwater management plan.[1] The HSPF model simulates streamflow and stage on a continuous basis using recorded climatological data as input. Daily peak flows and stages were simulated for Dousman Ditch at the outlet of each alternative detention basin for an approximately 49-year period of record from January 1940 through September 1988. The results presented in this appendix are for that time period.

The surface of the land on which the golf range is to be developed lies between elevation 826.5 and 827.6 feet above National Geodetic Vertical Datum, 1929 adjustment (NGVD29). Preliminary conceptual proposals for the proposed development call for the filling of land on the development site to elevation 827.6 feet above NGVD29. Such filling north of the 500-foot development zone adjacent to the proposed extension of Wisconsin Avenue would have to be offset by the provision of an equal amount of compensatory storage below the 100-year recurrence interval flood stage under buildout land use conditions. Because the feasibility of providing compensatory storage has not been fully explored, a range of flood levels from elevation 826.5 to 827.6 feet NGVD29 was considered in the analysis.

Table D-1 sets forth the findings of the hydrologic analyses. The following is a summary of those findings:

1. Under Alternative Plan No. 1—Structure Floodproofing and Elevation, and Alternative Plan No. 2—Acquisition and Removal of Floodprone Structures, the frequency and duration of flooding of the golf range site would not be affected because no changes would be made to the Dousman Ditch channel.

2. Under Alternative Plan No. 3—Limited Detention Storage with Structure Floodproofing , Elevation, and Removal; and Alternative Plan No. 10—Limited Dousman Ditch Detention Storage, Bridge and Culvert Modification, and Maximum On-Line Storage with Structure Floodproofing, Elevation, and Removal; and Alternative Plan No. 11—Limited Dousman Ditch Detention Storage, Underwood Creek Overflow Channel and Diversion, and Compensating Storage with Structure Floodproofing and

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[1] *That model is consistent with the HSPF model developed under the ongoing floodland boundary remapping and floodland storage area identification study for the City of Brookfield and the Village of Elm Grove.*

Table D-1

NUMBER AND AVERAGE DURATION OF SIMULATED FLOODING OCCURRENCES AT THE PROPOSED BLUE MOUND ROAD GOLF RANGE DEVELOPMENT

		Target Flood Stage Elevation (feet above NGVD29)		
Alternative[a,b]	Flood Elevation-Duration Condition	826.5	827.0	827.6
No. 3—Limited Detention Storage with Structure Floodproofing and Elevation; No. 10—Limited Dousman Ditch Detention Storage, Bridge and Culvert Modification, and Maximum On-Line Storage with Structure Floodproofing, Elevation, and Removal; and 11—Limited Dousman Ditch Detention Storage, Underwood Creek Overflow Channel and Diversion, and Compensating Storage with Structure Floodproofing and Removal	Number of times simulated peak daily flood stage elevation exceeded the target elevation for a duration of:[c]			
	One day or more	0	0	0
	Two days or more	0	0	0
	Three days or more	0	0	0
	Average duration in days of simulated peak daily flood stage in excess of target elevation for a duration of:			
	One day or more	0	0	0
	Two days or more	0	0	0
	Three days or more	0	0	0
No. 4—Detention Storage with Excavation Minimized, No Wetland Disturbance, and Structure Floodproofing and Elevation; and No. 9—Two Basin Detention Storage with Excavation Minimized, No Wetland Disturbance, and Structure Floodproofing and Elevation	Number of times simulated peak daily flood stage elevation exceeded the target elevation for a duration of:[c]			
	One day or more	67	45	30
	Two days or more	41	26	19
	Three days or more	19	16	11
	Average duration in days of simulated peak daily flood stage in excess of target elevation for a duration of:			
	One day or more	3.5	4.5	5.4
	Two days or more	3.7	4.9	5.8
	Three days or more	4.1	4.6	5.5
No. 5—Expanded Detention Storage with Excavation Minimized and Structure Floodproofing and Elevation; and No. 7—Expanded Two-Basin Detention Storage with Excavation Minimized and Structure Floodproofing and Elevation	Number of times simulated peak daily flood stage elevation exceeded the target elevation for a duration of:[c]			
	One day or more	104	65	47
	Two days or more	58	45	31
	Three days or more	28	23	17
	Average duration in days of simulated peak daily flood stage in excess of target elevation for a duration of:			
	One day or more	3.6	4.9	5.9
	Two days or more	4.2	5.0	6.1
	Three days or more	4.7	5.4	6.4

[a] *Under Alternative Plan No. 1—Structure Floodproofing and Elevation and Alternative Plan No. 2—Acquisition and Removal of Floodprone Structures, the frequency and duration of flooding of the Blue Mound Golf Range site would not be affected because no changes would be made to the Dousman Ditch channel.*

[b] *Under Alternative Plan No. 6—Expanded Detention Storage with Excavation Maximized and Structure Floodproofing and Elevation and Alternative Plan No. 8—Expanded Two-Basin Detention Storage with Excavation Maximized and Structure Floodproofing and Elevation, it would not be possible to develop the Blue Mound Road Golf Range as intended because the Golf Range site would be purchased and excavated to elevation 824 feet above NGVD29 to provide additional flood storage capacity.*

[c] *Based on simulated peak daily stages for the 49-year period extending from January 1940 through September 1988.*

Removal, the additional flood storage and conveyance provided above the permanent pond between elevations 824 and 827 feet above NGVD29 resulted in no flooding above elevation 826.5 for periods of one day or longer, during the simulation period. Flooding of the golf range site would be expected to occur less frequently under this alternative than under existing conditions as represented by Alternative Plan Nos. 1 and 2.

3. Under Alternative Plan No. 4—Detention Storage with Excavation Minimized, No Wetland Disturbance, and Structure Floodproofing and Elevation, and Alternative Plan No. 9—Two-Basin Detention Storage with Excavation Minimized, No Wetland Disturbance, and Structure Floodproofing and Elevation, the simulated daily peak flood stage exceeded elevation 826.5 feet NGVD29 for a duration of one day or more 67 times in 49 years. Therefore, it may be expected that the flood stage in the proposed golf range site would exceed elevation 826.5 feet above NGVD29 for a duration of one day or more about once every nine months. The average duration of flooding above that elevation was 3.5 days. The simulated daily peak flood stage exceeded elevation 826.5 feet above NGVD29 for a duration of three days or more 19 times in 49 years, or about once every 2.5 years. The average duration of flooding above that elevation was 4.1 days.

   The simulated daily peak flood stage exceeded the proposed project filling elevation of 827.6 feet above NGVD29 for a duration of one day or more 30 times in 49 years, or about once every 20 months. The average duration of flooding above that elevation was 5.4 days. The simulated daily peak flood stage exceeded elevation 827.6 feet above NGVD29 for a duration of three days or more 11 times, or about once every 4.5 years. The average duration of flooding above that elevation was 5.5 days.

4. Under Alternative Plan No. 5—Expanded Detention Storage with Excavation Minimized and Structure Floodproofing and Elevation, and Alternative Plan No. 7—Expanded Two-Basin Detention Storage with Excavation Minimized and Structure Floodproofing and Elevation, the simulated daily peak flood stage exceeded elevation 826.5 feet above NGVD29 for a duration of one day or more 104 times in 49 years, or about once every six months. The average duration of flooding above that elevation was 3.6 days. The simulated daily peak flood stage exceeded elevation 826.5 feet above NGVD29 for a duration of three days or more 28 times in 49 years, or about once every 20 months. The average duration of flooding above that elevation was 4.7 days.

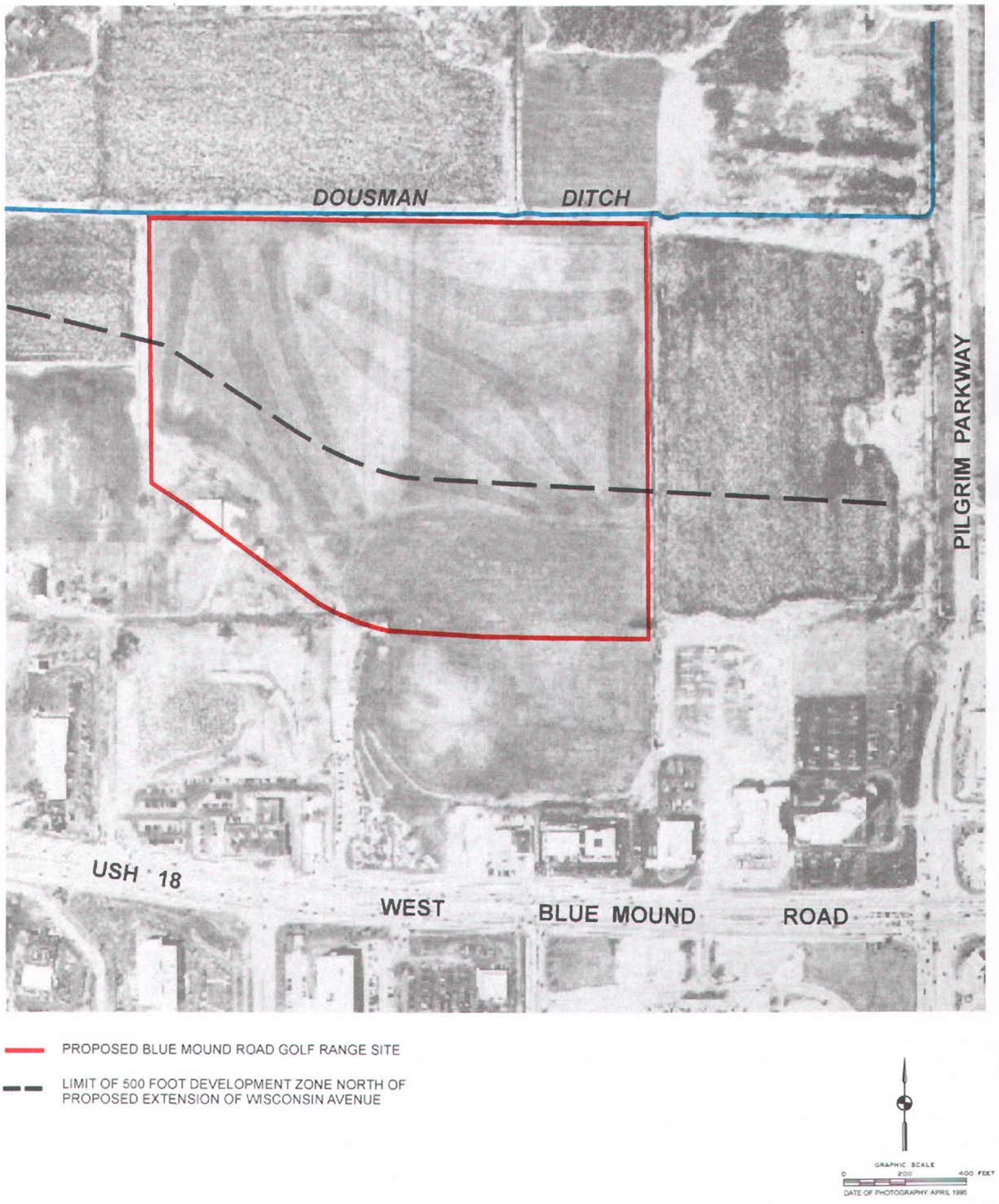
   The simulated daily peak flood stage exceeded the proposed project filling elevation of 827.6 feet above NGVD29 for a duration of one day or more 47 times in 49 years, or about once a year. The average duration of flooding above that elevation was 5.9 days. The simulated daily peak flood stage exceeded elevation 827.6 feet above NGVD29 for a duration of three days or more 17 times, or about once every three years. The average duration of flooding above that elevation was 6.4 days.

5. Under Alternative Plan No. 6—Expanded Detention Storage with Excavation Maximized and Structure Floodproofing and Elevation, and Alternative Plan No. 8—Expanded Two-Basin Detention Storage with Excavation Maximized and Structure Floodproofing and Elevation, it would not be possible to develop the golf range as intended because the site would be purchased and excavated to elevation 824 feet above NGVD29 to provide additional flood storage capacity. Frequent flooding of the excavated area would be expected.

The alternative plans that limit or eliminate sustained flooding of the golf range site and are, therefore, most compatible with the proposed development are Alternative Plan Nos. 1, 2, 3, 10, and 11. Alternative Plan Nos. 4 and 9 would result in more frequent flooding of the site and Alternative Plan Nos. 5 and 7 would cause the most frequent flooding. The implementation of Alternative Plan Nos. 6 and 8 would not permit development of the golf range as currently proposed.

Map D-1

LOCATION OF PROPOSED BLUEMOUND ROAD GOLF RANGE



Source: SEWRPC.

MINUTES OF SEPTEMBER 15, 1999, MEETING OF THE FULL UNDERWOOD CREEK FLOODING TASK FORCE

These are the minutes of the Underwood Creek Task Force meeting held on September 15, 1999 at 7:00 p.m. in the Common Council Chambers of Brookfield City Hall, 2000 North Calhoun Road, Brookfield, Wisconsin. (*Reports mentioned in these minutes are available at the Brookfield City Clerk's Office or the Elm Grove Village Hall).

Members Present: Gerald Fellows, James Heuler, John Schlosser, James Keyes, James Schwai, Richard Reinders, Neil Palmer, Jack Shaw, Chris Blackburn, Dawn Carson, James McGavock, James Garvens and Mike Jakus.

Staff Present: Mike Campbell, Andrea Steen-Crawford, Chuck Armao, Jim Nortman, Howard Young, State Rep. Marc Duff, State Sen. Margaret Farrow, Michael Bruch, Jr., Dean Marquardt, Tom Grisa, Mike Hahn, Carrie Bristoll-Groll and Mary Schulz.

Chris Blackburn called the Underwood Creek Task Force Meeting to order at 7:00 p.m.

Chris Blackburn moved to table the April 21, 1999 minutes of the Underwood Creek Task Force meeting. This was seconded by Gerald Fellows and carried unanimously.

Mike Hahn started out by giving recognition to the staff of the City of Brookfield and Village of Elm Grove, along with the members of the Underwood Creek Task Force for their collaborated efforts on the Stormwater Management Plan.

Mike Hahn introduced and summarized the Recommended Stormwater Management Plan*. The three main elements being: water quality management, stormwater drainage and floodland management. Some of the components of the plan are:

- construction of a dual-purpose wet detention basin with a permanent pond area of 19 areas along the upper reach of Dousman Ditch west of Pilgrim Parkway and north of Wisconsin Avenue extended
- provision of new or replacement culverts and storm sewers at problem areas throughout the study area
- limited swale modification
- acquisition of one house and lot and floodproofing of two houses
- construction of a stormwater pumping station along the east side of Lilly Road, north of W. North Avenue
- increased sweeping of about 23 miles of streets in critical land use areas in Brookfield and Elm Grove
- continued enforcement of the existing construction site erosion control ordinances
- site-specific best management practices designed to reduce the washoff of pollutants from new development, or redevelopment, sites
- maintenance of the existing 15 ponds in the study area
- more controlled application of sand on streets in the winter
- localized bank protection projects, using natural bioengineering techniques wherever practical

- public information and education efforts to promote good urban "housekeeping" practices that reduce nonpoint source pollution

Mike Hahn indicated that the estimated capital cost of the recommended water quality management plan element is about $4.1 million and the estimated capital cost of the recommended stormwater drainage plan element is about $5.2 million. Thus, the estimated total cost of the stormwater management plan component of the recommended plan is $9.3 million. The total annual operation and maintenance cost increase relative to existing conditions is estimated to be $28,000 for both the city and village.

Mike Hahn stated that the benefits of implementation of the Stormwater Management Plan are:

- Implementation of the recommended water quality management plan would provide controls on runoff from about 73 percent of the critical land uses in the study area and all areas of new development.
- Full implementation of the recommended stormwater drainage measures would provide a minor stormwater drainage system adequate to convey and/or store runoff from storms with recurrence intervals up to, and including 10 years and to generally provide an acceptable level of traffic service and access to property during such storms. Implementation of the recommended drainage measures would also avoid direct flooding of inhabited buildings during storms with recurrence intervals up to, and including 100 years. The recommended measures would help to mitigate, but not eliminate, flooding of basements due to sanitary sewer backup. Other measures directed toward reduction of infiltration and inflow to sanitary sewers, or in some cases increasing sanitary sewer capacities, would be required to fully alleviate sanitary sewer backup problems.

Components of the recommended Floodland Management Plan, which is directed towards the Underwood Creek & Dousman Ditch, are shown on Maps VI-2 and VI-2a.

- The dual-purpose wet detention basin along the upper reach Dousman Ditch
- About 14 acre-feet of floodwater storage volume in the east overbank of Underwood Creek in the City of Brookfield northwest of the intersection of W. North Avenue and Lilly Road
- Purchase and removal of six houses located east of Underwood Creek in the City to enable construction of the detention storage area
- About 35 acre-feet of floodwater storage volume in the northern portion of the Village Park
- Raising about 360 feet of Pilgrim Parkway south of Gebhardt Road an average of about 0.9 foot, and replacement of associated culverts, to avoid inundation of the roadway during a 100-year flood
- A 4,100 foot-long overflow channel along the west overbank of Underwood Creek, or possibly channel overbank lowering, from near the intersection of Mt. Kisco Drive and Underwood River Parkway to Juneau Boulevard and associated culverts at Marcella Avenue and the Village Hall Drive

- A 5,400 foot-long double six-foot high by seven-foot wide reinforced concrete box culvert diversion from Juneau Boulevard through the downtown portion of the Village of Elm Grove to a location about 450 feet east of the Milwaukee-Waukesha County line
- Floodproofing, or purchase and removal, of one house in Brookfield, two houses in Elm Grove, three apartment buildings in Elm Grove, one commercial building in Brookfield, and seven commercial buildings in Elm Grove
- Replacement culverts and road grade raise at Clearwater Drive
- About one acre-foot of floodwater storage volume near Clearwater Drive

The total capital cost of the floodland management element of the recommended plan is estimated to be $14.6 million, assuming it would be possible to floodproofing all of the buildings remaining in the floodplain. Assuming an annual interest rate of 6 percent, a project life and amortization period of 50 years, and annual operation and maintenance costs of $36,000 per year, the average annual cost of the alternative plan is $965,000. The average annual flood damage abatement benefit is estimated to be $135,000, yielding a benefit-cost ratio of 0.14.

The benefits of implementing the Floodland Management Plan component would eliminate structure flood damages due to direct overland flooding along Underwood Creek for floods up to and including the 100-year recurrence interval flood event under planned land use and channel conditions. Damages due to street flooding would be reduced, but not eliminated by implementation of this plan in the absence of other measures directed toward reduction of infiltration and inflow to sanitary sewers.

The total cost of the recommended plan is broken down as follows:

Capital Cost – The total capital cost of the recommended stormwater and floodland management plan is estimated to be between $24.0 million and $31.4 million, depending on whether certain buildings remaining in the floodplain after construction of the detention storage area can be floodproofed or must be purchased. The lower cost would apply if all buildings remaining in the floodplain could be floodproofed. The higher cost would apply if those buildings could not be floodproofed and they were purchased and removed.

Annual Operation and Maintenance Cost Increase – The total operation and maintenance cost increase relative to existing conditions is estimated to be $64,000.

Preliminary Suggested Cost Apportionment – Based on the preliminary suggested capital cost appointment:

- The City of Brookfield share of the estimated plan capital costs would be from $11.1 million to $14.2 million.
- The Village of Elm Grove share would be from $12.6 million to $17.2 million.
- The private sector share would be from $23,000 to $283,000.

The City share of the estimated annual operation and maintenance costs would be about $29,000 and the Village share would be $35,000.

This completed the report from Mike Hahn.

At this time, Chris Blackburn asked if there were any questions from the Task Force members.

Jim McGavock was opposed to the open pond along Dousman Ditch. He said it would be an attractive nuisance for children, who are naturally drawn to water. Who would be responsible for the liability of the pond. Ponds are for pollution control, not flood control. Also, the inflow and outflow of water of the pond would be minor, therefore causing algae and insects to be present. He would rather see a dry detention area established. Mike Hahn replied that certain design and safety measures can be taken to prevent these problems. The pond would have flat slopes and a buffer area along the shoreline. The water quality function is important and would treat runoff from Brookfield Square and much of the commercial development along the Bluemound corridor. Another function is to store runoff from new development in this area. The pond could be located to an area farther away from residential development. Mike Hahn also indicated that the water speed/velocity would be very minimal in this area. Mike Hahn stated that the legal council for the City and Village would have to look into the liability issue.

Alderman Jim Garvens indicated that he represents a district that has modest homes. The plan calls for demolishing 6 homes in his district. Is it possible for these homes to be floodproofed rather than be removed. Mike Hahn replied that the removal of these homes is tied in with the development of floodwater storage areas. If the city would not remove the homes, the potential for development of storage areas is diminished.

Howard Young asked if the level of water at the creek stage in Wauwatosa would increase. Does this mean under the conditions of the 100 year flood or under any conditions. Mike Hahn replied that the water level will not increase during the 100 year flood.

A question was raised on what is the reduction in the flood elevation? Mike Hahn indicated that the reduction in the flood elevation will vary along the stream. The area between the County Line and North Avenue would have a reduction of between .7 and 3.5 ft. The greatest reduction would be in Elm Grove at, and upstream of, Watertown Plank Road.

James Schlosser stated that the sanitary concerns are not directly addressed by the solution. Mike Hahn indicated that the plan would lower flood stages and there would be improvements to storm sewers and culverts. He stressed that it would be impossible to make everything high & dry. James Schlosser said that a possible option to consider, along with the recommended solutions, would be bypass pumps. Neil Palmer stated the currently Elm Grove is pursuing sanitary sewer solutions. Andrea Steen-Crawford indicated that Elm Grove has submitted 5 applications to the DNR for sanitary sewer bypasses.

Neil Palmer said that the individual communities have the option of saying "no" to any portion of the plan. Communities have to decide what they can do and what they can afford to due.

A question was raised whether the report would be put on the Internet. Neil Palmer stated that there would be problems with putting graphics on the Internet. Dean Marquardt indicated that the city staff can put the report on the City Web Page. SERWPC can provide the report on disk for the city.

Jack Shaw moved to accept the Preliminary Draft Recommended Stormwater and Floodland Management Plan. This was seconded by James Schlosser and carried unanimously.

Chris Blackburn inquired about the status of the permit process. Michael Bruch, Jr., DNR Rep., stated that most of the permits applied for would be issued. There may be a problem with the permit allowing the bypass channel through the Wetlands. Someone questioned why developers are allowed to build near wetland. Mr. Bruch stated that any project which affects the wetlands would have an alternate project plan. The rule is to minimize the damage to any wetland area.

Neil Palmer suggested that the individual communities meet with their members of the Underwood Creek Task Force and develop suggestions regarding the report to be discussed at the combined Underwood Creek Task Force Meeting which will be held on Wednesday, October 13, 1999 at 7:00 p.m. at the Village of Elm Grove.

Neil Palmer moved to adjourn the Underwood Creek Task Force Meeting. This was seconded by Alderman Jim Garvens and carried unanimously. 8:45 p.m.

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Appendix F

MINUTES OF SEPTEMBER 23, 1999, MEETING OF THE CITY OF BROOKFIELD SUBCOMMITTEE OF THE UNDERWOOD CREEK FLOODING TASK FORCE

The September 23, 1999 meeting of the Underwood Creek Task Force (City of Brookfield members only) held at Brookfield City Hall in the Council Chambers, was called to order by chairman Chris Blackburn at 7:00 p. m.

Members present were Jim McGavock, Jack Shaw, Chris Blackburn, Dawn Carson, Rob Buikema, Alderman Mike Jakus, Alderman Jim Garvens, also present were Tom Grisa, Public Works Director and Dean Marquardt, Administrative Services Director.

The City of Brookfield members of the Underwood Creek Task Force on Flooding acknowledge the SEWRPC community assistance planning report no. 236, a stormwater and floodland management plan for the Dousman Ditch and Underwood Creek Subwatersheds in the City of Brookfield and Village of Elm Grove. SEWRPC technical staff, specifically Mike Hahn, has completed a daunting task during the past year.

The Underwood Creek Task Force mission was to "develop recommendations for the Village of Elm Grove and City of Brookfield to improve stormwater management and sanitary sewer performance and to mitigate the effects of flooding within the Underwood Creek Basin". The Task Force has approved broad policy recommendations that were adopted by the Citywide Flood Task Force. The SEWRPC preliminary report represents one of the final steps for the combined task force.

The Task Force members held considerable discussion of the SEWRPC preliminary stormwater and floodland management plan for the Dousman Ditch and Underwood Creek Subwatersheds. Identifying and acknowledging concerns for the retention structure located in the Dousman Ditch subwatershed. A map of the subwatershed located within the City of Brookfield was presented. Alderman Jakus explained to the Task Force the fact that the Dousman Ditch and Underwood Creek subwatersheds were only two of seven subwatersheds in the City. The City must weigh all the economic factors throughout the community before implementing any stormwater or floodland management plan.

The Task Force members feel positive about the work that has been completed. However, there are concerns about other problems that may not have been identified at this time. Brookfield needs to work on these issues. The Board of Public Works will be reviewing this report and the reports on the other five subwatersheds, and will need to address the financial and policy issues as well as review and recommend an implementation plan to the Common Council.

The Task Force discussed the process and path that the combined Task Force had traveled for the past year and assembled their report and recommendations.

a. The City of Brookfield members of the Underwood Creek Task Force accept the report as a planning document that should be used as a guide as the various elements of the City's stormwater management plan are reviewed for design and implementation.
b. The City of Brookfield and Village of Elm Grove members of the task force members work with the boards and committees of their respective communities to complete the implementation process of the overall stormwater and floodland management plans. If it is determined in the future that a joint body of the task force is required, the task force members will reconvene.
c. The City of Brookfield members of the Underwood Task Force do not support or accept the cost-sharing ratio presented in the preliminary plan. However, there is a unanimous desire of the members to maintain a spirit of cooperation, as both communities must simultaneously address stormwater and floodland management.

d. Any improvements made within the City of Brookfield must maintain current flow rates or less into the Village of Elm Grove.
e. The Task Force members support the need for water quality measures and believes the City of Brookfield should investigate all water quality measures including and beyond those identified in the plan with consideration for location, effectiveness, and available finances.
f. The City of Brookfield members of the Task Force request that specific protective and prevention efforts for mitigating sanitary sewer backup are identified and that affected persons be provided with education and financial/grant concepts for the purpose of assisting residents in the prevention of sanitary sewer backups.
g. Three members of the task force to be appointed to serve on the Citywide Task Force on Flooding to provide representation for the citizens in the Underwood Creek and Dousman Ditch subwatersheds.
h. The City of Brookfield members of the task force request that the Board of Public Works view the future of the homes identified in the SEWRPC for acquisition as a high priority. The decision making process for the final disposition of these homes should be expedient to reduce the time of uncertainty for the owners.
i. The task force requests that the Board of Public Works be the authority to implement the stormwater and floodland management plans.

The Task Force stressed that the City should focus on the continuing education of the citizens as the plans are implemented and provide educational seminars before spring of 2000.

Jim McGavock moved approval of the nine recommendations, Jack Shaw second the motion. The motion passed by a unanimous vote.

Alderman Garvens moved the meeting be adjourned, second by Jack Shaw, motion carried. 9:35 p.m.

Appendix G

MINUTES OF OCTOBER 13, 1999, PUBLIC INFORMATIONAL MEETING SPONSORED BY THE VILLAGE OF ELM GROVE SUBCOMMITTEE OF THE UNDERWOOD CREEK FLOODING TASK FORCE

ELM GROVE REPRESENTATIVES OF THE UNDERWOOD CREEK TASK FORCE
OCTOBER 13, 1999

Present: Jerry Fellows, James Keyes, James Schwai, Richard Reinders, John Bunce, Paul Freedy and Neil Palmer.

Also present: Mike Hahn - SEWRPC, Mike Campbell - Ruekert & Mielke, Andrea Steen Crawford, Chuck Armao, Senator Farrow, Rep. Duff, Jim Nortman, Susan Freedy, William Eagan, George Haas, Andy Azpell, Tim Clark, Steve and Irene Enrich, Mike and Mary Heuser, Mary Leach, George Boxhorn, John Walker, Bob Biebel - SEWRPC, Gordon and Mary Barrington, Dennis Kaun, John DeCarlo, John Lochacz, Arthur Skalitzky, Pat Ruttum, Janet Wintersberger, Richard Hinchcliff, J. Henkle, Maureen Polczynski, Peggy Lane, Jane Guhl, Dick and Peg Raney, Dick Schlondrop, Ronald Evenson, Kathleen Geralts, Michael Rauh, Linda Mack, Ralph Ward, Joanne Seeger, Barry Martin, Steve Smith -DNR, Mike Bruch - DNR and Sharon Gayan - DNR.

Chairman Fellows called the meeting to order at 7:08 p.m. He introduced the task force, the Village Board, Rep. Mark Duff and Senator Margaret Farrow who were in attendance.

SEWPRC PRESENTATION OF PRELIMINARY DRAFT

Mike Hahn, Principal Engineer with SEWRPC, presented the preliminary plan. He advised that the plan is based on fully developed land use throughout the subwatershed and addresses 1) Water quality management, 2) Stormwater drainage and 3) Floodland management. The plan includes three storage components:

- Dousman ditch
- North Avenue and Lilly Road
- Village Park

The proposed overflow channel and underground box culvert system which nearly parallels the creek through the Village were discussed.

Public Comment on Issues of Feasibility and Implementation of the Plan

Joe Henika, 15375 Cascade Drive, spoke about the increase in the floodwater due to development. He felt that the plan would be effective in addressing flood concerns through detention.

Dick Raney, 13455 Marquette Avenue, questioned whether assessed value of properties reflects fair market value before or after the 1998 flood. He suggested streamlining the creek and general clean up. He asked about implementation of the plan. Mr. Palmer noted the significant efforts by the DPW to keep the creek clear from debris. He then outlined the timetable for implementation including permitting/approvals: 9-24 plus months and engineering design: 24 plus months. Palmer noted that some plan elements have been implemented already. Representative Marc Duff noted that the state budget is awaiting the Governor's signature. The budget proposes $18 million in flood abatement grants, which could provide up to $3.6 million per community. Additional grants may be available for the water quality components of the plan. Senator Farrow advocated a regional concept. Dennis Kaun, 1780 Wedgewood West, expressed frustration over the regulatory timetable. Mike Rauh, 840 Terrace Drive questioned the proposed cost split and runoff from future development. Mike Hahn explained the proposed cost allocation assigns full costs of the stormwater plan to the community in which the improvements are made. The flood control and water quality components are proposed to be split 60%. Elm Grove and 40% Brookfield. Hahn noted that the plan is based on a full development land use plan. The plan is designed to hold the line on waters leaving the subwatertshed.

Peggy Raney asked about the berm and whether it could be relocated to protect homes on Legion Drive if it were on the east side of the creek. Mr. Hahn explained that there is no impact from the berm beyond a 2 year storm and that storm event does not produce flooding of structures. Dick Raney and Mike Rauh expressed frustration over increased asphalt areas at Dick Manhardt's and Becker Ritter funeral home.

Mike Bruch of DNR described the application review process that will be followed. Mr. Palmer noted that the taskforce considered a dredging/channelization proposal but felt that there was very low probability of regulatory approval. Additionally such a plan would have had adverse downstream impacts.

Joanne Seeger, 13400 Elmhurst Parkway asked whether developers have to comply with the same DNR rules noting that Fleming Company easily obtained a permit to reconstruct the box culvert. Mr. Palmer noted the simplified permit process for maintenance work like the Fleming Company project.

Marna Rauh, 840 Terrace Drive asked why it takes so long to get a permit to dredge. She noted that the meander of the creek slows down flow. Joe Henika cautioned against shifting the problem to Wauwatosa. Pat Ruttum asked about the characteristics of the overflow channel. She noted that the proposed detention areas are not permanently wet. Linda Mack asked whether trees would be removed and a degradation of the neighborhood aesthetics and spoke against the sewer bypass proposals.

Taskforce Member John Schlosser responded that some trees would need to be removed for the overflow channel, but that the area would be open and without degrading the neighborhood. He described how the channel would convey waters above the ten year storm event and provide a level of protection for the neighborhood. The Village Manager reported details of the sewer bypass design. She noted that the pumps would discharge to a force main connected to the interceptor. An overflow valve at the connection of the force main to the interceptor would allow direct discharge into the creek for maximum dilution in the event that the interceptor is surcharged. Ms. Steen Crawford noted that no sewage would be pumped into open ditches. Mr. Campbell noted that a telemetry system is part of the plan for the sewer bypass pumps to monitor discharge levels.

Barry Martin, 13450 Elmhurst Parkway, felt that the plan is a local solution, not a regional one. He asked how to quantify the results of the Village's efforts to date. Mr. Campbell noted MMSD gauges on the interceptor and the proposed telemetry for the bypass pumps. Campbell noted that a flow monitoring gauge could be installed in the creek at North Avenue to measure the flow into the Village. Mr. Palmer noted the work of Village staff with WEPCO and the Village's monitoring of electrical feeder outages. Mr. Hahn noted the integration of the plan with rest of the Menomonee River watershed including areas where MMSD has jurisdiction.

Mr. Barrington asked whether the plan would give protection for the 1998 event. Mr. Hahn noted that the plan provides protection from a 100-year storm, not the 10" rainfall of the 1998 event which equated to a 350-year event. A question was asked if Brookfield's participation is needed for implementation.

Dr. DeCarlo, 13955 Underwood River Pkwy asked why wetlands would be converted to a grass lined channel. Dick Raney asked what recourse a down stream community has from increased flows and can we shut down development upstream. Joanne Seeger urged pressure for a shortened regulatory review period. Palmer noted that our state elected officials will help to expedite the process and noted that DNR and MMSD have been involved in this planning process. Dick Reinders noted the 1970's flood control plan was voted down by the Elm Grove citizenry. He urged promotion of a new plan to the citizens of Elm Grove.

Mr. Keyes and Mr. Schlosser moved and second to recommend the plan to the Village Board. The motion carried by unanimous vote.

Respectfully submitted,

Andrea Steen Crawford

Andrea Steen Crawford
Village Manager

Appendix H

WISCONSIN DEPARTMENT OF NATURAL RESOURCES REVIEW OF THE PRELIMINARY DRAFT PLAN AND REGIONAL PLANNING COMMISSION STAFF RESPONSE

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
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TDD 414-263-8713

RECEIVED
DEC 27 1999
SEWRPC

December 20, 1999

File Ref: 3500

Ms. Andrea Steen Crawford, Manager
Village of Elm Grove
13600 Juneau Blvd.
Elm Grove, WI 53122-0906

Subject: Draft Stormwater and Flood Management Plan for Dousman Ditch and Underwood Creek Subwatersheds

Dear Ms. Crawford:

This letter provides the Department of Natural Resources' general response to the draft Stormwater and Flood Management Plan for the Dousman Ditch and Underwood Creek Subwatersheds (Plan) prepared by the Southeastern Wisconsin Regional Planning Commission (SEWRPC). Thank you for allowing us the opportunity to comment on the Plan during this early phase of the process.

Our comments are based on a preliminary review of the major concepts of the Plan and the alternative, "Limited Dousman Ditch Detention Storage, Underwood Creek Overflow Channel and Diversion, and Compensating Storage, with Structure Floodproofing and Removal" (Alternative 11). Due to the complexity and scope of the flooding and water quality issues addressed, evaluation of the details of the Plan is a significant undertaking. However, the Department did not evaluate the Plan on it's individual merit. Rather this preliminary review was conducted in the broader context of how this alternative will interact with other Watercourse Studies and Flood Control Plans in the Menomonee River Watershed being carried out by the Milwaukee Metropolitan Sewerage District. Ultimately, our evaluation will require a significant investment of time and resources. Our initial response is restricted to the basic tenets of the Plan and the recommended alternative. Please consider the following comments prior to finalizing the selection of an alternative, contracting with an engineering or consulting firm or applying for permits.

The recommended alternative involves no in-channel work on Underwood Creek and we commend the Village of Elm Grove for this environmentally sensitive approach. However, Alternative 11 relies on a project involving significant wetland disturbance. Clearly, the most extensive wetland impacts would be those associated with the overflow channel. Over half of the proposed 4,100 foot channel would bisect shoreland-wetlands along Underwood Creek. The systems-planning approach used to develop this alternative does not allow a precise estimate of the wetland disturbance associated with the overflow channel. Based on the channel dimensions reported in the Plan, the proposed excavated area for the new channel will disturb between 2.7 and 22 acres of wetlands. Even at the lowest end of this range, a 2.7 acre wetland disturbance is significant. In addition, an even larger area of the wetlands is likely to be affected by indirect impacts associated with the construction of the overflow channel.

The Plan indicates that the flood water storage function of wetlands will be enhanced, but it does not include any evaluation of how the overflow channel will impact the other vital functions performed by these wetlands. In addition to basic flood storage capacity, a thorough and comprehensive evaluation of the effects on all the other functional values of these wetlands will be required. Further consideration must also be given to the project because a species included on the State's Natural Heritage List with a Special Concern status has been observed in the proposed project area.

The Plan mentions, but does not provide a clear representation, the Alternatives Analysis that will be required under the Administrative Code Chapter NR103 Water Quality Standards for Wetlands. Chapter NR 103 requires that all projects meet a standard, which states that there are no practicable alternatives to avoiding impacts to wetlands. To meet this standard, project designs that can avoid/minimize wetland impacts must be presented and compared through an Alternatives Analysis procedure. The outcome of the process may not be the ideal project design desired by the applicant. However, the Chapter NR103 Alternatives Analysis process has been used to successfully protect the wetlands of the State of Wisconsin since it's inception in 1991. We have concluded that substantial information will be needed regarding the presented alternatives.

All alternatives which can fulfill the basic project purpose of flood control while avoiding or minimizing wetland impacts will have to be explored in greater detail before this project moves forward. The Southeastern Wisconsin Regional Planning Commission may want to expand the Plan to include an analysis for the Chapter NR103 process. The Department can only consider permitting wetland impacts if the "no practicable alternatives" test is met. If wetland impacts cannot be avoided, the project design must be evaluated with the goal of minimizing these impacts. Again, this is considered only after all alternatives and project minimization is exhausted. If no practicable alternative for this project exists but it is determined that the project would result in a significant adverse impact to wetlands, the Department will be unable to authorize or issue permits for the project.

Many of the activities associated with the implementation of the Plan will potentially require Chapter 30 Waterway and Wetland Permits. Wetland impacts not covered under Chapter 30 may require permitting by the U.S. Army Corps of Engineers. The federal permits issued by the U.S. Army Corps of Engineers are not valid until the State grants Water Quality Certification under authority embodied in Section 401 of the Federal Clean Water Act. In summary, the Chapter NR103 Alternatives Analysis will be required for all jurisdictional wetlands impacted by proposed construction activities, whether the Department's authority arises from Chapter 30 or the Section 401 Water Quality Certification process.

Chapter 30 Permits will likely be required for grading in excess of 10,000 square feet (on the unbroken slope), outfall structures, culverts, ponds and the overflow channel depending upon the final design and proximity to navigable waters. The Chapter 30 application for the overflow channel, culverts, ponds, and outfall structures will require a hydraulic and hydrologic analysis, sediment analyses, erosion control plans and spoils management plans. The overflow channel as it is currently proposed will require an Environmental Assessment and a thirty-day public notice and comment period. Any phase of the project causing a disturbance of 5 acres or more will also require a Chapter NR216 Construction Site Erosion Control Permit.

At present, the Plan does not adequately address the issue of the hydraulic and hydrologic effects the overflow channel may have in downstream areas. The potential effects at the confluence of the overflow channel and Underwood Creek are of particular concern. The hydraulic and hydrologic effects of the recommended alternative will have to be demonstrated to comply with all requirements contained in Chapter NR116 (Wisconsin's Floodplain Management Program) before any permits can be issued. During the course of our review we noted that the continuous simulation hydrologic model for the recommended alternative had been revised to simulate the period of stream flow from 1940 to 1997, while the model, as applied to the other ten alternatives included streamflows through 1988. The Department will seek assurance that this difference in the modeling does not impair the validity of comparisons between the eleven alternatives addressed by the Plan.

The Plan was developed within a specific framework to meet the planning needs of the Village of Elm Grove and the City of Brookfield. Within the Implementation section of the Plan, SEWRPC suggests that an important first step is to seek the Department's endorsement of the Plan. As previously discussed, this letter serves to provide our comments during this preliminary phase of the project. These comments do not constitute an endorsement of the plan, but rather provide a framework within which future Water Regulation and Zoning permitting decisions can be assessed.

The Stormwater and Flood Management Plan for the Dousman Ditch and Underwood Creek Subwatersheds (draft) provides a foundation for refining, evaluating and ultimately selecting an alternative. The elements of all eleven alternatives provide an excellent basis for developing a direction for the future to mitigate flooding problems in this area. We believe the plan should be used as an informational and analytical tool to develop a practical approach that mitigates flooding and minimizes the adverse environmental impacts to wetlands.

Clearly, the permitting requirements for a project of this magnitude are extensive, the Department is prepared to assist the Village throughout the application and review process regardless of the final project design. The public has the opportunity to comment on the design during the permitting process.

The Department will continue to work closely with the Village of Elm Grove and SEWRPC to achieve the most beneficial outcome in developing a practical direction for the Underwood Creek Subwatershed. We would like to schedule a meeting with you during the last week in January to discuss the next steps in this process. Karen Van Atta will contact you to arrange a meeting time and place. The Department is committed to working with the Village of Elm Grove in partnership to address the flood control concerns on Underwood Creek on an accelerated basis.

If you have any other questions or concerns please feel free to contact me at (414) 263-8707.

Sincerely,

Sharon L. Gayan

Sharon L. Gayan
Milwaukee River Basin Water Leader

c. Charles Krohn, Southeast Region Water Team Leader
Gloria McCutcheon, Southeast Regional Director
Greg Pilarski, Southeast Fox River Basin Team Leader
MMSD, Kevin Shafer
SEWRPC, Phil Evenson
WDNR/ Will Wawrzyn, Mike Bruch, Greg Breese

COPY

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January 5, 2000

Ms. Sharon L. Gayan
Milwaukee River Basin Water Leader
Southeast Region Water Program
Wisconsin Department of Natural
Resources, Southeast Region
2300 N. Dr. Martin Luther King, Jr. Drive
P.O. Box 12436
Milwaukee, WI 53212-0436

Dear Ms. Gayan:

We are writing in response to your December 20, 1999, letter to Ms. Andrea Steen Crawford, Elm Grove Village Manager, in which you provided Department comments on the August 1999 preliminary draft of SEWRPC Community Assistance Planning Report No. 236, *A Stormwater and Floodland Management Plan for the Dousman Ditch and Underwood Creek Subwatersheds in the City of Brookfield and the Village of Elm Grove, Waukesha County, Wisconsin*. We appreciate the efforts of you and your staff in reviewing the plan.

Your review was primarily directed toward a portion of the recommended floodland management plan element; however, as you are aware, the plan also recommends comprehensive solutions to stormwater management problems throughout the study area and includes other floodland management components in the City of Brookfield. You note that your review was conducted in the broader context of the watercourse system plan that the Milwaukee Metropolitan Sewerage District (MMSD) is preparing for the Menomonee River watershed, but, with the exception of your comment regarding potential downstream impacts of plan implementation, none of your comments relates to issues connected with the MMSD watercourse system plan. We coordinated our planning efforts with those of the MMSD. However, the recommended floodland management plan is designed to be independent of the MMSD plan in that the facilities needed to ensure that flood flows and stages would not increase along Underwood Creek downstream of the Village of Elm Grove are provided in Brookfield and Elm Grove. Thus, the recommended plan may be implemented independently of any projects recommended under the MMSD plan.

The main emphasis of your comments is on the potential impacts to wetlands of implementing the recommended floodland management plan element. You note that the Department will need to expend significant time and resources in the future as the project is reviewed under the permitting process relative to either Chapter 30 of the *Wisconsin Statutes* or Section 401 of the Federal Clean Water Act, and that State water quality certification will be required for activities in jurisdictional wetlands under Chapter NR 103 of the *Wisconsin Administrative Code*. The plan report specifically recognizes those regulatory issues and instructs the City and the Village to seek legal counsel prior to proceeding with any activities that may require permits.

You suggest that the Commission may want to include practicable alternatives analyses for use in the Chapter NR 103 process. The report presents a comprehensive analysis of stormwater and floodland management alternatives which consider potential wetland impacts in the evaluation process. In the past when wetland alternatives analyses have been provided at the system planning stage, the Department has deferred consideration of the wetland aspects of projects until the permitting phase which generally coincides with the detailed project design process. Thus, we believe that expanded Chapter NR 103 alternatives analyses would be most effectively conducted under the detailed design and implementation phases of the project.

We are puzzled by your comment that "the plan does not adequately address the issue of the hydraulic and hydrologic effects the overflow channel may have in downstream areas." Those effects are specifically quantified in the preliminary draft report. The "Recommended Floodland Management Plan" section of Chapter VI includes quantification of the reductions in the 100-year recurrence interval flood stage that would be anticipated in the Village of Elm Grove and the City of Brookfield due to implementation of the recommended plan. It also states that the provision of floodwater storage in Brookfield and Elm Grove "would avoid 100-year flood flow and stage increases in the City of Wauwatosa downstream of the Village of Elm Grove." To further clarify the issue regarding downstream flows and stages, that statement will be expanded in the final report to recognize that there would be no increase in downstream flood flows or stages during floods with recurrence intervals ranging from two through 100 years. A comparison of 100-year flood flows under existing and recommended conditions is set forth in Table VI-6 of the draft report. That comparison, which is based on flood quantiles developed from simulation of streamflow for the period from 1940 through 1997, clearly demonstrates that flood flows along the entire length of Underwood Creek would remain the same, or be reduced, under recommended plan conditions.

We agree with your statement that "the hydrologic and hydraulic effects of the recommended alternative will have to be demonstrated to comply with all requirements contained in Chapter NR 116 (Wisconsin's Floodplain Management Program)." Such compliance was a guiding standard that was conscientiously applied throughout the planning process and the recommended plan meets that standard. In order to formally recognize the application of that standard, Table III-1 of the report will be revised to include a standard under Objective No. 1 that states:

> "Plan components shall be designed to comply with the requirements of Chapter NR 116 of the Wisconsin Administrative Code."

You note that the recommended floodland management plan was analyzed using flood quantiles developed from simulation of streamflow for the period from 1940 through 1997, while flows used for development of the other floodland management alternatives were based on a simulation period from 1940 through 1988. The 100-year flood flows determined from simulation of the longer period of record changed by less than 10 percent relative to those using the period from 1940 through 1988. In the reaches of potential significant flood damage, the difference in peak flows was only between 5 and 6 percent. The relatively small changes in flood flows due to application of the two periods of record have no significant effect on the comparison of alternative floodland management plans, since very similar hydrologic and hydraulic conditions were used to evaluate all alternatives.

Your letter expresses concern about potential hydraulic and hydrologic effects at the confluence of the overflow channel and Underwood Creek. In the absence of further explanation of what effects may be of concern, we cannot respond to this comment.

When the various component projects of the recommended plan are scheduled for implementation and the communities begin the permitting process, we will be pleased to provide the Department the hydrologic and hydraulic models developed under the plan.

Thank you for your efforts in assisting with the preparation of the plan, in reviewing the preliminary draft plan report, and in offering your assistance and cooperation in implementing solutions to the significant flooding and stormwater management problems identified under the plan. We appreciate the opportunity to participate in the coordination meeting that the Department plans to schedule near the end of January 2000.

Sincerely,

Philip C. Evenson
Executive Director

PCE/MGH/pk
#9524 V1 - UCDDDNRREVIEWRESPONSE

cc: Ms. Andrea Steen Crawford, Village of Elm Grove
Mr. Dean R. Marquardt, City of Brookfield
Mr. Thomas M. Grisa, City of Brookfield
Ms. Susan L. Baldwin, Milwaukee County Department of Parks, Recreation and Culture
Mr. Kevin L. Shafer, MMSD
Mr. Michael F. Campbell, Ruekert & Mielke, Inc.

Appendix I

EVALUATION OF DOWNSTREAM EFFECTS OF PLAN IMPLEMENTATION AS REQUESTED BY THE CITY OF WAUWATOSA

COPY

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December 22, 1999

Mr. Charles Armao
Director of Public Works
Village of Elm Grove
Village Hall
13600 Juneau Boulevard
Elm Grove, WI 53122-0906

Dear Mr. Armao:

We are writing to provide an evaluation of issues related to the potential downstream effects of implementing the recommended plan set forth in the August 1999 preliminary draft of SEWRPC Community Assistance Planning Report No. 236 (CAPR No. 236), *A Stormwater And Floodland Management Plan for the Dousman Ditch and Underwood Creek Subwatersheds in the City Of Brookfield and the Village of Elm Grove.* This evaluation was requested at an October 11, 1999 intergovernmental meeting attended by you; Mr. S. Howard Young, the Administrator of the City of Wauwatosa Engineering and Operations Department; Mr. Michael F. Campbell, of Ruekert & Mielke, Inc., the Village engineer; and Mr. Michael G. Hahn, of the Commission staff. It is our understanding that Mr. Young will consider pursuing endorsement of the plan by the Wauwatosa City Council and that the Village will provide this evaluation to him in support of that endorsement.

The hydrologic modeling conducted for the floodland management element of the study indicates that the provision of additional floodwater storage volume as called for under the recommended floodland management plan would limit the two- through 100-year flood flows and stages to existing levels in the City of Wauwatosa. Extrapolation beyond the 100 year recurrence interval is somewhat speculative, since flood recurrence intervals were estimated based on simulation of a 58-year period of record. However, if such an extrapolation is made, the modeling results also show that for floods with recurrence intervals up to, and including, 500 years, flood flows and stages would not be expected to increase in areas of potential structure flooding in the City of Wauwatosa.

During the October meeting, Mr. Young inquired about the impact on the City of Wauwatosa of a hypothetical very large storm which would be spatially limited to the 1.9-square-mile portion of the Underwood Creek subwatershed downstream of the recommended floodwater storage areas. The area downstream of the floodwater storage sites represents only about 20 percent of the total area in the City of Brookfield and the Village of Elm Grove that is tributary to Underwood Creek at the Milwaukee-Waukesha County line. Even if an extreme event such as the August 6, 1998 storm, which produced peak rainfall amounts in the Underwood Creek subwatershed that were two to three times the 100-year amount, were to occur over the 1.9-square-mile downstream area in Elm Grove, it would not be expected to result in peak flood flows, volumes, and stages in Wauwatosa that exceed the 100-year peak flow under existing conditions. That conclusion is based on the following factors:

1) Because the land cover in the 1.9-square-mile area is similar to that of the watershed as a whole, the tributary area over which the heavy rain would fall is about one-fifth of the subwatershed area, and the volume of rainfall would be only two to three times the 100-year

storm volume for the same duration, the total volume of runoff from the extreme storm would be less than the volume of runoff from a 100-year storm occurring over the entire subwatershed.

2) Most of the runoff from the subject area would be conveyed to the existing Underwood Creek stream channel, rather than the recommended double box culvert; thus, available floodplain storage volume would be utilized to reduce peak flood flows.

3) Simulation of historical flood flows indicates that, during large, rainfall-generated floods, peak flows occur at about the same time in Underwood Creek at the Milwaukee-Waukesha County line and in the South Branch of Underwood Creek, which joins Underwood Creek just east of the County line. If the heavy rainfall were concentrated in the area tributary to the lower reach of Underwood Creek in the Village of Elm Grove, it would be expected that the peak flow would occur at an earlier time than it would for storms occurring over the entire area tributary to the Creek at the County line. Thus, it would be expected that the individual flood peaks from Underwood Creek and the South Branch would be more offset in time and the resultant combined peak in the City of Wauwatosa would be lower than if significant runoff were occurring throughout the Underwood Creek subwatershed upstream of the County line.

The stormwater and floodland management plan has been reviewed by the Milwaukee Metropolitan Sewerage District and it is our understanding that the District concurs with the conclusion that implementation of the recommended plan would not be expected to increase flood flows and stages downstream of the Village of Elm Grove.

It should also be noted that the detailed design of facilities in the City of Brookfield and the Village of Elm Grove will also apply the objective of the system plan that there should be no increases in downstream flows or stages. This should ensure that the project will not negatively impact flooding in the City of Wauwatosa.

In light of the above, we reiterate our conclusion that implementation of the preliminary recommended stormwater and floodland management plan would not increase downstream flood flows and stages along Underwood Creek or the Menomonee River in the City of Wauwatosa over a range of floods with recurrence intervals up to, and beyond 100 years.

Should you have any questions or comments regarding this issue, please contact Mr. Hahn directly.

Sincerely,

Philip C. Evenson
Executive Director

PCE/MGH/mlh
cc: Mr. S. Howard Young, City of Wauwatosa
Mr. Michael F. Campbell, Ruekert & Mielke, Inc.
Mr. Michael J. Bruch, Jr., WDNR-Southeast Region
Mr. Kevin Shafer, MMSD
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Appendix J

ELM GROVE VILLAGE BOARD RESOLUTION OF ADOPTION

VILLAGE OF ELM GROVE
RESOLUTION #000313

ADOPTING THE PRELIMINARY DRAFT SOUTHEASTERN WISCONSIN REGIONAL PLANNING COMMISSION COMMUNITY ASSISTANCE PLANNING REPORT NO. 236 FOR THE DOUSMAN DITCH AND UNDERWOOD CREEK SUBWATERSHED IN THE CITY OF BROOKFIELD AND THE VILLAGE OF ELM GROVE WAUKESHA COUNTY, WISCONSIN

WHEREAS, the Village of Elm Grove seeks to adopt a set of objectives and supporting standards to guide the development of an effective stormwater and floodland management system; and

WHEREAS, stormwater and floodland management is best accomplished on a watershed and subwatershed basis instead of along strict municipal boundaries; and

WHEREAS, the City of Brookfield and the Village of Elm Grove appointed a joint Taskforce to study flooding and stormwater management within the Underwood Creek and Dousman Ditch watersheds; and

WHEREAS, the Village of Elm Grove is required by Wisconsin Administrative Code NR 216 to obtain a stormwater discharge permit which is conditioned upon the adoption of a stormwater management plan; and

WHEREAS, the adoption of the Stormwater and Floodland Management Plan will qualify the Village to apply for grant funding for projects consistent with the plan; and

WHEREAS, adoption of the Stormwater and Floodland Management Plan does not in any way obligate the Village to fund all or any of the individual improvements proposed in the plan; and

WHEREAS, it is acknowledged that the Stormwater and Floodland Management Plan is a preliminary draft format and therefore subject to change and modifications; and

WHEREAS, suggestions for additional plan modifications have already been made by the Village of Elm Grove representatives to the Underwood Creek Taskforce which are currently being analyzed by SEWRPC; and

WHEREAS, the Village of Elm Grove representatives to the Underwood Creek Taskforce have unanimously and enthusiastically recommended adoption of the preliminary plan as presented; and

NOW THEREFORE BE IT RESOLVED by the Board of Trustees of the Village of Elm Grove that the Southeastern Wisconsin Regional Planning Commission Community Assistance Planning Report No. 236 be formally adopted as the preliminary draft, Stormwater and Floodland Management Plan for the Dousman Ditch and Underwood Creek Subwatersheds in the City of Brookfield and the Village of Elm Grove.

Adopted this _____ day of March, 2000.

VILLAGE OF ELM GROVE
ELM GROVE, WISCONSIN

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James W. Nortman, Village President

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Mary S. Stredni, Village Clerk

Appendix K

ESTABLISHMENT OF A STORMWATER UTILITY

The purpose of a stormwater utility is to administer a stormwater management program; to fund the capital costs of upgrading existing stormwater management system where necessary; to fund the local portion of the public sector capital cost for stormwater management facilities in areas of new development; and to fund operation and maintenance costs of all facilities for which the public sector is responsible. Section 66.076 of the State of Wisconsin Statutes was amended in December of 1997 to give municipalities the power to impose "service charges for a stormwater and surface water sewerage system." A stormwater utility could be used to impose such charges. Prior to establishment of a utility, it is recommended that a stormwater management system plan be in place to identify stormwater management priorities and to provide the framework for administration of an effective stormwater management program.

The main source of revenues to the utility would be user charges for properties within the geographic boundaries of the utility. Such user charges provide an equitable and dependable means of financing a stormwater management program. The utility could be structured along the lines of an urban drainage district, with its boundaries extending across civil divisions, giving the utility authority over all stormwater management facilities in a subwatershed. Administration of a utility including parts of several civil divisions would require considerable coordination between local units of government and the utility to avoid conflicts between the functions of the utility and the historic functions of the local governments. For a given year, funding requirements for upgrading and maintenance of the existing stormwater management system would be determined based on the capital project prioritization developed for the stormwater management system plan along with anticipated annual system maintenance costs. Annual funding for new developments could be covered by fees charged to developers to cover the cost of specific new stormwater management facilities, or the developer could be required to design and pay for stormwater management facilities as a condition of plat approval. If a new development were to contribute runoff to an existing or planned centralized detention facility which would also serve other new or existing development, the developer of the new subdivision would also be required to pay a fee to the utility commensurate with the runoff contribution of the new subdivision to the detention facility. Where such centralized detention facilities are located to receive runoff from several existing or proposed properties, it may be necessary for the utility to issue bonds to finance the construction of the facility and then recover the portion of the cost attributable to new development, including operation and maintenance and debt service, through fees charged to developers. Following construction of the stormwater management system for a new development, the occupants of the development would be charged an annual user fee as for all other existing development.

The most equitable means of establishing the proportional user charge for a given property is to base the charge on the amount of uncontrolled runoff from the property. In areas of the country where stormwater utilities have been established, the most common indicator of runoff contributed is the percentage of impervious area of a given parcel of land. Although other factors, such as land slope, would also affect the rate of runoff, the amount of impervious area is the main factor in determining the volume of runoff. Various methods of classifying properties according to percent impervious area have been utilized, including the use of land zoning classes and the application of typical imperviousness ratios by land use based on measurements made from aerial photos or in the field. The main criterion in selecting a method for establishing the proportional user charge is to maintain equitability without making the method overly cumbersome and costly for the utility to apply. Methods using readily available information such as zoning classifications meet that criterion reasonably well.

To further standardize the rate classifications, some utilities establish a base residential rate, expressed as one equivalent service unit (ESU), or one equivalent residential unit (ERU).[1] Nonresidential properties or higher-density residential properties are then charged a multiple of ESUs based on their greater overall area and higher proportion of impervious area.

Once the proportional rate structure has been established, the monthly charge for each property classification, or the charge per ESU, must be established by balancing the annual stormwater management needs for capital and maintenance expenditures against the inclination and ability of the affected property owners to pay. Experience has shown that an extensive public information program explaining the need for stormwater management and the advantages of a stormwater utility is essential to the success of a utility. This is especially important for a stormwater utility because the need for proper stormwater management facilities, which function only during periods of runoff from rainfall or snowmelt, is less apparent to users than the need for sanitary sewer and water services, which are used daily. Accordingly, it has been found that most users will accept a stormwater utility charge of from one-half to one-third the charge for sanitary sewer and water services.[2]

It has been found that the establishment of the administrative framework for a stormwater utility, along with the development of public acceptance of such a utility, can take several years. It may be desirable to initially set modest goals of funding annual operation and maintenance, along with the highest priority capital projects, and deferring other capital projects until the effectiveness of the stormwater management utility has been demonstrated to the public. Once the utility is established, it may be possible to issue revenue bonds supported by the proceeds from user charges.[3] The proceeds from those bonds could then be used to finance needed capital projects.

The main advantages of the establishment of a stormwater utility for administration and financing of stormwater management projects are that the application of user fees would distribute the costs of the projects equitably among those receiving services; collection of fees from developers and users would establish a dependable revenue source to meet stormwater management needs; and establishment of utility district boundaries across civil divisions would enable control of stormwater management facilities on a systemwide basis, consistent with a stormwater management plan.

The main disadvantages of the establishment of a stormwater utility for both administration and financing are that administration of a stormwater management program through a stormwater utility may duplicate an existing administrative and review function already performed satisfactorily by local staff and commissions; the time required to establish the utility could delay implementation of the stormwater management plan; while the establishment of utility district boundaries across civil divisions enables systemwide control of stormwater management facilities by the utility, such extension of control may be resisted by local units of government; and tax exempt properties may resist the imposition of stormwater fees.

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[1] *Hector J. Cyre, "Developing a Stormwater Management Utility,"* APWA Reporter, *March 1987*

[2] Ibid.

[3] *American Public Works Association,* Urban Stormwater Management Report

Appendix L

FLOOD HAZARD MITIGATION FUNDING SOURCES

As noted in Chapter VII of this report, there are several options available to the City of Brookfield and the Village of Elm Grove for financing a local floodland management program. The identification of potential funding sources, including sources other than solely local-level sources, is an integral part of the implementation of a successful plan. The following description of funding sources includes those that appear to be potentially applicable as of early in the year 2000. However, funding programs and opportunities are constantly changing. Accordingly, the involved local staff have and will continue to become familiar with the potential funding sources and programs that may be utilized as such sources and programs become available. It is intended that this list facilitate the implementation of the recommended floodland management activities set forth in this report. Some of the programs described herein may not be available under all envisioned conditions to the City and Village or to their residents and/or property owners for a variety of reasons, including, for example, eligibility requirements or lack of funds at a given time in Federal and/or State budgets. Nonetheless, the list of sources and programs should provide a starting point for identifying possible funding sources for implementing the flood mitigation plan recommended in this report.

FEDERAL EMERGENCY MANAGEMENT AGENCY PROGRAMS

The Federal Emergency Management Agency (FEMA) funds the Hazard Mitigation Grant, Flood Mitigation Assistance, and Public Assistance Programs. In the State of Wisconsin the programs are administered through the Wisconsin Department of Military Affairs, Division of Emergency Management. The Community Rating System is a FEMA program directed towards improving management of floodlands. These programs are described below.

Hazard Mitigation Grant Program

The Hazard Mitigation Grant Program (HMGP) can provide up to 75 percent of the costs attendant to the floodproofing or acquisition and relocation of flood-prone properties, or to the elevation of structures in compliance with National Flood Insurance Program (NFIP) standards. Under the HMGP, the balance of the costs is shared by the State of Wisconsin (12.5 percent) and the grantee (12.5 percent). Communities in Wisconsin can apply through the State for HMGP funds only after a Presidential disaster declaration is issued for the area involved. HMGP funds must be applied for within 60 days of the declaration. The State, as HMGP grantee, is responsible for identifying and prioritizing projects. Eligible projects must be included as part of the grantee's flood mitigation plan and must meet cost-benefit criteria established by FEMA. Although State and local units of government are eligible applicants, HMGP funds can be provided to individuals for eligible projects. The HMGP gives priority to properties identified by FEMA as repetitive-loss properties.

Flood Mitigation Assistance Program

The Flood Mitigation Assistance (FMA) program can potentially provide up to 75 percent of the costs attendant to the acquisition, relocation, elevation, or floodproofing of structures insured under the NFIP. In addition to participating in the NFIP, eligible program applicants must meet cost-benefit criteria established by FEMA. The City of Brookfield and Village of Elm Grove are eligible to apply for flood mitigation funding under the FMA program, but under recent indications, it appears that the amount of funding available under this program has been relatively small.

Public Assistance Program

FEMA's Public Assistance Program can provide some limited assistance with respect to structure elevation and relocation. For example, if entire portions of a community were to be relocated outside of a floodplain, this program can assist in rebuilding the necessary infrastructure in the new location. Funding under this program is provided for repair of infrastructure damaged during a flood that results in a Presidential disaster declaration. If a community determines that a badly damaged facility is not to be repaired, the estimated damage amount may be used to fund hazard mitigation measures.

Community Rating System

Discounts may be obtained on Federal flood insurance premiums depending on community activities relative to public information, mapping and regulations, flood damage reduction, and flood preparedness.

U.S. ARMY CORPS OF ENGINEERS

The following Corps of Engineers programs are potential sources of funding for implementing the floodland management recommendations of this plan; however, the plan components may not meet Corps economic feasibility criteria.

- Section 22—Water resources planning assistance—50 percent Federal, 50 percent local cost share
- Section 205—Small flood control projects—Maximum $5 million per project. 75 percent Federal, 25 percent local cost share
- Section 208—Clearing debris and sediment from channels for flood prevention—Maximum $500,000 per project. 75 percent Federal, 25 percent local cost share
- Section 14—Emergency streambank and shoreline protection—Maximum $500,000 per project. 75 percent Federal, 25 percent local cost share

U.S. DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT COMMUNITY DEVELOPMENT BLOCK GRANT PROGRAM

Under the Community Development Block Grant (CDBG) program, funded by the U.S. Department of Housing and Urban Development, funds are provided to areas for which a Presidential disaster declaration has been issued. Funds obtained under this program may be used to address long-term needs as well as emergency response activities. In Waukesha County, CDBG grants are provided by the Federal government to the County.

U.S. SMALL BUSINESS ADMINISTRATION PROGRAMS

The U.S. Small Business Administration (SBA) provides disaster loans to homeowners and businesses to repair or replace property damaged in a declared disaster. SBA loans are granted only for uninsured losses. Loans may be used to meet required building codes, such as the NFIP requirements. SBA may also provide loans for involuntary relocations out of special flood hazard areas when such locations are required by local officials. While SBA's enabling legislation generally prohibits the agency from making disaster loans for voluntary relocations, there are exceptions that can be made, including relocations of homeowners, renters, and business owners out of a special flood hazard area. These loans would be limited to the amount necessary to repair or replace the damage at the disaster site. SBA loans may also be used to refinance existing mortgages.

WISCONSIN DEPARTMENT OF NATURAL RESOURCES PROGRAMS

The Wisconsin Department of Natural Resources (WDNR) operates two programs that may serve as potential funding sources for the City and Village floodland management efforts. These programs are described below.

Stewardship Grant Program

The administrative rules for the State of Wisconsin Stewardship Grant Program are set forth in Chapters NR 50 and 51 of the *Wisconsin Administrative Code*. The WDNR's Urban Green Space (UGS) program which is a component of the Stewardship Grant Program provides 50 percent matching grants to cities, villages, towns, counties, public inland lake protection and rehabilitation districts, and qualified nonprofit conservation organizations for the acquisition of land. The intent of the program is to provide natural open space within or near urban areas and protect scenic or ecological features. The City and Village are eligible to apply for grants under the UGS program. Funding for streambank protection projects may also be available through the Stewardship program.

Urban Rivers Grants Program

The WDNR's Urban Rivers Grants Program (URGP) provides 50 percent matching grants to municipalities to acquire land, or rights to land, on or adjacent to rivers that flow through urban areas, in order to preserve or restore urban rivers or riverfronts for the purposes of economic revitalization and the encouragement of outdoor recreational activities. The City and Village are eligible to apply for grants under the URGP.