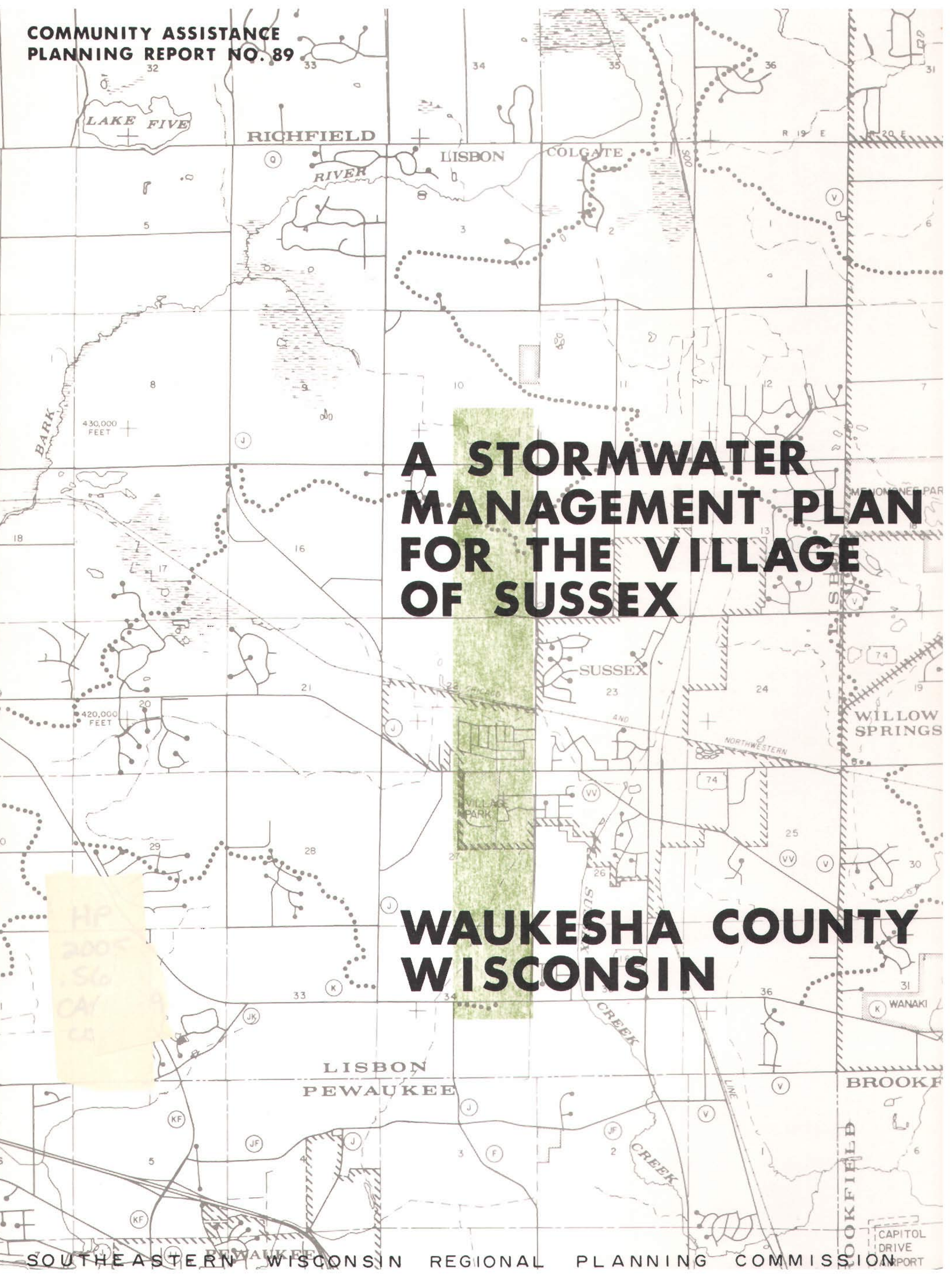
COMMUNITY ASSISTANCE
PLANNING REPORT NO. 89

A STORMWATER MANAGEMENT PLAN FOR THE VILLAGE OF SUSSEX

WAUKESHA COUNTY WISCONSIN



SOUTHEASTERN WISCONSIN REGIONAL PLANNING COMMISSION

Special acknowledgement is due former Village Administrator William R. Ross and Mr. Joseph E. Stuber, SEWRPC Senior Engineer, for their contribution to this report.

COMMUNITY ASSISTANCE PLANNING REPORT
NUMBER 89

A STORMWATER MANAGEMENT PLAN FOR THE VILLAGE OF SUSSEX

Village of Sussex
Waukesha County, Wisconsin

Prepared by the
Southeastern Wisconsin Regional Planning Commission
P. O. Box 769
Old Courthouse Building
916 N. East Avenue
Waukesha, Wisconsin 53187-1607

October 1983

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SOUTHEASTERN WISCONSIN REGIONAL PLANNING COMMISSION

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October 12, 1983

Village President, Village Board,
and Village Plan Commission
c/o Village Clerk
Village of Sussex
N63 W23626 Silver Spring Drive
Sussex, Wisconsin 58089

Ladies and Gentlemen:

On October 5, 1981, the Village of Sussex requested that the Southeastern Wisconsin Regional Planning Commission prepare a stormwater management plan for the Village. The Regional Planning Commission staff, working with the Village Administrator, Village Engineer, and Plan Commission, has now completed all of the technical work required and is pleased to herewith transmit the completed stormwater management plan for consideration and adoption by the Village Plan Commission and Village Board.

In addition to the stormwater management plan, the Commission staff prepared maps of the existing Village of Sussex stormwater drainage system. These maps were prepared on 1 inch equals 200 feet scale topographic maps and are intended to be used in the design of future stormwater drainage facilities. The stormwater management plan presented herein is consistent with regional as well as local land use development objectives, and is intended to serve as a guide for the making of public decisions on the development of stormwater management facilities as development occurs within the urban service area of the Village of Sussex.

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

Sincerely,

Kurt W. Bauer
Executive Director

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Chapter I

INTRODUCTION

BACKGROUND

The Village of Sussex is experiencing certain modest stormwater drainage problems. These include ponding of stormwater on streets and around structures and, in some cases, flooding of basements. These existing problems require resolution. More importantly, however, the Village, located on the western fringe of the Milwaukee urbanized area, has potential for rapid growth and development. This growth and development could result in the conversion over the next two decades of nearly 1,700 acres of land from rural to urban use, increasing urban land use in the Village and environs from a 1980 level of 893 acres to a level of 2,589 acres by the year 2000. In the absence of adequate planning and engineering, this conversion of land from rural to urban use may be expected to exacerbate the existing and to create new and costly stormwater drainage problems. The capital cost of providing storm sewerage facilities for the new urban land uses alone could range from $5.4 million to $14.4 million over the next 20 years. The need to minimize these costs, together with the need to resolve the existing and avoid the creation of new stormwater drainage problems, dictates the need to prepare a long-range stormwater management plan for the Village and environs.

The purpose of this report, and of the supporting inventories and analyses, is to develop and present a recommended stormwater management plan for the Village of Sussex and environs. The plan seeks to promote the development of an effective stormwater management system for the study area through the year 2000, a system which will minimize damages attendant to poor drainage while reducing downstream flooding. More specifically, this report:

1. Describes the existing stormwater drainage system and the existing stormwater drainage and related problems of the Village and environs and identifies the causes of these problems;

2. Sets forth proposed future land use conditions and related stormwater management requirements;

3. Provides a set of stormwater management objectives and supporting standards to guide the development of an effective stormwater management system;

4. Presents alternative stormwater management system plans;

5. Provides a comparative evaluation of the technical, economic, and environmental features of the alternative plans;

6. Recommends a stormwater management plan for the Village and environs consisting of various structural and nonstructural measures; and

7. Identifies the responsibilities of, and actions required by, the various governmental units and agencies concerned to carry out the recommended plan.

This report was prepared by the staff of the Southeastern Wisconsin Regional Planning Commission in cooperation with the staff of the Village of Sussex in response to a letter request from the Village dated August 24, 1981. The recommended stormwater management plan for the Village, as presented herein, is properly set within the context of the broader flood control and water quality management recommendations set forth in the adopted comprehensive plan for the Fox River watershed;[1] the stormwater management related water quality recommendations set forth in the adopted areawide water quality management plan;[2] and the floodland information set forth in a report previously prepared for the Village by the Regional Planning Commission on Sussex and Willow Springs Creeks.[3]

Distinction Between Stormwater Drainage and Flood Control

Both stormwater drainage and flood control deal with the problems of disposal of unwanted water, and the distinction between the two issues is not always clear-cut. For the purposes of this report, flood control is defined as the prevention of damage from the overflow of natural streams and watercourses. Drainage is defined as the disposal of excess stormwater on the land surface before such water has entered stream channels. This report focuses on the latter, and addresses flood control only as necessary to avoid the intensification of existing, or the creation of new, flood control problems along the natural streams and watercourses of the study area which must receive the discharge from the existing and proposed urban drainage facilities.

NEED FOR AND IMPORTANCE OF STORMWATER MANAGEMENT PLANNING

Stormwater drainage--the collection, transport, and disposal of excess stormwater--is one of the most important and costly requirements of sound urban development. Good stormwater drainage is essential to the provision of an attractive and efficient, as well as to a safe and healthful, environment for urban life.

Inadequate stormwater drainage can be even more costly, disrupting the safe and efficient movement of people and goods essential to the proper functioning of any urban area. Inadequate stormwater drainage can also undermine the structural stability of pavements, utilities, and buildings requiring costly maintenance and reconstruction. Inadequate stormwater drainage can also depreciate and destroy the market value of real property with an attendant loss of tax base.

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[1]See SEWRPC Planning Report No. 12, A Comprehensive Plan for the Fox River Watershed, Volume One, Inventory Findings and Forecasts; and Volume Two, Alternative Plans and Recommended Plan.

[2]See SEWRPC Planning Report No. 30, A Regional Water Quality Management Plan for Southeastern Wisconsin: 2000, Volume One, Inventory Findings; Volume Two, Alternative Plans; and Volume Three, Recommended Plan.

[3]See SEWRPC Community Assistance Planning Report No. 11, Floodland Information Report for Sussex Creek and Willow Springs Creek, Village of Sussex, Waukesha County, Wisconsin.

Inadequate stormwater drainage can create serious hazards to public health. Poor drainage can result in the excessive infiltration and inflow of clear water into sanitary sewerage systems with attendant surcharging of sanitary sewers, the backing of sanitary sewage into residential and commercial buildings, the bypassing of raw sewage to streams and watercourses through sanitary sewer system flow relief devices, and the disruption of sewage treatment processes. In extreme situations inadequate stormwater drainage can constitute a hazard to human life. Inadequate stormwater drainage can also cause serious and costly soil erosion and sedimentation, create unsightly depositions of debris and may promote the breeding of mosquitoes and other troublesome insects with hazards to the health of humans and of domestic animals.

Municipal officials have long recognized the hazards to human health and safety, and the economic losses attendant to inadequate stormwater drainage. Such officials are increasingly recognizing the adverse ecological and environmental impacts of improperly managed stormwater runoff, including the pollution of surface waters, the reduction of groundwater recharge, and the adverse effects on desirable forms of plant and animal life.

Because of its important social, economic, and environmental impacts, and because of the complex nature of the phenomena involved, stormwater drainage is a problem which requires sound resolution through fairly sophisticated planning and engineering. The factors which must be considered in the planning and design of stormwater drainage facilities are complex and highly interrelated. Perhaps the most important of these factors is the magnitude and frequency of the flows that must be accommodated. Yet, this variable cannot be determined with certainty since it is dependent on the occurrence of random meteorological events, as well as on topographic, pedologic, and land use conditions. Moreover, the factors determining the quantity and quality of the runoff to be accommodated by an urban stormwater drainage system are altered by urbanization itself, which particularly affects the overall imperviousness of the catchment area concerned, reduces the infiltration capacity of soils, reduces the amount of natural depression storage, and reduces the flow times in the drainage system thereby significantly increasing the rate and volume of stormwater runoff.

Application of the sciences of hydrology and hydraulics, as well as the art of urban engineering, is, therefore, important to the sound planning and design of urban stormwater drainage systems. 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 drainage systems requires the collection and analyses of 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 drainage systems requires the collection and analysis of definitive information on the configuration of the natural and artificial stormwater drainage systems of the study area, including information on the shape and dimensions of the cross-sectional areas, on the longitudinal gradients, and on the roughness and attendant hydraulic performance of the collection, storage, and conveyance facilities involved.

Thus, properly conceived, 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 through time. In addition to knowledge of the technical aspects of stormwater management systems, knowledge of the economic and environmental impacts of such systems, and of the public attitudes involved is also required.

BASIC CONCEPTS INVOLVED

The basic concepts underlying urban stormwater management are undergoing revision. The old concepts sought to eliminate excess surface water during and after a rainfall as quickly as possible through the provision of an efficient drainage system, a system usually consisting of enclosed conduits, although sometimes consisting of improved open channels. The problems created by application of the traditional approach to urban stormwater drainage were more or less acceptable when urban development was compact and confined to relatively small areas. These problems have become increasingly serious, aggravating, and unacceptable as the pattern of urban development has changed and urban land uses have diffused over ever larger areas.

The new concepts emphasize retention or detention of rainfall onsite, even at some localized inconvenience, thus reducing both the total and the peak rate of runoff and protecting against increased downstream flooding. The new concepts also look to controlling the quality, as well as the quantity, of runoff and seek to manage stormwater as a potentially valuable resource rather than as a nuisance to be disposed of as quickly as possible.

Stormwater runoff systems are generally designed to fulfill two basic objectives: 1) to prevent significant damage from any major storm event which is reasonably foreseeable, and 2) to provide an acceptable degree of rapid stormwater drainage allowing convenient access to and egress from the various land uses of an urban area following minor, more frequent rainfall events. Thus, the total stormwater runoff system for an area may be conceived of as consisting of a major element operating infrequently and a minor element operating frequently.

Both of these elements of the system can, under certain conditions, utilize stormwater retention or detention as a potential design solution. The benefits of stormwater storage are that it will reduce the high kinetic energy of surface runoff, reduce peak discharges, provide multiple-use opportunities for recreational and aesthetic purposes, provide groundwater recharge, trap some pollutants, and reduce the adverse impacts of the remaining pollutants by controlled release.

Development of storage is facilitated by the current emphasis on planned residential communities which incorporate more open space. Proper planning for this type of residential development is conducive to the provision of retention-detention sites which are compatible with the surrounding land and city scapes. This storage complements the environment by permitting the dual use of open spaces at relatively low cost to the developer and at relatively little inconvenience to the residents of the community. This practice of detaining or retaining stormwater within the confines of an urban area to mitigate flooding, soil erosion, sedimentation, and pollutant contributions is increasingly being recognized as a sound and cost-effective stormwater management approach.

The recommended stormwater management plan for the Village of Sussex, as set forth herein, incorporates compatible multiple-use planning concepts and recognizes the constraints imposed by other community needs, such as park and open space, transportation, and water supply. Drainage requirements under existing and planned year 2000 land use conditions are evaluated. Flood control as well as drainage problems are addressed as necessary. Finally, the plan encompasses not only the existing and planned future urban service area of the Village, but the entire upstream watersheds of the natural streams and watercourses flowing through the study area which must receive the discharge of the existing and proposed engineered urban drainage systems.

REVIEW OF PREVIOUS STUDIES

Some of the basic data required for the stormwater management planning effort was provided in previous studies by the Regional Planning Commission. The results of these studies which were incorporated into the stormwater management planning effort, as appropriate, are briefly summarized below.

1. SEWRPC Community Assistance Planning Report No. 11, Floodland Information Report for Sussex Creek and Willow Springs Creek, Village of Sussex, Waukesha County, Wisconsin, March 1977.

   This report represents a refinement and extension of SEWRPC Planning Report No. 12, A Comprehensive Plan for the Fox River Watershed, for the Village of Sussex and its tributary area. Based on historic flood flow data and related information collected since 1940, the report states that the Village of Sussex has experienced at least one major flood event--in April 1973--and at least one minor flood event--in September 1972. Flood problems in the Village appear to occur primarily along Sussex Creek downstream of Main Street and upstream of Maple Avenue. Minor overland flooding and isolated basement and street flooding--actually a manifestation of inadequate urban drainage--were reported. A detailed inventory was conducted of the hydrologic-hydraulic systems of the Sussex Creek and Willow Springs Creek watersheds. A hydrologic-hydraulic simulation model was used to determine selected 10- through 500-year recurrence interval flood discharges and stages under existing 1975 and planned year 2000 land use conditions. The mathematical simulation model was also used to identify bridges and culverts producing major backwater effects and to determine the likely effect of altering those bridges and culverts. It was concluded that alteration or replacement of the Main Street culvert on the East Branch of Sussex Creek could significantly reduce the 100-year recurrence interval flood stage and associated area of inundation immediately upstream of the culvert.

2. SEWRPC Community Assistance Planning Report No. 51, A Land Use Plan for the Village of Sussex: 2000, January 1982.

   This report identifies probable future land use needs for the Village and environs through the year 2000, and, based upon careful consideration of the existing cultural and natural resource features of the study area, the plans and policies of other units and agencies of government concerned, and the land use development objectives of the Village, sets forth a sound land use plan and proposed implementation measures. Urban land use within the proposed urban service area of the Village of Sussex is anticipated to nearly triple between 1980 and the year 2000, increasing from 893 to 2,589 acres. The plan recommends that intensive urban development be encouraged to occur only in those areas which are covered by soils suitable for such development; which are not subject to special hazards, such as flooding; and which can be readily served by essential municipal services and facilities. Development of environmental corridors and prime agricultural land is not recommended.

SUMMARY

The Village of Sussex, located on the western fringe of the Milwaukee urbanized area, has potential for rapid growth and development. This growth and development may result in an almost threefold increase in the amount of land devoted to urban use in the Village and environs and, in the absence of sound planning and engineering, may be expected to exacerbate existing and to create costly new stormwater drainage problems. The capital cost of providing storm sewerage facilities for the new urban land uses alone could range from $5.4 million to $14.4 million over the next 20 years. The need to minimize these costs, together with the need to resolve the existing and avoid the creation of new stormwater drainage problems, dictates the need to prepare a long-range stormwater management plan for the Village of Sussex and environs.

This report presents such a recommended stormwater management plan. The plan seeks to promote the development of an effective stormwater system for the study area through the year 2000, a system which will minimize damages attendant to poor drainage while reducing downstream flooding. More specifically, this report describes the existing stormwater drainage system and stormwater drainage problems of the Sussex area; describes proposed future land use conditions and identifies related stormwater management requirements; provides a set of stormwater management objectives and supporting principles and standards to guide the development of an effective stormwater management system for the area; presents alternative stormwater management system plans and provides a comparative evaluation of the technical, economic, and environmental features of these alternative plans; recommends a stormwater management plan for the Village and environs; and sets forth a plan implementation program.

The plan focuses on stormwater drainage as opposed to flood control problems, addressing the latter only as necessary to avoid the intensification of existing or the creation of new flood control problems along the natural streams and watercourses of the study area which must receive the discharge from the existing and proposed urban drainage facilities. The plan recognizes that good stormwater drainage is essential to the provision of an attractive and efficient, as well as to a 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, stormwater management planning must be based upon knowledge of the art of urban 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 relating to stormwater drainage.

The recommended stormwater management plan presented herein also recognizes that the basic concepts underlying urban stormwater management are undergoing revision. The old concepts sought to eliminate excess surface water during and after a rainfall as quickly as possible through the provision of an efficient drainage system, a system consisting of enclosed conduits and improved open channels. The new concepts emphasize retention or detention of rainfall onsite, even at some localized inconvenience, thus reducing both the total volume and the peak rate of runoff and providing protection against increased downstream flooding. The new concepts also look to controlling the quality, as well as the quantity, of runoff and seek to manage stormwater as a potentially valuable resource rather than as a nuisance to be disposed of as quickly as possible.

Accordingly, 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 of excess runoff. The recommended stormwater management plan set forth herein thus incorporates compatible multiuse 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. Drainage requirements are evaluated under existing and planned land use conditions; flood control, as well as drainage problems are addressed as necessary; and the plan encompasses not only the existing and planned future urban service area of the Village but the entire upstream watersheds of the natural streams and watercourses flowing through the study area, which streams and watercourses must constitute the outlets for the existing and proposed engineered urban drainage system of the area.

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Chapter II

OVERVIEW OF THE STUDY AREA

INTRODUCTION

The primary focus of the stormwater management plan presented in this report consists of the urban service area of the Village of Sussex as proposed in the adopted local land use plan. This urban service area is shown on Map 1. Stormwater from this planned urban area is drained to three separate surface water systems--those systems being the intermittent and perennial streams of the Sussex Creek subwatershed, the Willow Springs Creek subwatershed, and the Pewaukee River subwatershed. In addition to serving as outlets for stormwater drainage from the urban service area of the Village, Sussex Creek and Willow Springs Creek drain areas located upstream of the planned urban service area. These upstream tributary drainage areas must be considered, as well as the drainage areas which are partially within and extend downstream of the planned urban service area, in the proper design of a stormwater management system for the Village. Thus, the total study area herein considered for stormwater management planning purposes, as shown on Map 1, includes the drainage subbasins of the natural watersheds which are upstream and tributary to the natural surface water drainage system of the planned urban service area and the drainage subbasins of these watersheds which are within and extend downstream of the Sussex planned urban service area. The study area boundary as well as the 1982 corporate limits of the Village of Sussex, the year 2000 planned urban service area for the Village, the natural stream and watercourse system, the subbasin boundaries, and the watershed boundaries are shown on Map 1.

The areal extent of the study area is 9,824 acres, of which 2,062 acres, or 21 percent, lie within the 1982 corporate limits of the Village, and 2,980 acres, or 30 percent, lie within the year 2000 planned urban service area, as shown in Table 1. About 6,467 acres, or 66 percent of the total study area, drain to Sussex Creek; about 2,422 acres, or 25 percent, drain to Willow Springs Creek; and about 935 acres, or 9 percent, drain to a headwater reach of the Pewaukee River.

VILLAGE OF SUSSEX AND PLANNED 2000 URBAN SERVICE AREA

In 1980 the Village of Sussex had a resident population of about 3,500 persons, about 25 percent higher than the 1970 population of about 2,800 persons. The adopted village land use plan envisions a population within the urban service area of the Village of about 10,800 persons by the year 2000. To accommodate this anticipated increase in population, and associated commercial and industrial development, the adopted land use plan for the Village recommends an urban service area of 2,938 acres,[1] 42 percent larger than the

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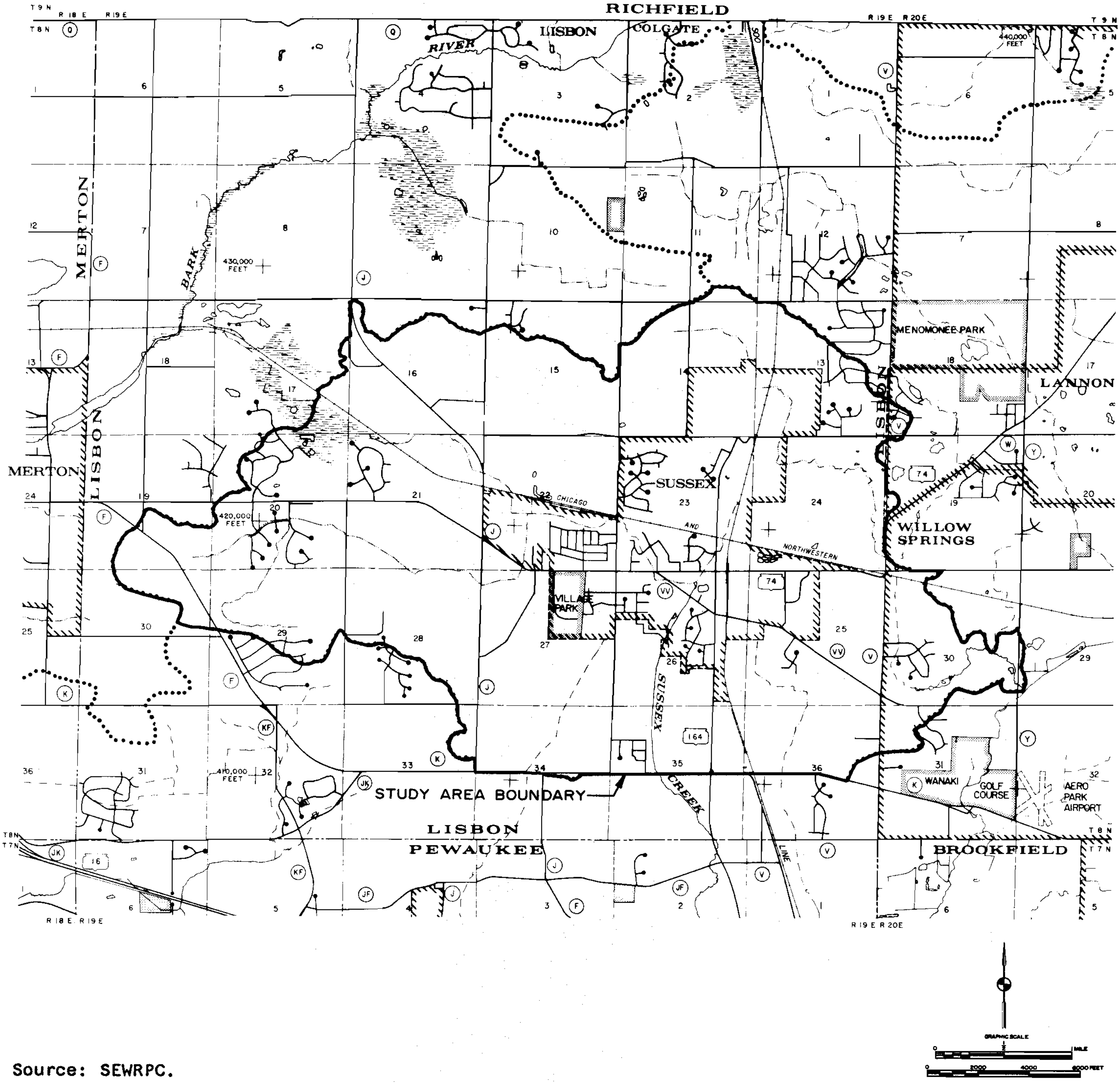
[1]The extent of the year 2000 planned urban service area is 42 acres greater than the area of 2,938 acres delineated in SEWRPC Community Assistance Planning Report No. 51, A Land Use Plan for the Village of Sussex: 2000 because the urban service area for this report includes areas within the 1981 village corporate limits which are not expected to receive urban services.

Map 1

VILLAGE OF SUSSEX STORMWATER MANAGEMENT STUDY AREA



Source: SEWRPC.

Table 1

AREAL EXTENT OF STUDY AREA

Area	Extent	Percent of Total Study Area
1982 Village of Sussex Corporate Limits.....	2,062	21.0
Year 2000 Planned Urban Service Area Outside 1982 Village of Sussex Corporate Limits..................	918	9.3
Total Year 2000 Planned Urban Service Area	2,980	30.3
Study Area Outside Year 2000 Urban Service Area.......................	6,844	69.7
Total Study Area	9,824	100.0

Source: SEWRPC.

2,062-acre area located within the 1982 corporate boundaries of the Village. This local land use plan is documented in SEWRPC Community Assistance Planning Report No. 51, A Land Use Plan for the Village of Sussex: 2000, January 1982.

As set forth in Table 2, about 1,369 acres, or 66 percent of the 1982 incorporated area of the Village of Sussex, drain to Sussex Creek under existing conditions; 443 acres, or 22 percent, drain to Willow Springs Creek; and 250 acres, or 12 percent, drain to a headwater reach of the Pewaukee River. Of the planned urban service area of the Village of 2,980 acres for the year 2000, about 1,844 acres, or 62 percent, drain to Sussex Creek; 712 acres, or 24 percent, drain to Willow Springs Creek; and 424 acres, or 14 percent, drain to a headwater reach of the Pewaukee River. Table 3 sets forth the area and proportion of the study area located within various civil division boundaries as of 1982.

SURFACE WATER DRAINAGE IN STUDY AREA

Selected characteristics of the surface water drainage system of the study area and certain related lowland features are shown on Map 2, which includes watershed boundaries, perennial and intermittent streams and watercourses, minor lakes and ponds, the 100-year recurrence interval floodplains, and the area served by engineered storm sewer systems.

The existing engineered storm sewer system for the Village of Sussex as of 1982 had a tributary drainage area of about 396 acres. The storm drainage system consists principally of subsurface conduits with several short reaches of engineered drainage channels. The existing storm sewer system contains no public stormwater storage or pumping facilities. The existing system actually consists of 24 subsystems, as shown on Map 2, discharging to 24 stormwater outfalls ranging in size from 12 inches to 48 inches in diameter. As shown on Map 2, 23 of the outfalls discharge to Sussex Creek, while one outfall discharges to a headwater reach of the Pewaukee River.

Table 2

AREA AND PROPORTION OF SUSSEX CREEK, WILLOW SPRINGS CREEK, AND PEWAUKEE RIVER SUBWATERSHEDS WITHIN THE VILLAGE OF SUSSEX 1982 CORPORATE LIMITS, THE YEAR 2000 PLANNED URBAN SERVICE AREA, AND THE STUDY AREA

	Village of Sussex 1982 Corporate Limits		Year 2000 Planned Urban Service Area Outside the Village Corporate Limits		Year 2000 Planned Urban Service Area		Total Study Area	
Subwatershed	Area (acres)	Percent of Total	Area (acres)	Percent of Total	Area (acres)	Percent of Total	Area (acres)	Percent of Total
Sussex Creek.....	1,369.0	66.4	475.5	51.8	1,844.5	61.9	6,466.7	65.8
Willow Springs Creek..........	443.0	21.5	268.6	29.3	711.6	23.9	2,422.5	24.7
Pewaukee River...	250.0	12.1	173.6	18.9	423.6	14.2	934.9	9.5
Total	2,062.0	100.0	917.7	100.0	2,979.7	100.0	9,824.1	100.0

Source: SEWRPC.

Table 3

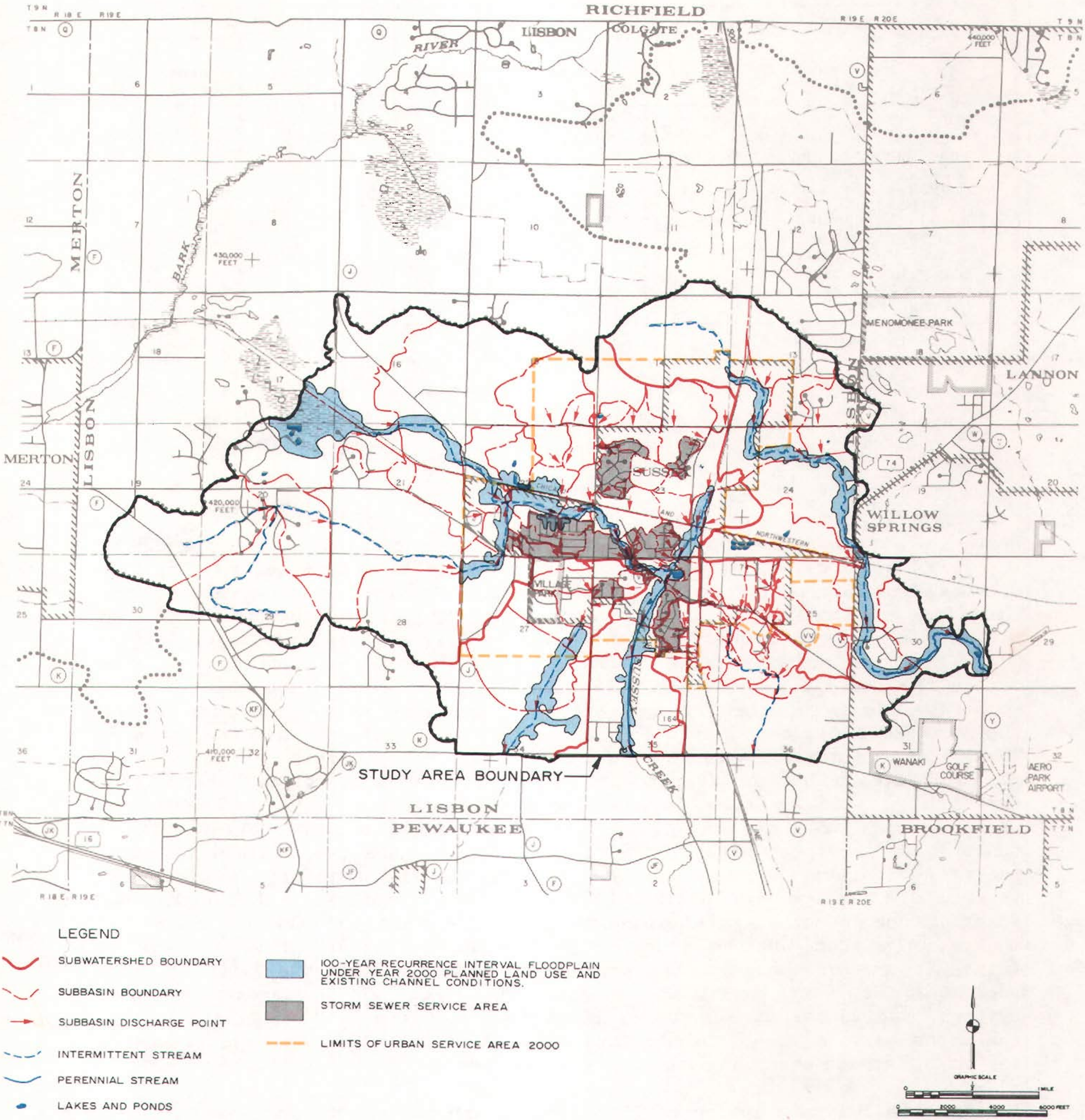
AREA AND PROPORTION OF SUSSEX CREEK, WILLOW SPRINGS CREEK, AND PEWAUKEE RIVER SUBWATERSHEDS WITHIN THE STUDY AREA IN VARIOUS CIVIL DIVISIONS IN WAUKESHA COUNTY: 1982

		Area	
Subwatershed	1982 Civil Division	Acres	Percent of Watershed
Sussex Creek	Village of Sussex...........	1,369.0	21.2
	Town of Lisbon..............	5,097.7	78.8
	Subtotal	6,466.7	100.0
Willow Springs Creek	Village of Lannon............	30.3	1.2
	Village of Menomonee Falls...	522.5	21.6
	Village of Sussex...........	443.0	18.3
	Town of Lisbon..............	1,426.7	58.9
	Subtotal	2,422.5	100.0
Pewaukee River	Village of Sussex...........	250.0	26.7
	Town of Lisbon..............	684.9	73.3
	Subtotal	934.9	100.0
Total Study Area	Village of Lannon............	30.3	0.3
	Village of Menomonee Falls...	522.5	5.3
	Village of Sussex...........	2,062.0	21.0
	Town of Lisbon..............	7,209.3	73.4
	Total	9,824.1	100.0

Source: SEWRPC.

Map 2

SELECTED CHARACTERISTICS OF THE VILLAGE OF SUSSEX STORMWATER MANAGEMENT STUDY AREA SURFACE WATER DRAINAGE SYSTEM: 1982



Source: SEWRPC.

Table 4

LENGTH OF PERENNIAL AND INTERMITTENT STREAMS

Area	Perennial		Intermittent	
	Length of Stream (miles)	Percent of Total	Length of Stream (miles)	Percent of Total
1982 Village of Sussex Corporate Limits...........	0.66	23.2	3.85	23.7
Year 2000 Planned Urban Service Area Outside 1982 Village of Sussex Corporate Limits..........	0.13	4.6	0.91	5.6
Total Year 2000 Planned Urban Service Area for Village...........	0.79	27.8	4.76	29.3
Study Area Outside Year 2000 Planned Urban Service Area.........	2.05	72.2	11.48	70.7
Total Study Area	2.84	100.0	16.24	100.0

Source: SEWRPC.

Perennial streams, or watercourses which maintain a continuous flow throughout the year, serve as the major drainage outlets for the storm sewers, drainage ditches, and intermittent streams. Intermittent streams are those watercourses which do not sustain continuous flow during dry periods. Perennial streams within the study area consist of portions of Sussex Creek and Willow Springs Creek. As set forth in Table 4, there are 2.84 miles of perennial streams within the study area of which 0.66 mile, or 23 percent, lie within the 1982 corporate limits of the Village, and 0.79 mile, or 28 percent, lie within the year 2000 planned urban service area of the Village. Also as shown in Table 4, there are 16.24 miles of intermittent streams within the study area, of which 3.85 miles, or 24 percent, lie within the 1982 corporate limits of the Village, and 4.76 miles, or 29 percent, lie within the year 2000 planned urban service area of the Village. This network of streams serves a vital function by providing natural drainage for those areas not drained by engineered storm sewer systems and by receiving the discharge of the engineered storm sewer systems and drainage ditches. Both perennial and intermittent streams comprise important components of the existing and planned stormwater management systems of the study area. The importance of these streams to future stormwater management is primarily due to two factors: 1) the streams accommodate surface runoff and provide an outlet for engineered drainage systems, and 2) the streams carry flows from upstream areas into and through the urban service area, transmitting flows from both the upstream areas and the urban service area to downstream areas.

A more detailed description of the existing stormwater drainage system is set forth in Chapter III, "Inventory and Analysis."

SUMMARY

This stormwater management plan focuses on the planned urban service area for the Village of Sussex for the year 2000. The study area also includes the drainage subbasins of the natural watersheds which lie upstream of and are tributary to the drainage system of the planned urban service area and the drainage subbasins which extend downstream of the urban service area. The study area is drained by Sussex Creek, Willow Springs Creek, and a headwater reach of the Pewaukee River. The areal extent of the study area is 9,824 acres, of which 2,062 acres, or 21 percent, lie within the 1982 corporate limits of the Village of Sussex, and 2,980 acres, or 30 percent, lie within the year 2000 planned urban service area for the Village of Sussex.

The 1980 resident population of the Village of 3,500 persons represented an increase of 25 percent over the 1970 population. By the year 2000 the population of the urban service area is expected to increase to about 10,800 persons. To accommodate this population increase, the adopted local land use plan for the Village anticipates an urban service area which is 42 percent larger than the area located within the 1982 corporate village limits.

The existing 1982 engineered storm sewer system for the Village had a tributary drainage area of about 396 acres. The storm sewer system consists of subsurface conduits, surface drainage ditches and channels, and outlets. There are about 2.84 miles of perennial streams and about 16.24 miles of intermittent streams within the study area. Both the perennial and intermittent streams are important components of the existing drainage system and will remain important parts of the planned future drainage system.

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Chapter III

INVENTORY AND ANALYSIS

INTRODUCTION

Accurate information on certain pertinent natural and man-made features of the study area is essential to sound stormwater management planning. Accordingly, the collation and collection of definitive information on key hydrologic and hydraulic characteristics of the stormwater management planning area, on the existing stormwater drainage system of that area, and on the erosion and sedimentation characteristics of that area becomes the first operational step in the stormwater management planning process. The resulting information is essential to the planning process because alternative stormwater management plans cannot be formulated and evaluated without an in-depth knowledge of the pertinent existing conditions in the planning area. This is particularly true for stormwater management planning, 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.

Accordingly, this chapter presents pertinent data on the location, configuration and capacity of the existing stormwater drainage system of the Sussex area, on the magnitude of stormwater flows to be accommodated by that system, and on the hydrologic phenomena governing the magnitude and frequency of those stormwater flows. Also, presented are data on actual historic flood events and on existing drainage problems. The data pertinent to stormwater management planning are presented in this chapter under the headings land use, land use regulations, climate, soils, stormwater drainage systems, stormwater management problems, and erosion and sedimentation problems. Because water quality impacts are becoming increasingly of concern in stormwater management, this chapter also presents data on existing water quality conditions in the Sussex area and discusses those sources of pollution related to stormwater management.

LAND USE

The type, density, and spatial distribution of land uses are important determinants of the quantity and quality of stormwater runoff. The amount of impervious area, the type of stormwater drainage system, the level and characteristics of human activity, and the type and amount of water pollutant deposition all vary with land use. A careful determination and analysis of the existing land use pattern, and of the physical characteristics of the land itself, constituted an important basis for the recommended land use plan set forth in SEWRPC Community Assistance Planning Report No. 51, A Land Use Plan for the Village of Sussex: 2000 (January 1982). The land use information herein presented is drawn from that report. Pertinent data on the existing land use pattern in the Sussex area are presented in Table 5, and that pattern is shown on Map 3. Detailed historic and existing demographic and economic data for the Sussex area are also set forth in the above-referenced planning report. Information that is directly related to land use planning and indirectly related to stormwater management planning is not repeated herein. That demographic and

Table 5

EXISTING LAND USE CONDITIONS IN THE VILLAGE OF SUSSEX STUDY AREA: 1980

Land Use Category	Village of Sussex		Sussex Year 2000 Urban Service Area		Study Area	
	Acres	Percent of Total	Acres	Percent of Total	Acres	Percent of Total
Urban						
Residential	341	17	387	12	1,338	13
Vacant Residential	56	3	57	2	216	2
Residential Subtotal	397	20	444	14	1,554	15
Governmental and Institutional	51	3	114	4	125	1
Commercial	23	1	27	1	37	1
Industrial	45	2	45	1	397	4
Transportation and Utilities	221	11	236	7	320	3
Recreation	76	4	76	2	171	2
Nonresidential Subtotal	406	21	498	16	1,050	11
Urban Subtotal	803	41	942	30	2,604	26
Rural						
Woodlands	49	2	162	5	363	4
Wetlands	134	7	315	10	928	9
Agriculture and Open Lands	998	50	1,744	55	5,912	61
Surface Water	1	--[a]	1	--[a]	17	--[a]
Rural Subtotal	1,182	59	2,222	70	7,220	74
Total	1,985	100	3,164	100	9,824	100

[a] Less than 0.5 percent.

Source: SEWRPC.

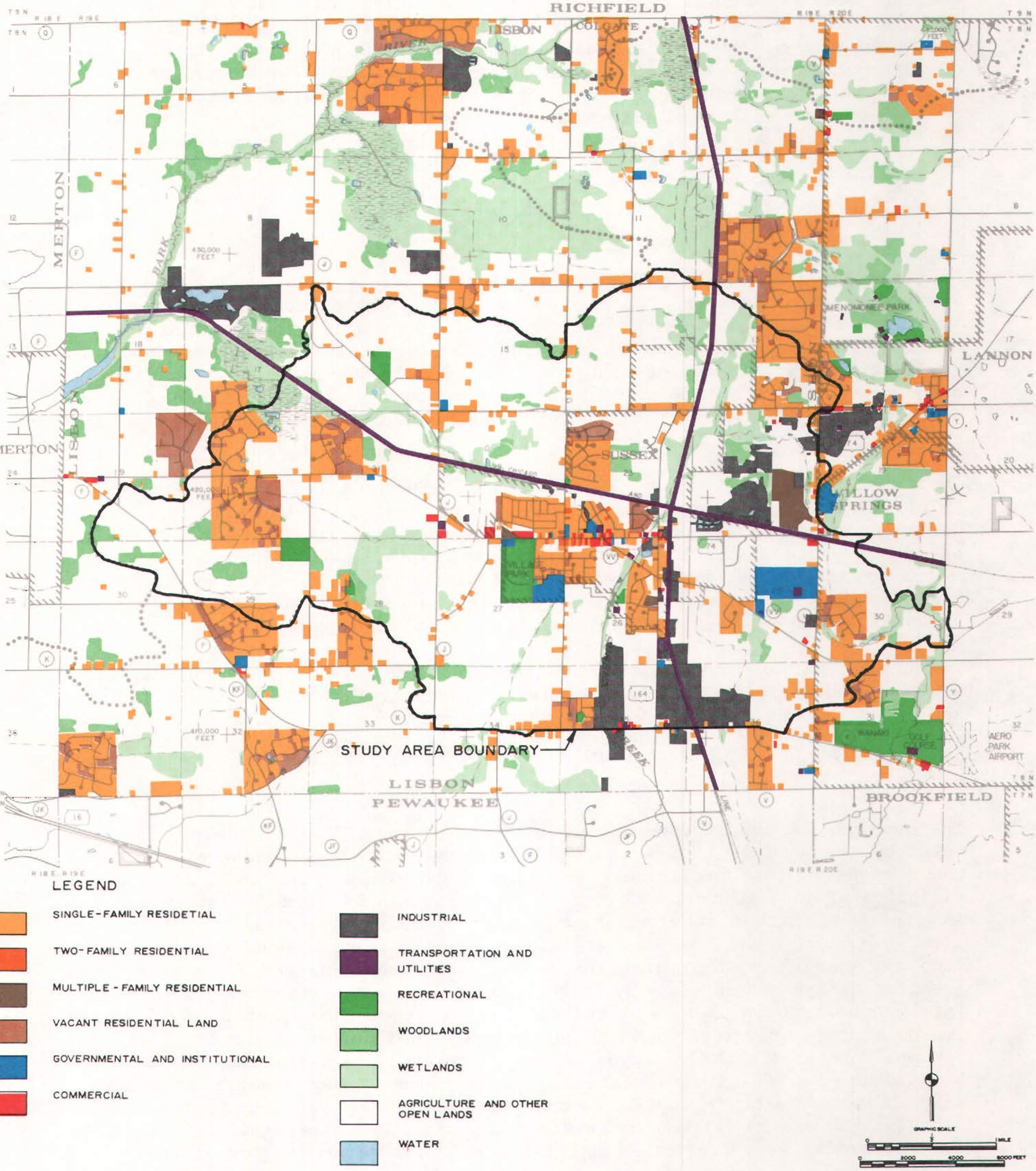
economic information has, however, been taken into full account herein through consideration of the land use data which are more directly related to stormwater management.

The study area encompasses a total area of about 9,824 acres, or 15.35 square miles. As indicated in Table 5, in 1980 urban land uses accounted for about 2,604 acres, or about 26 percent of the total study area. Of these developed urban land uses, residential uses occupied 1,554 acres, or 60 percent, while the remaining urban land uses--governmental and institutional, commercial, industrial, transportation and utilities, and recreational--together occupied 1,050 acres, or the remaining 40 percent. In 1980, rural land uses still accounted for 7,220 acres, or 74 percent of the total study area. Agricultural and other open lands occupied 5,912 acres, or 82 percent of the rural area. Other rural land uses, including wetlands, woodlands, and open water, occupied 1,308 acres, or 13 percent of the study area, and 18 percent of the rural area.

As of 1980, the incorporated Village of Sussex encompassed approximately 1,985 acres, or 20 percent of the study area. Urban land uses within the Village accounted for 803 acres, or 41 percent of the total incorporated area, with the dominant urban land use being residential, covering 397 acres, or 20 percent of the total incorporated area, but 49 percent of the developed urban area of the Village. Rural land uses still accounted for 1,182 acres, or 59 percent of the total area of the Village, with the dominant use being agriculture and other open lands, which occupied 998 acres, or 84 percent of the rural land area.

Map 3

EXISTING LAND USE IN THE VILLAGE OF SUSSEX STUDY AREA



Source: SEWRPC.

The urban service area for the Village of Sussex, as delineated in this report, which consists of the incorporated area of the Village of Sussex and such surrounding area as is envisioned in the recommended land use plan for the Village to be in urban use by the year 2000, encompasses 3,164 acres, or 32 percent of the study area. In 1980, urban land uses accounted for 942 acres, or 30 percent of this urban service area. Residential land use occupied 444 acres, or 14 percent of this urban service area. Rural land uses accounted for 2,222 acres, or 70 percent, with agriculture and other open lands occupying 1,744 acres, or 55 percent of the urban service area. The remaining 15 percent of the urban service area consisted of wetlands and woodlands.

LAND USE REGULATIONS

Pertinent existing land use regulations in the study area include zoning and land division ordinances. Comprehensive zoning represents one of the most important tools available to local units of government for directing the use of lands in the public interest, and, consequently, such zoning has important implications for stormwater management. Zoning in the planning area is exercised by the Village of Sussex in the incorporated portion of the study area, and jointly by the Town of Lisbon and by Waukesha County in the unincorporated portion of the study area.

The current Village of Sussex zoning ordinance became effective on February 28, 1978. This ordinance provides for one agricultural district, five residential districts, two business districts, two industrial districts, one park district, one conservancy district, two floodland districts, and a planned development overlay district. The application of these districts is shown on Map 4. Table 6 presents a brief summary of the regulations governing each district and the amount of acreage assigned to each district on the village zoning map.

The current Town of Lisbon zoning ordinance provides one agricultural district, five residential districts, three business districts, two industrial districts, and one quarrying district. The application of these districts is also shown on Map 4. Table 6 presents a brief summary of the regulations governing each district and the amount of acreage assigned to each district on the town zoning map within the study area.

The subdivision and improvement of land within the Village of Sussex is regulated by the Village of Sussex subdivision and platting ordinance. The ordinance requires that preliminary and final subdivision plats be filed for all divisions of land which create five or more parcels of land 1.5 acres or less in area. It further requires that a certified survey map be filed for all divisions of land which create at least two but not more than four parcels of land any one of which is less than 35 acres in area. The ordinance sets forth specific design and improvement requirements for preliminary and final plats. Furthermore, the ordinance requires that a subdivider install subdivision improvements, including curb and gutter and storm sewers prior to final plat approval and that park and school sites be reserved or dedicated, or that a fee be paid in lieu of site dedication. The improvement requirements of the village land subdivision control ordinance commit the Village to the use of urban street cross-sections and attendant urban storm sewerage facilities, and are, accordingly, important considerations in the stormwater management planning process.

Table 6

SUMMARY OF EXISTING ZONING DISTRICTS IN THE VILLAGE OF SUSSEX AND THE TOWN OF LISBON: 1980

Zoning District	Permitted Uses	Conditional Uses	Minimum Lot Area	Minimum Lot Width (feet)	Acres[a]	Percent of Civil Division Within Study Area	Percent of Study Area
		VILLAGE OF SUSSEX ZONING ORDINANCE					
A-1 Agricultural District	General farming	Dumps, disposal areas, incinerators, commercial raising of livestock, airports, airstrips, and landing fields	20 acres	500	237	11.9	2.41
R-1 Single-Family Residential District	Single-family dwellings with attached garages	Utilities, public and private schools, colleges, hospitals, clubs, rest homes, nursing homes, elderly housing, children's nurseries, and detached garages	20,000 square feet	120	98	4.9	1.00
R-2 Single-Family Residential District	Single-family dwellings	Same as R-1 Single-Family Residential District	16,000 square feet	100	119	6.0	1.21
R-3 Single-Family Residential District	Single-family dwellings	Utilities, public and private schools, colleges, hospitals, clubs, rest homes, nursing homes, elderly housing, and children's nurseries	12,000 square feet	80	641	32.3	6.52
R-4 Two-Family Residential District	One- and two-family dwellings	Utilities, public and private schools, colleges, hospitals, clubs, rest homes, nursing homes, elderly housing, children's nurseries, and conversion of single-family dwellings to two-family dwellings	10,000 square feet	90	28	1.4	0.29
R-5 Multifamily Residential District	Two-family and multifamily dwellings	Same as R-4 Two-Family Residential District	12,000 square feet	120	57	2.9	0.58
B-1 Neighborhood Business District	Retail establishments providing convenience goods and services	Drive-in theaters, motels, funeral homes, drive-in banks, tourist homes, vehicle sales and service, and commercial recreation facilities	2 acres	200	25	1.3	0.25
B-2 Community Business District	All uses permitted in the B-1 Neighborhood Business District, appliance stores, department stores, financial institutions, furniture stores, liquor stores, office supply stores, places of entertainment, plumbing supply stores, variety stores, and similar uses	Funeral homes, drive-in banks, tourist homes, vehicle sales and service, and commercial recreation facilities	5,000 square feet	60	37	1.9	0.38
M-1 Industrial District	Automotive body repair and upholstery, commercial bakeries, commercial greenhouses, distributors, farm machinery sales and repair, painting, printinging, warehousing, wholesaling, and light industrial plants	Governmental and cultural uses, public passenger transportation terminals, dumps, pea vineries, creameries, condenseries, and commercial service establishments	10,000 square feet	80	334	16.8	3.40
M-2 Heavy Industrial District	All uses permitted in the M-1 Industrial District, freight yards, freight terminals and transshipment depots, inside storage, and breweries	All conditional uses permitted in the M-1 Industrial District and the manufacturing and processing of such products as abrasives, acid, bleach, chlorine, plastic rubber, gasoline, grease, soap, incinerators, slaugher houses, tanneries, and weaving facilities	20,000 square feet	120	199	10.0	2.03
P-1 Park District	Parks and playgrounds, tot lots, picnicking, hiking and nature trails, boating, fishing, swimming, sledding, outdoor skating rinks, and skiing	Archery ranges, bathhouses, beaches, boating, camps, conservatories, driving ranges, golf courses, gymnasiums, hunting, ice boating, marinas, music halls, polo fields, pools, riding academies, skating rinks, sport fields, swimming pools, and zoological and botanical gardens	None	None	80	4.0	0.81

Table 6 (continued)

Zoning District	Permitted Uses	Conditional Uses	Minimum Lot Area	Minimum Lot Width (feet)	Acres[a]	Percent of Civil Division Within Study Area	Percent of Study Area
VILLAGE OF SUSSEX ZONING ORDINANCE (continued)							
C-1 Conservancy District	Fishing, hunting; preservation of scenic, historic, and scientific areas; public fish hatcheries; soil and water conservation; sustained yield forestry; stream bank and lake shore protection; water retention and wildlife areas; harvesting of wild crops; and public parks	Accessory structures which are floodproofed	None	None	8	0.4	0.08
F-1 Floodway District	Drainage movement of floodwater, navigation, stream bank protection, water measurement and control facilities, grazing, horticulture, open parking and loading areas, open markets, open recreational uses, outdoor plant nurseries, pasturing, sod farms, truck farming, utilities, viticulture, wild crop harvesting, and wildlife preserves	Open space related uses	None	None	97	4.9	0.99
FFO Floodplain Fringe Overlay District	Uses not involving structures which are permitted in an underlying use district	Residential, commercial, industrial and other nonresidential structures when fill requirements are met	None	None	25	1.3	0.25
PDO Planned Development Overlay District	Use permitted in an underlying use district	None	None	None	N/A	--	--
Total--Village of Sussex	--	--	--	--	1,985	100.0	20.20
TOWN OF LISBON ZONING ORDINANCE							
Conservancy District	Grazing, harvesting of wild crops; hunting; fishing; sustained yield forestry; dams; hydroelectric power stations; telephone, telegraph, and power transmission lines; nonresidential buildings used solely in conjunction with the raising of water fowl, minnows, and other similar lowland animals, fowl, or fish	None	None	None	529	7.2	5.4
Residence "Estate" District	One-family dwellings, public parks and recreation areas, crop and tree farming, keeping of poultry and domestic livestock, horticulture, accessory buildings, and home occupations	Cemeteries, private clubs and outdoor recreation facilities, public buildings and uses, and public and commercial disposal operations	3 acres	200	--	--	--
Residence "A-1" District	Same as permitted in the Residence "Estate" District, with certain requirements regarding the keeping of poultry and domestic livestock	Same as permitted in the Residence "Estate" District	40,000 square feet	150	101	1.4	1.0
Residence "A-2" District	Same as permitted in the Residence "A-1" District	Same as permitted in the Residence "A-1" District	30,000 square feet	120	4,763	64.8	48.5
Residence "A-3" District	Same as permitted in the Residence A-2" District	Same as permitted in the Residence "A-2" District	30,000 square feet	120	613	8.3	6.3

Table 6 (continued)

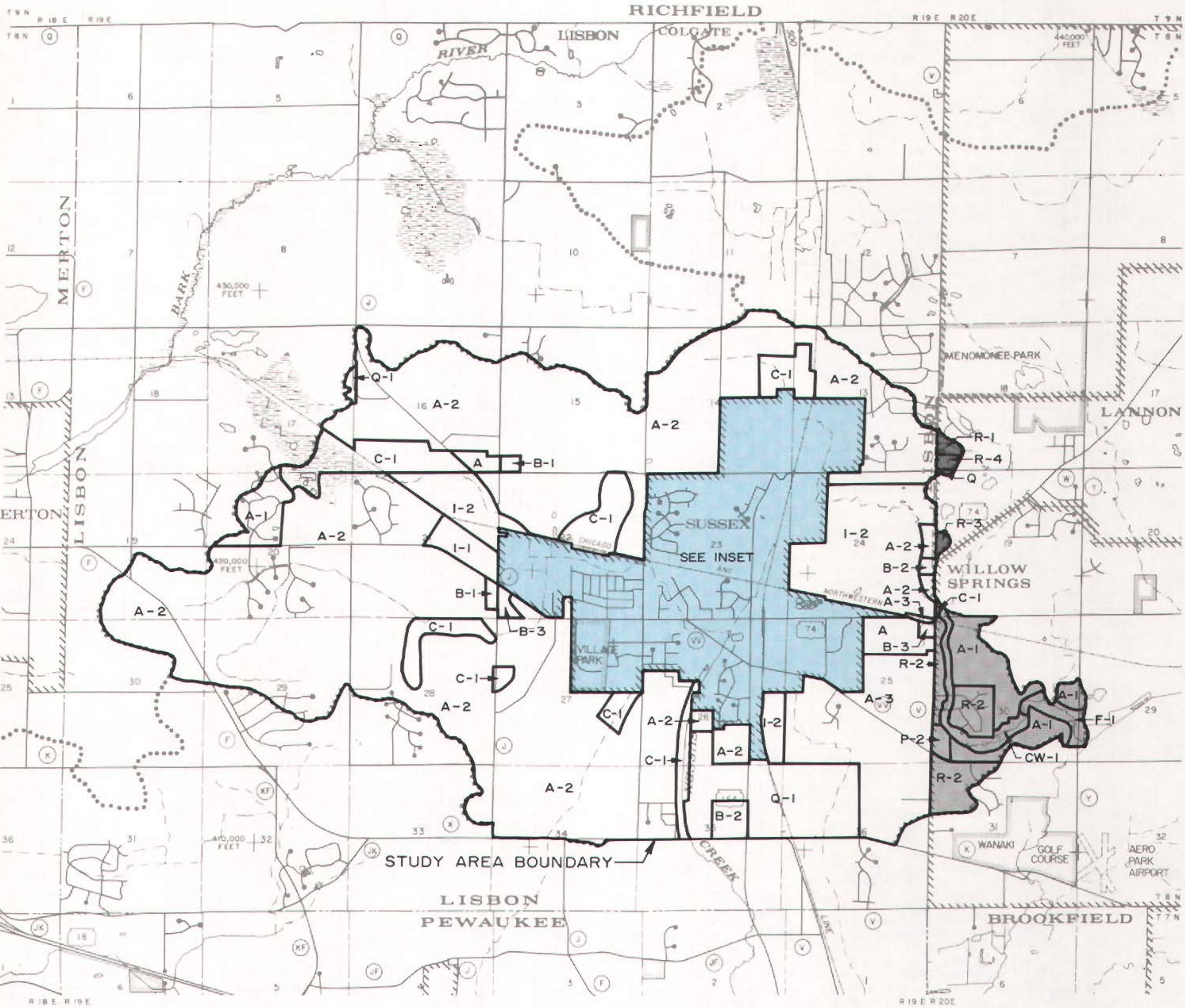
Zoning District	Permitted Uses	Conditional Uses	Minimum Lot Area	Minimum Lot Width (feet)	Acres[a]	Percent of Civil Division Within Study Area	Percent of Study Area
TOWN OF LISBON ZONING ORDINANCE (continued)							
Residence "M" District	Same as permitted in the Residence "A-3" District, real estate and insurances offices as home occupations	Same as permitted in the Residence "A-3" District plus two-family and multifamily dwellings	20,000 square feet	120	--	--	--
Agricultural District	Any use permitted in the Residence "M" District except multifamily dwellings; farm uses, nurseries, greenhouses, hatcheries, and roadside stands	Airports, landing fields, animal hospitals, kennels, cemeteries, mausoleums, fur farms, pig farms, wholesale *fattening* of livestock, pea vineries, creameries and condenseries, laboratories, motels, private clubs, outdoor recreational facilities, outdoor theaters, public buildings and uses, quarrying, trailer camps, commercial fish or bait ponds, and public and commercial disposal operations	3 acres	200	91	1.2	0.9
Quarrying District	Quarrying and related operations	Quarrying	None	None	366	5.0	3.7
Restricted Business District	Single-family residences in conjunction with permitted business uses, boarding houses, delicatessens, florists shops, funeral homes, gift shops, interior decorator, professional offices, restaurants, tourist homes, and similar uses	Automobile service stations, cemeteries, private clubs, outdoor recreational facilities, public buildings and uses, commercial fish or bait ponds, public and commercial disposal operations, restaurants, lake resorts, taverns, and similar uses	20,000 square feet	120	16	0.2	0.2
Local Business District	Any use permitted in the Restricted Business District, appliance stores, barber and beauty shops, banks, clothing and drug stores, furniture stores, grocery and hardware stores, music and radio stores, photographers, shoe stores, filling stations, garages, and similar uses	Same as permitted in Restricted Business District	20,000 square feet	120	49	0.7	0.5
General Business District	Any use permitted in the Local Business District, wholesalers, distributors, theaters, used car lots, dry cleaning, automobile sales and repair, printing, dairies, hotels, laundries, private vocational schools, lockers and cold storage plants, and other similar uses	Automobile service stations, animal hospitals and kennels, cemeteries, drive-in restaurants, laboratories, motels, private clubs, outdoor recreational facilities, outdoor theaters, quarrying, trailer camps, commercial fish and bait ponds, public and commercial disposal operations, restaurants, lake resorts, taverns, and similar uses	20,000 square feet	120	33	0.5	0.3
Limited Industrial District	Any use permitted in the General Business or Agricultural District, trades and industries of a restrictive character	Same as permitted in the *General* Business District plus fur farms, pig farms, wholesale livestock fattening of livestock, pea vineries, creameries, and condenseries	1 acre	150	65	0.9	0.7
General Industrial District	Any use permitted in the Limited Industrial District, and other commercial or industrial uses not otherwise prohibited by law	Same as permitted in the Limited Industrial District	1 acre	150	719	9.8	7.3
Total--Town of Lisbon	--	--	--	--	7,345	100.0	74.8

[a]Rounded to nearest acre.

Source: SEWRPC.

Map 4

EXISTING ZONING IN THE VILLAGE OF SUSSEX STUDY AREA: 1980



LEGEND

VILLAGE OF SUSSEX (SEE INSET)

TOWN OF LISBON

A-1	RESIDENCE	I-1	LIMITED INDUSTRIAL
A-2	RESIDENCE	I-2	GENERAL INDUSTRIAL
A-3	RESIDENCE	A	AGRICULTURAL
B-1	RESTRICTED BUSINESS	Q-1	QUARRYING
B-2	LOCAL BUSINESS	C-1	CONSERVANCY
B-3	GENERAL BUSINESS		

VILLAGE OF MENOMONEE FALLS

A-1	AGRICULTURAL
C-1	NEIGHBORHOOD BUSINESS
CW-1	CONSERVANCY-WETLANDS
F-1	FLOODLANDS
P-2	INSTITUTIONAL
R-2	SINGLE FAMILY RESIDENCE

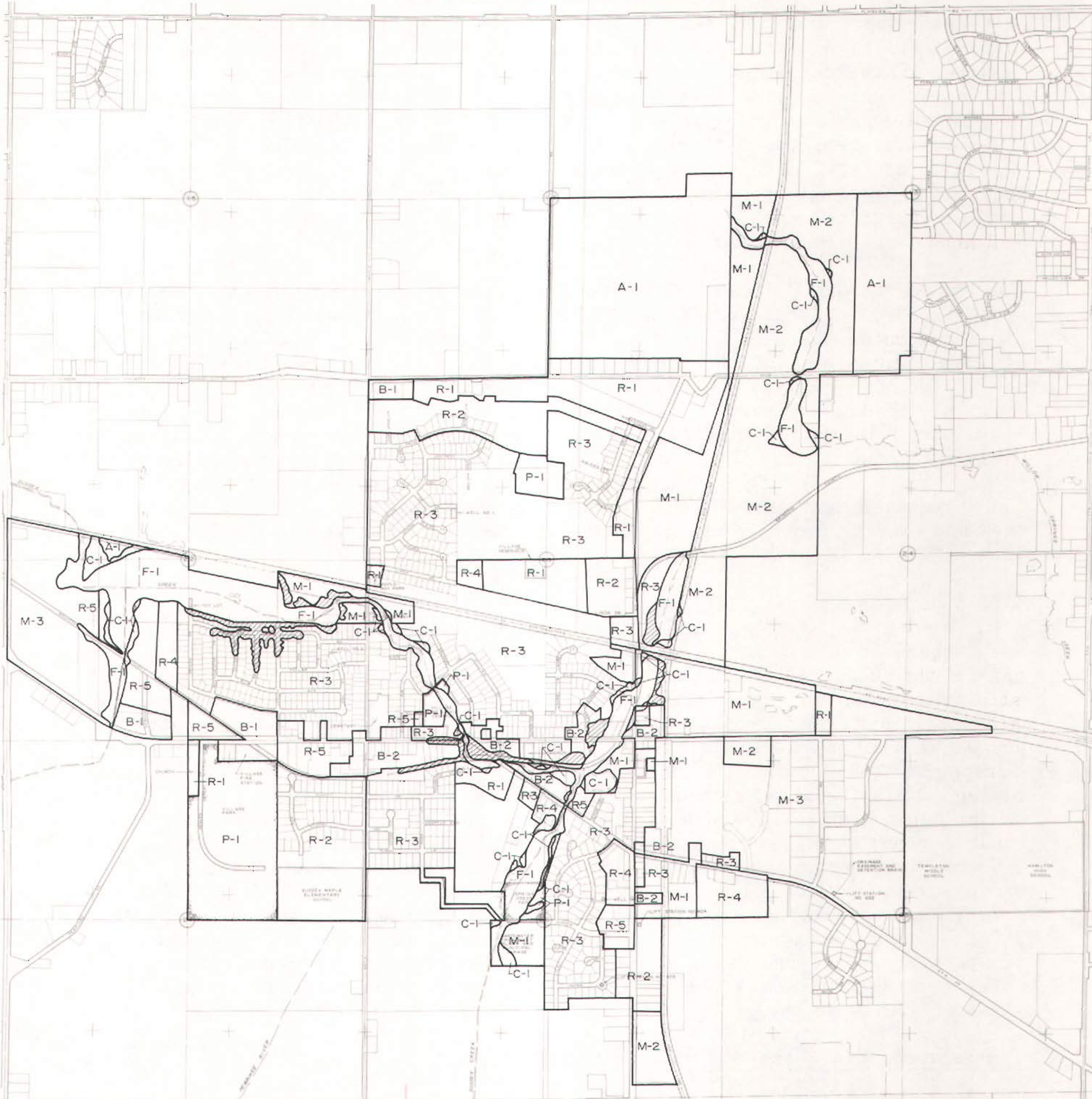
VILLAGE OF LANNON

R-1	RESIDENTIAL
R-2	RESIDENTIAL
R-3	RESIDENTIAL
Q	QUARRY

GRAPHIC SCALE: 0 — 1 MILE; 0 — 2000 — 4000 — 6000 FEET

Source: SEWRPC.

Map 4 (continued)



LEGEND

—	ZONING DISTRICT BOUNDARY LINE	R-4	TWO-FAMILY RESIDENTIAL DISTRICT	M-2	HEAVY INDUSTRIAL DISTRICT
A-1	AGRICULTURAL DISTRICT	R-5	MULTIPLE-FAMILY RESIDENTIAL DISTRICT	P-1	PARK DISTRICT
R-1	SINGLE-FAMILY RESIDENTIAL DISTRICT	B-1	NEIGHBORHOOD BUSINESS DISTRICT	C-1	LOWLAND CONSERVANCY DISTRICT
R-2	SINGLE-FAMILY RESIDENTIAL DISTRICT	B-2	COMMUNITY BUSINESS DISTRICT	F-1	FLOODWAY DISTRICT
R-3	SINGLE-FAMILY RESIDENTIAL DISTRICT	M-1	INDUSTRIAL DISTRICT	(hatched)	FLOODPLAIN FRINGE OVERLAY DISTRICT

GRAPHIC SCALE

0 800 1600 2400 FEET

The subdivision and improvement of land within the Town of Lisbon is regulated by the Town of Lisbon subdivision control ordinance. The ordinance requires that preliminary and final subdivision plats be filed for all divisions of land which create five or more parcels of land 1.5 acres or less in area. It further requires that a certified survey map be filed for all divisions of land which create two but not more than four parcels of land that are five acres or less in size. Furthermore, the ordinance requires that a subdivider install subdivision improvements, including road ditches and culverts, prior to final plat approval, and that open spaces be reserved or dedicated or that a fee be paid in lieu of dedication. The improvement requirements of the land subdivision control ordinance commits the Town to the use of rural street cross-sections and attendant rural stormwater drainage facilities.

The Waukesha County Board of Supervisors adopted a shoreland and floodland protection zoning ordinance in 1970. This ordinance, prepared pursuant to the requirements of the Wisconsin Water Resources Act of 1965, imposes special land use regulations on all lands located within 1,000 feet of the shoreline of any navigable lake, pond, or flowage, and within 300 feet of the shoreline of any navigable river or stream or to the landward side of the floodplain, whichever is greater. This ordinance is important to stormwater management planning in that it protects the floodlands and wetlands, and the attendant floodwater storage capacity, along the major streams--Sussex Creek, Willow Springs Creek, and an unnamed tributary to the Pewaukee River--from intrusion by incompatible uses and thereby protects the major outlets for storm drainage systems.

CLIMATE AND HYDROLOGY

Air temperatures and the type, intensity, and duration of precipitation events affect the extent of areas subject to inundation and the type and magnitude of stormwater problems which occur throughout the study area. The study area has a typical continental-type climate characterized primarily by a continuous progression of markedly different seasons and a wide range in monthly temperatures. The study area lies 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. Meteorologic data are available from the Waukesha National Weather Service Station, located in relatively close proximity to the Village of Sussex.

Temperature and Seasonal Considerations

Air temperatures, which exhibit a wide monthly range in the study area, are relevant to stormwater management planning and determine whether precipitation occurs as rainfall or snowfall, whether the ground is frozen and therefore essentially impervious, and the rate of snowmelt and attendant runoff.

Monthly air temperature variations at the Waukesha National Weather Service Station are presented in Table 7. Summer temperatures, as measured by the

Table 7

MONTHLY TEMPERATURE CHARACTERISTICS AT THE WAUKESHA WEATHER STATION: 1940 THROUGH 1977

Month	Average Daily Maximum (°F)	Average Daily Minimum (°F)	Mean (°F)[a]
January........	27	11	19
February.......	31	15	23
March..........	40	23	32
April..........	56	35	46
May............	67	45	56
June...........	78	55	67
July...........	83	60	72
August.........	81	59	70
September......	73	51	62
October........	63	41	52
November.......	45	29	37
December.......	32	17	25
Year	56.3	36.8	46.8

[a]The monthly mean temperature is the mean of the average daily maximum temperature and the average daily minimum temperature for each month.

Source: The National Weather Service and SEWRPC.

monthly means for June, July, and August, average from 67°F to 72°F. Winter temperatures, as measured by the monthly means for December, January, and February, average from 19°F to 25°F. For the period of 1930 through 1977 at Waukesha, the maximum recorded temperature was 109°F in July 1936, and the lowest recorded temperature was -27°F in January 1944. 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 study area. 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 and lakes begin to freeze over in late November, and ice breakup usually occurs in late March or early April. Ice jams at bridges in spring can be a major cause of localized flooding. Such occurrences can be severe when combined with spring rainfall periods.

Precipitation

Precipitation within the study area takes the form of rain, sleet, hail, and snow, and ranges from gentle showers of trace quantities to brief, but intense and potentially destructive, thunderstorms or major rainfall-snowmelt events causing 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 Waukesha National Weather Service Station for the period from 1890 through 1980 are presented in Table 8. The average annual total precipitation in the Sussex area based on the City of Waukesha data is 30.87 inches, expressed as a water equivalent, while the average annual snowfall and sleet measured as snow and sleet is 41.8 inches. Assuming that 10 inches of measured snowfall and sleet are equivalent to one inch of water, the average annual snowfall of 41.8 inches is equivalent to 4.18 inches of water and, therefore, only about 14 percent of the average annual total precipitation occurs as snowfall and sleet. Average total monthly precipitation for the Sussex area ranges from 1.04 inches in

Table 8

MONTHLY PRECIPITATION CHARACTERISTICS AT THE WAUKESHA WEATHER STATION

Month	Average Total Precipitation 1890 Through 1980 (inches)	Average Snow and Sleet 1930 Through 1959 (inches)
January....	1.56	11.8
February...	1.04	6.6
March......	2.20	10.7
April......	2.96	1.1
May........	3.32	0.4
June.......	3.74	--
July.......	3.67	--
August.....	3.12	--
September..	3.20	--
October....	2.12	--
November...	2.18	3.5
December...	1.69	7.7
Year	30.87	41.8

Source: The National Weather Service and SEWRPC.

February to 3.74 inches in June. The principal snowfall months are December, January, February, and March, during which 88 percent of the average annual snowfall may be expected to occur.

An important consideration in stormwater drainage is the seasonal nature of precipitation patterns and the occurrence of major storms in the spring when ground is either frozen or saturated. These periods generally result in the most significant stormwater drainage problems in the study area. During the period of 1940 through 1980, most floods occurred in the Fox River watershed during late winter or early spring. During that period, 56 percent of the yearly peak flows occurred in March or April.

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 9. 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 55 percent of the average annual precipitation of 31.30 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 161 percent of the average annual precipitation. The maximum monthly precipitation measured in southeastern Wisconsin was 13.17 inches, which occurred at West Bend in August 1924. The maximum 24-hour precipitation recorded in southeastern Wisconsin was in the West Bend area on August 4, 1924, when 7.58 inches of rain fell.

Table 9

EXTREME PRECIPITATION PERIODS IN SOUTHEASTERN WISCONSIN: SELECTED YEARS 1870 THROUGH 1981

Observation Station		Period of Precipitation Records Except Where Indicated Otherwise	Total Precipitation						
			Maximum Annual		Minimum Annual		Maximum Monthly		
Name	County		Amount	Year	Amount	Year	Amount	Month	Year
Mitchell Field.....	Milwaukee	1870-1980	50.36[a]	1876	18.69[a]	1901	10.03	June	1917
Racine...........	Racine	1895-1980	48.33	1954	17.75	1910	10.98	May	1933
Waukesha..........	Waukesha	1892-1980	43.57	1938	17.30	1901	11.41	July	1952
West Bend.........	Washington	1922-1980	40.52	1938	19.72	1901	13.14[b]	August	1924
West Allis........	Milwaukee	1954-1981	42.85	1960	17.49	1963	9.63	June	1954
Mt. Mary College...	Milwaukee	1954-1981	41.25	1965	18.50	1963	10.17	June	1968

[a] Based on the period 1841-1970.

[b] Based on the period 1895-1959 in A Survey Report for Flood Control on the Milwaukee River and Tributaries, U. S. Army Engineer District, Chicago, Corps of Engineers, November 1964.

Source: U. S. Army Corps of Engineers, the National Weather Service, Wisconsin Statistical Reporting Service, and SEWRPC.

Based on a period of record from 1892 through 1980 at Waukesha, the minimum annual precipitation was 17.30 inches reported in 1901, and the maximum annual precipitation was 43.57 inches reported in 1938. The maximum monthly precipitation was 11.41 inches recorded in July 1952, and the maximum 24-hour precipitation was 5.09 inches recorded on July 18, 1952. The maximum and minimum annual snowfall amounts were 83.0 inches in 1917-1918, and 9.1 inches in 1967-1968, respectively.

Stormwater drainage system design must consider the characteristics of rainfall events for periods of time substantially shorter than 24 hours. The characteristics of rainfall events over these shorter peak precipitation periods are discussed in the section on hydrology.

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 facilities. Snow cover in the Sussex area is most likely during the months of December, January, and February, during which at least a 0.40 probability exists of having one inch or more of snow cover, as measured at the Milwaukee weather station. 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 the proportion of rainfall or snowmelt that will run off the land directly into storm sewerage systems or into 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, extending 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.

Hydrology

Rainfall intensity-duration-frequency relationships are an important element in stormwater management data analysis and system design. Such relationships facilitate determination of the average rainfall intensity--normally expressed in inches per hour--which is 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 developed a set of rainfall intensity-duration-frequency relationships using both a graphic procedure and a mathematical curve fitting method executed by a digital computer program. The data, based upon 64 years of record collected by the National Weather Service at the Mitchell Field Observation Station in Milwaukee, are shown in tabular form in Table 10 and presented in Figure 1. The intensity-duration-frequency equations resulting from the analysis of the Milwaukee data are presented in Table 11.

The intensity-duration-frequency data set forth in Table 10 are based on a frequency analysis of Milwaukee rainfall for the 64-year period from 1903 through 1966 and, therefore, along with the curves in Figure 1 and the equations in

Table 10

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	4.32	3.40	2.89	1.93	1.16	0.70	0.098
5	5.55	4.55	3.79	2.57	1.57	0.95	0.135
10	6.37	5.31	4.38	3.00	1.84	1.12	0.160
25	7.40	6.27	5.13	3.54	2.19	1.33	0.191
50	8.17	6.98	5.69	3.94	2.44	1.48	0.215
100	8.93	7.68	6.23	4.34	2.70	1.54	0.238

[a] These data are based on a statistical analysis of Milwaukee rainfall data for the 64-year period of 1903 through 1966.

[b] Intensity expressed in inches per hour.

Source: SEWRPC.

Table 11

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

Recurrence Interval (years)	Equation[b]	
	Duration of Five Minutes or More But Less Than 60 Minutes	Duration of 60 Minutes or More Through 24 Hours
2	$I = \frac{87.5}{15.4 + T}$	$I = 28.9\ T^{-0.781}$
5	$I = \frac{120.2}{16.6 + T}$	$I = 38.2\ T^{-0.776}$
10	$I = \frac{141.8}{17.1 + T}$	$I = 44.2\ T^{-0.772}$
25	$I = \frac{170.1}{17.8 + T}$	$I = 52.3\ T^{-0.771}$
50	$I = \frac{190.1}{18.0 + T}$	$I = 57.3\ T^{-0.768}$
100	$I = \frac{211.4}{18.4 + T}$	$I = 63.5\ T^{-0.768}$

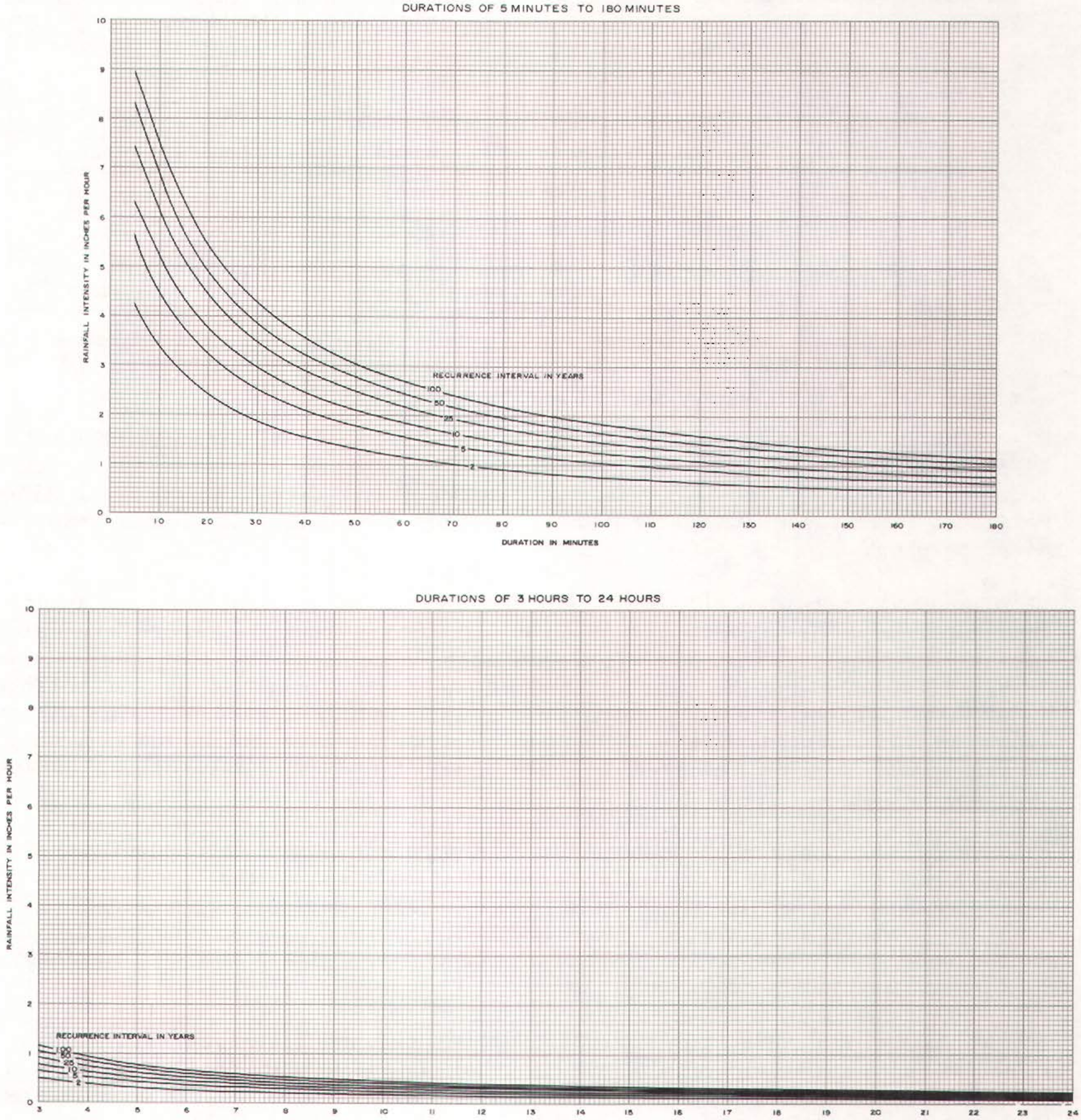
[a] The equations are based on Milwaukee rainfall data for the 64-year period of 1903 through 1966. These equations are applicable, within an accuracy of ±10 percent, to the entire Southeastern Wisconsin Region.

[b] I = Rainfall intensity in inches per hour.
T = Duration in minutes.

Source: SEWRPC.

Figure 1

POINT RAINFALL INTENSITY-DURATION-FREQUENCY RELATIONSHIPS FOR MILWAUKEE, WISCONSIN



Source: SEWRPC.

Table 11, are directly applicable to the greater Milwaukee area. Analyses conducted by the Commission staff have indicated that these data sources are valid and reasonable for use anywhere in southeastern Wisconsin, including the Sussex area.

The volume of rainfall and stormwater associated with a given storm is also useful in assessing the adequacy of stormwater drainage systems. The determination of annual maximum precipitation event volumes was based on about

Table 12

SELECTED INFORMATION ABOUT PRECIPITATION EVENTS AS DEFINED USING MINIMUM ANTECEDENT AND SUBSEQUENT DRY PERIODS OF 1, 2, 3, 6, 12, AND 24 HOURS[a]

Minimum Antecedent and Subsequent Dry Period (hours)	Number of Precipitation Events		Smallest Event (inches)	Largest Event (inches)	Median Event (inches)
	In 37-Year Period	Average Per Year			
1	6,719	182	0.01	3.42	0.04
2	5,577	151	0.01	4.16	0.06
3	5,008	136	0.01	4.31	0.07
6	4,147	113	0.01	6.05	0.10
12	3,458	94	0.01	6.20	0.14
24	2,842	77	0.01	6.20	0.19

[a]Based on approximately 37 years of hourly precipitation data for the Milwaukee National Weather Service Station from January 1, 1940 through October 31, 1976.

Source: The National Weather Service and SEWRPC.

37 years of hourly precipitation data--January 1, 1940 through October 31, 1976--as recorded at the Milwaukee National Weather Service station currently located at General Mitchell Field. These data had been previously obtained, verified, and placed in a computer file under the Commission water resources planning program.

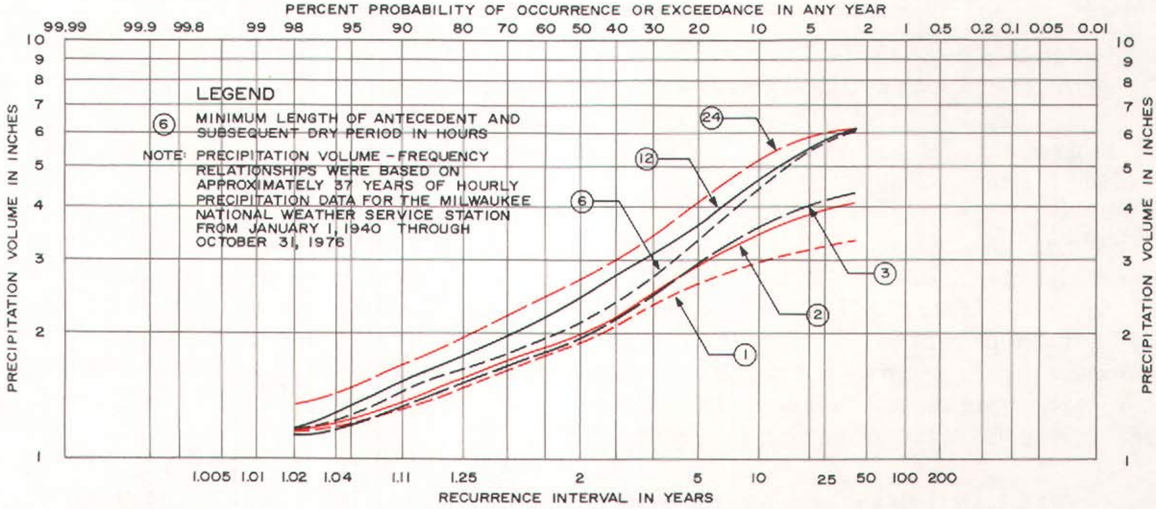
A "discrete" precipitation event may be defined as a continuous or uninterrupted period of rainfall. The available historic records report precipitation on an hourly basis; therefore, in accordance with the above definition, a precipitation event would be defined as the period preceded by and followed by at least one hour during which no precipitation was recorded. The minimum length of the antecedent and subsequent dry period used to define a precipitation event must be tailored to the intended use of the resulting data on rainfall volumes.

Because of the apparent importance of the minimum length antecedent and subsequent dry period used to define precipitation events, the 37-year precipitation record was analyzed using a range of dry periods. Specifically, the number, time of occurrence, and depth of precipitation events during that period were determined using minimum antecedent and subsequent dry periods of 1, 2, 3, 6, 12, and 24 hours.

Table 12 presents selected information about the precipitation events identified for each of the six minimum lengths of antecedent and subsequent dry periods, including the number of events in the 37-year period, the average number of events per year, the depth of the largest and smallest events, and the depth of the median event. As would be expected, the total number of events in the 37-year period and the average number of events per year decreases as the minimum length of the antecedent and subsequent dry period increases. For example, using a minimum antecedent and subsequent dry period of one hour, 6,719 precipitation events occurred during a 37-year period for an average of 182 per year with the largest event having a depth of 3.42 inches. When the minimum antecedent and subsequent dry period is increased to 24 hours, the number of precipitation events in the 37-year period decreases 58 percent to 2,842, or an average of 77 events per year, and the magnitude of the largest event increases by 81 percent to 6.20 inches.

Figure 2

PRECIPITATION VOLUME-FREQUENCY RELATIONSHIPS FOR A STORM EVENT DEFINED BY MINIMUM ANTECEDENT AND SUBSEQUENT DRY PERIODS OF 1, 2, 3, 6, 12, AND 24 HOURS OVER THE PERIOD OF 1940 THROUGH 1976



Source: SEWRPC.

Figure 2 permits determination of a precipitation volume for a specified design frequency or recurrence interval and a specified minimum length antecedent and subsequent dry period. That design precipitation volume can then be converted to a design stormwater runoff volume. Rainfall-runoff relationships and calculations are discussed in more detail in Chapter VII of this report.

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 storage. The soil characteristics and 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, in 1963, negotiated a cooperative agreement with the U. S. Soil Conservation Service under which detailed operational soil surveys were completed for the entire planning 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 of soils within the Region 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, resource conservation purposes, and underlying stormwater management purposes. Detailed soils maps are available of the study area 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 poor drainage.

The spatial distribution of the four hydrologic soil groups within the study area is shown on Map 5. Hydrologic soil group A does not appear in the study area, whereas hydrologic soil groups B, C, and D comprise 66 percent, 15 percent, and 16 percent, respectively, of the study area. The remaining 3 percent is covered by man-made features. It is important to note that about two-thirds of the study area is covered by group B soils which generate only moderate runoff compared with other soil groups.

Areas covered by soils having a shallow depth to bedrock tend to be very costly to develop, particularly to serve with sanitary and storm sewers and public water supply mains. Map 6 presents those soils underlain by bedrock five feet or less from the surface. These soils cover about 1,850 acres, or approximately 19 percent of the study area.

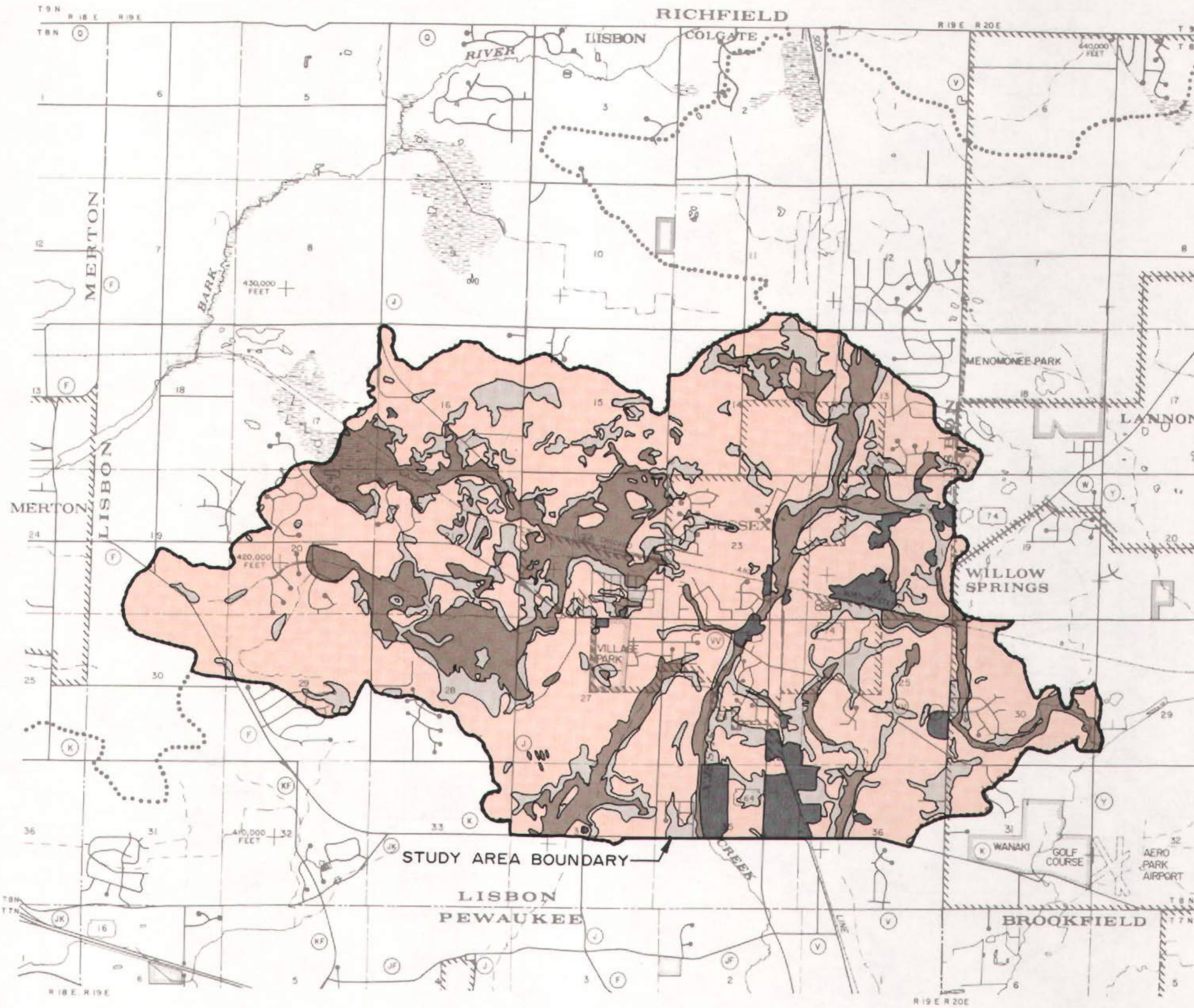
WATER QUALITY

The quality of the surface waters in the study area, primarily Sussex Creek and its tributaries, Willow Springs Creek, the unnamed tributary of the Pewaukee River, and a few small ponds, is an ancillary albeit important concern of this study. Improper stormwater management may result in pollutant contributions from the watershed to the streams and in high-flow velocities and volumes causing erosion of stream banks and undermining of the root systems of trees and shrubs which stabilize these banks. 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, also results in the discharge of other pollutants, such as nutrients, pesticides, and metals, which are transported in the stream system attached to sediment particles. High pollutant concentrations and excessive erosion and sedimentation in the streams and ponds also reduce the suitability of these surface waters for recreational uses such as swimming, fishing, and boating, and limit the ability of the water body to support desirable forms of fish and other aquatic life. Stormwater runoff from urban lands, including lawns and pavements can also contain relatively high concentrations of water pollutants such as organic substances, nutrients, fecal coliform organisms, metals, and sediment.

The proper planning and design of stormwater management facilities requires consideration of the potential impacts of the recommended management measures, and of alternatives thereto, on water quality conditions. Thus, definitive data on existing water quality conditions are important in the stormwater management planning effort, serving as a baseline for assessing the potential changes in

Map 5

HYDROLOGIC SOIL GROUPS WITHIN THE VILLAGE OF SUSSEX STUDY AREA



LEGEND

(NONE) GROUP A WELL DRAINED SOIL

GROUP B MODERATELY DRAINED SOIL

GROUP C POORLY DRAINED SOIL

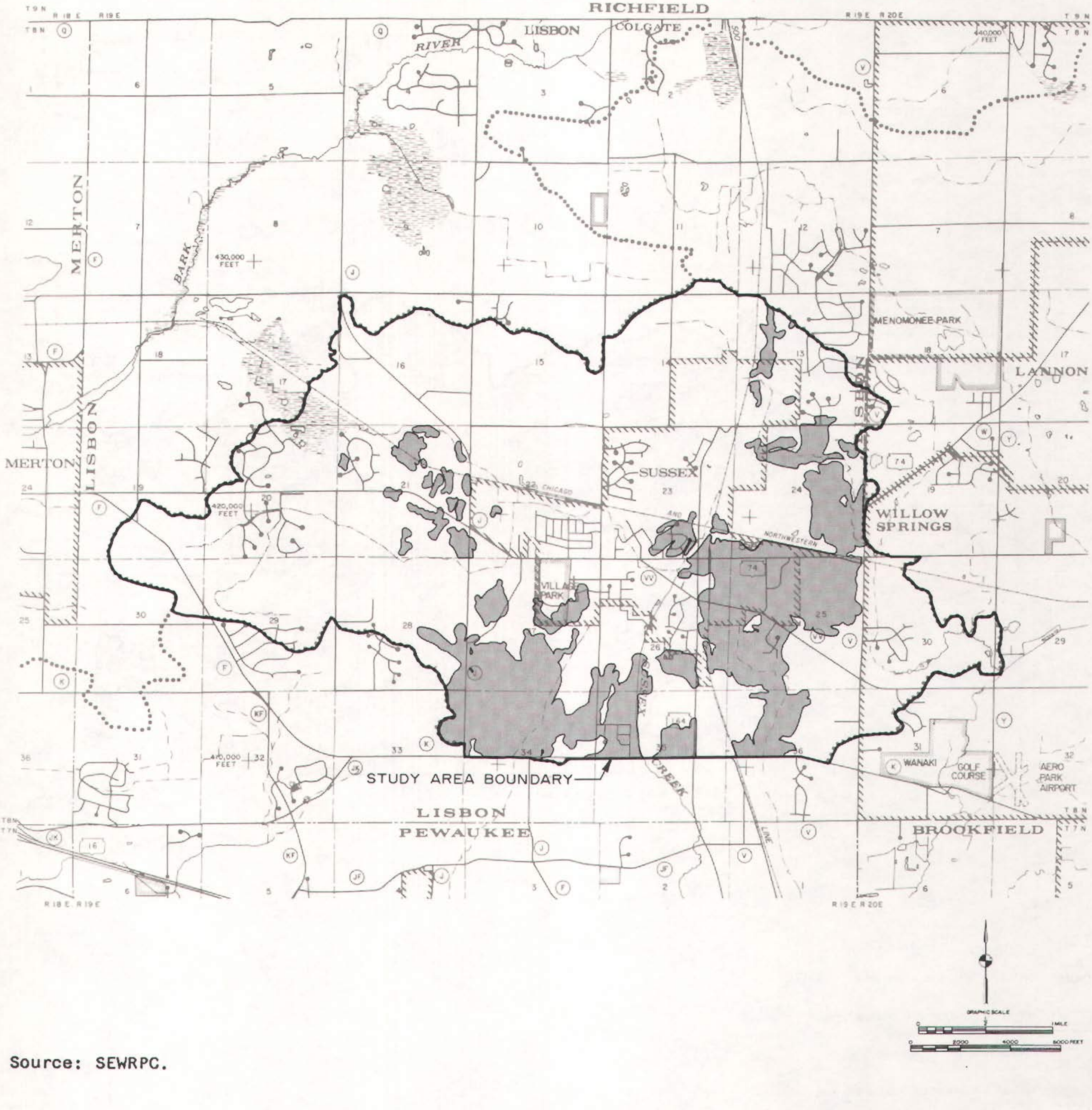
GROUP D VERY POORLY DRAINED SOIL

MAN MADE FEATURES OR DISTURBED SOILS

Source: SEWRPC.

Map 6

SOILS UNDERLAIN BY BEDROCK FIVE FEET OR LESS FROM THE SURFACE WITHIN THE VILLAGE OF SUSSEX STUDY AREA



Source: SEWRPC.

Table 13

WATER QUALITY CONDITIONS IN SUSSEX CREEK AT STH 164 LOCATED ABOUT THREE MILES DOWNSTREAM OF THE VILLAGE OF SUSSEX: 1968 THROUGH 1975

Parameter	Number of Analyses	Maximum	Average	Minimum
Chloride (mg/l)	22	98.0	64.9	37.0
Dissolved Oxygen (mg/l)	29	13.7	7.1	4.4
Ammonia-Nitrogen (mg/l)	8	0.58	0.22	0.08
Organic-Nitrogen (mg/l)	8	1.75	1.12	0.68
Total-Nitrogen (mg/l)	8	5.09	3.95	2.56
Specific Conductance (umhos/cm at 25°C)	29	1,036	825	360
Nitrite-Nitrogen (mg/l)	12	0.33	0.17	0.05
Nitrate-Nitrogen (mg/l)	12	3.23	2.55	0.99
Total Phosphorus (mg/l)	8	0.87	0.51	0.02
Fecal Coliform (MFFCC/100 ml)	12	2,500	809	10
Temperature (°F)	30	80.0	65.5	60.0
pH (standard units)	22	8.7	8.0	7.6

Source: SEWRPC.

water quality conditions that may be anticipated upon implementation of recommended stormwater management measures. As part of the Commission's long-term water quality monitoring program, water quality conditions in Sussex Creek at STH 164--located about three miles downstream of the Village--were monitored annually from 1968 through 1975. The sampling site was located downstream of the Sussex wastewater treatment plant and the Mammoth Springs Canning Corporation and Halquist Stone Company, Inc. industrial wastewater outfalls. Stream water samples were generally collected during summer low-flow conditions. Storm event samples are not available. A summary of the resulting water quality data is set forth in Table 13.

An analysis of the water quality data presented in Table 13 indicates that Sussex Creek exhibited relatively high concentrations of nutrients--nitrogen and phosphorus--and fecal coliform organisms through 1975. The average phosphorus concentration was over five times the Commission-recommended maximum standard to support recreational uses of 0.1 mg/l. The high nutrient concentrations present through 1975 are largely attributable to discharges from the Sussex wastewater treatment facility. In 1975, the Sussex wastewater treatment facility effluent discharge contained an average of 4.5 mg/l of total phosphorus. The installation of phosphorus removal facilities at the Sussex wastewater treatment plant in 1976 has substantially reduced the concentrations of phosphorus contained in the effluent. In 1981, the treatment plant effluent contained an average phosphorus concentration of only 0.16 mg/l. The average fecal coliform level measured in Sussex Creek was twice as high as the recommended standard for fecal coliform to support full-body contact recreational water uses. Common sources of high levels of fecal coliform are malfunctioning onsite sewage disposal systems; bypasses, discharges, and leaks from sanitary sewers and treatment facilities; livestock raising operations; and domestic pet and wildlife wastes. The dissolved oxygen concentrations and temperature levels measured in Sussex Creek were generally suitable to support desirable forms of fish and other aquatic life. The chloride concentrations, often used as an indication of human impact on a water body, were relatively high, but within the range of values found in the Fox River watershed. Sources of chloride include wastewater treatment facility effluent, street deicing salts, runoff from livestock operations, and industrial discharges.

The identification and quantification of water pollution sources, as well as the relationship between pollution sources and water quality conditions, are set forth in SEWRPC Planning Report No. 30, A Regional Water Quality Management Plan for Southeastern Wisconsin: 2000. The information provided in that report on pollution source and water quality was used in the development of the Sussex stormwater management plan as that plan relates to the type, quantity, and control of pollution sources.

STORMWATER DRAINAGE SYSTEM

The existing stormwater drainage system serving the study area is influenced by the topography of the land surface; the watershed subbasins or drainage areas to specific stream reaches; the streams, drainage channels, and ponds; and any engineered drainage systems.

Topography

Topography, or relative elevation of the land surface within the study area, is one of the most important considerations in the planning and design of a stormwater management system. The topography of the land surface defines drainage areas, influences the rate and magnitude of surface water runoff and soil erosion, and determines the uses to which the land can be put and, therefore, the related stormwater management needs.

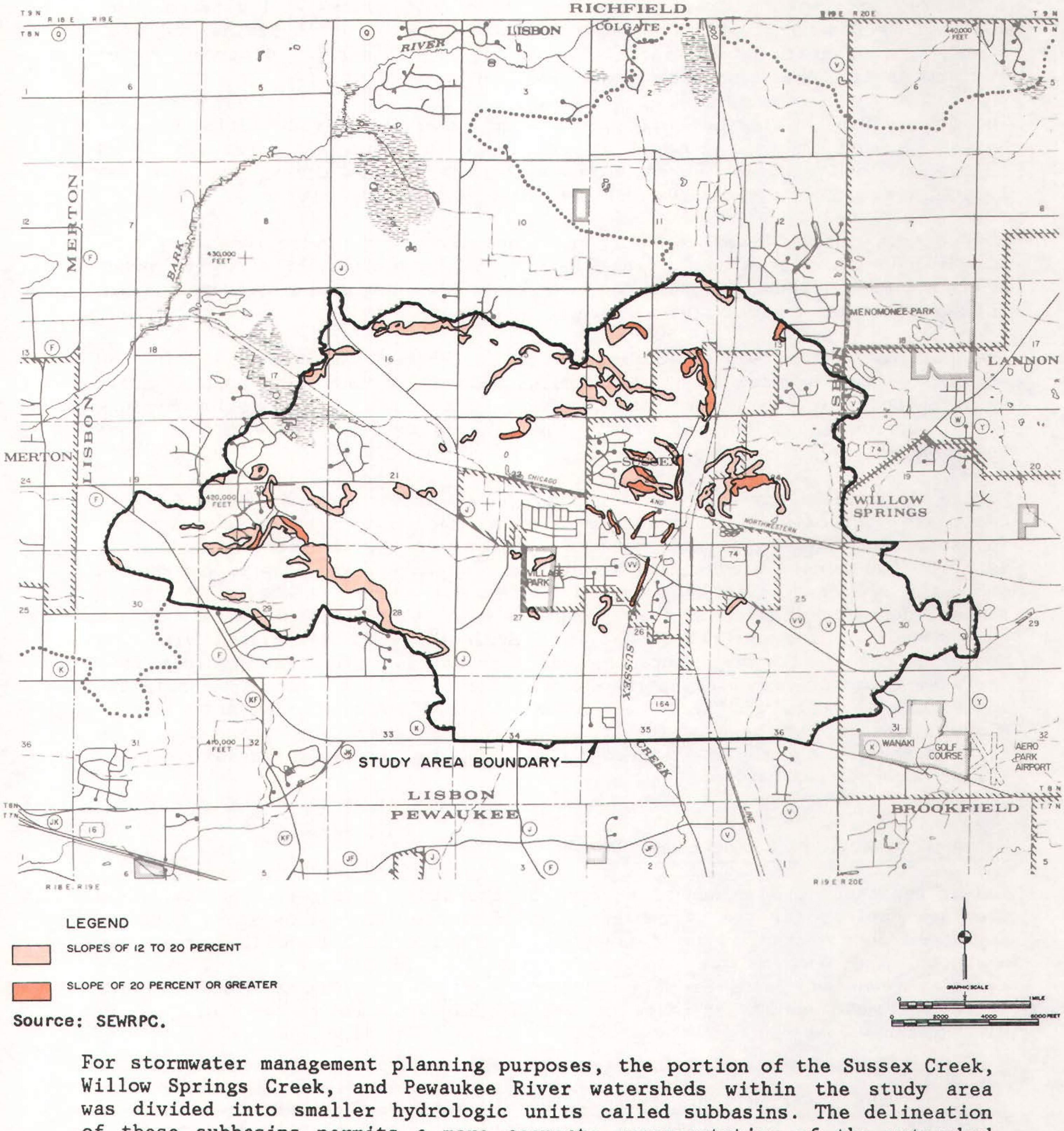
The elevation of the study area ranges from a low of about 830 feet above the National Geodetic Vertical Datum (NGVD) in the southwest one-quarter of Section 29, Township 8 North, Range 20 East, in the Village of Menomonee Falls, to a high of about 1,140 feet above the NGVD at the northwest one-quarter of Section 29, Township 8 North, Range 19 East, in the Town of Lisbon. Land surface slopes for small drainage areas range from a low of about 0.12 percent for a drainage area located in the northeast one-quarter of Section 26, Township 8 North, Range 19 East, to a high of about 9.17 percent for a drainage area located in the northeast one-quarter of Section 27, Township 8 North, Range 19 East. Areas with steep slopes within the study area are shown on Map 7. About 365 acres, or 4 percent, of the study area are marked by slopes ranging from 12 to 20 percent; and 86 acres, or about 1 percent, are marked by slopes greater than 20 percent. 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.

Watershed Subbasins

Stormwater from the entire study area, as delineated in Chapter II, is drained to three separate surface water systems--those systems being the intermittent and perennial streams of the Sussex Creek watershed, the Willow Springs Creek watershed, and the Pewaukee River watershed. In addition to serving as outlets for stormwater drainage from the urban service area of the Village, Sussex Creek and Willow Springs Creek drain areas located upstream of the planned urban service area. These upstream tributary drainage areas must be considered, as well as the drainage areas partially within and extending downstream of the planned urban service area, in the proper design of a stormwater management system for the Village.

Map 7

AREAS WITH STEEP SLOPES WITHIN THE VILLAGE OF SUSSEX STUDY AREA



LEGEND

SLOPES OF 12 TO 20 PERCENT

SLOPE OF 20 PERCENT OR GREATER

Source: SEWRPC.

For stormwater management planning purposes, the portion of the Sussex Creek, Willow Springs Creek, and Pewaukee River watersheds within the study area was divided into smaller hydrologic units called subbasins. The delineation of these subbasins permits a more accurate representation of the watershed hydrology in the computer model used to simulate stormwater runoff. The subbasin was thus the basic inventory unit within which watershed hydrologic characteristics were quantified prior to hydrologic modeling.

A number of considerations entered into the delineation of the subbasins. Using the topographic maps, the subbasins were delineated to provide a desired approximate areal extent tributary to streams and watercourses, and to have discharge points located at confluences of tributaries and main stems; at, or near, bridges and culverts; at the boundaries of areas served by storm sewers, and at selected storm sewer inlets and outlets.

The Sussex Creek watershed within the study area was divided into 90 subbasins ranging in size from about two acres to about 560 acres, as shown on Map 8. Twenty-two of the subbasins within the Sussex Creek watershed are located within the service area of the existing storm sewer system.

The portion of the Pewaukee River watershed that lies within the study area was divided into 11 subbasins ranging in size from about 18 acres to about 293 acres. Two subbasins within the Pewaukee River watershed are located within the service area of the existing storm sewer system.

The portion of the Willow Springs Creek watershed that lies within the study area was divided into 16 subbasins ranging in size from approximately 53 acres to about 466 acres. None of the subbasins within the Willow Springs Creek watershed are located within the service area of the existing storm sewer system.

Within the total study area there are 117 subbasins, of which 24, or 21 percent, are located within the service area of the existing storm sewer system. The subbasins have an average size of about 85 acres; the smallest subbasin is about two acres in size, the largest is 560 acres. As shown on Map 8, the subbasins are designated by a branch number and a reach number. The branch number identifies the individual branch or major tributary to the main drainage channel of the watershed. The main drainageway is designated with the number one with the major branches or tributaries following in order from upstream tributaries to downstream tributaries. The reach numbers designate individual segments of the main drainage channel and its tributaries beginning with zero at the most upstream reach and continuing downstream. The reach numbering system is designed so that smaller numbered reaches drain to larger numbered reaches.

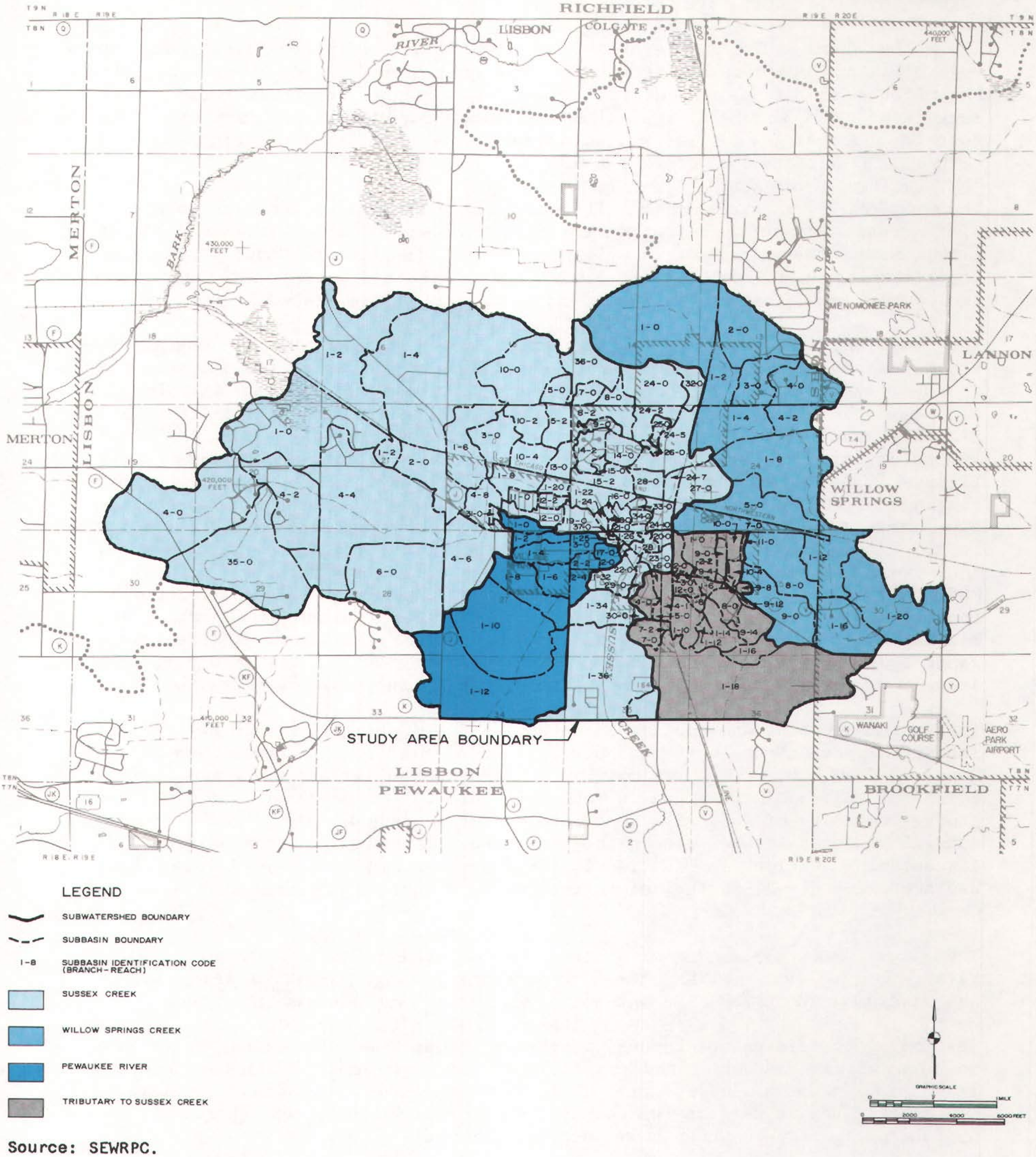
Streams, Drainage Channels, and Ponds

The intermittent and perennial streams in the study area serve as the major drainage outlets for the storm sewers and drainage ditches. As such, they are important components of the drainage system which must be characterized in order to plan a stormwater management system. All known intermittent and perennial streams and ponds in the study area are shown on Map 9. Table 14 sets forth pertinent characteristics of the drainageways and major storm sewers within each subbasin.

The Sussex Creek watershed contains 1.57 miles of perennial streams and 14.21 miles of intermittent streams. The average streambed slopes range from 0.02 percent to 1.82 percent. Channel roughness coefficients, expressed as

Map 8

WATERSHED SUBBASINS WITHIN THE VILLAGE OF SUSSEX STUDY AREA



Source: SEWRPC.

Manning's "n" values, range from 0.028 to 0.050.[1] Typical channel bottom widths range from about one foot to 20 feet. There are 20 ponds within the watershed, with a total area of 20.14 acres.

The Willow Springs Creek watershed contains 0.89 mile of perennial streams and 6.46 miles of intermittent streams. Average streambed slopes within each subbasin range from 0.17 percent to 0.94 percent. Channel roughness coefficients range from 0.027 to 0.035. Typical channel bottom widths range from about one foot to about six feet. The Willow Springs Creek watershed contains 20 ponds with a total surface area of 5.93 acres.

The Pewaukee River watershed that lies within the study area contains no perennial streams and two miles of intermittent streams. Average streambed slopes within each subbasin range from 0.14 percent to 1.16 percent. Channel roughness coefficients range from 0.032 to 0.036. Typical channel bottom widths vary from two to five feet. There are no ponds located within the watershed.

The location, configuration, and tributary areas of the existing engineered storm sewer system serving the Village of Sussex is shown on the map enclosed in the back cover of this report, together with street grades, manhole rim and sewer invert elevations, sewer grades, and sewer lengths and sizes. The existing storm sewer system serves a tributary drainage area of about 495 acres, or 25 percent of the area within the 1980 corporate limits of the Village. The system consists of approximately 30,082 lineal feet of sewers ranging in size from a 12-inch diameter circular sewer to a 29-by-45-inch pipe arch. Chapter VII of this report sets forth selected characteristics of the storm sewer system within each subbasin in the study area. Most of the sewers are constructed of reinforced concrete pipe. There are a total of 262 storm sewer inlets and catch basins, 172 manholes, and 25 outfalls in the system. Twenty-three of the outfalls discharge to Sussex Creek, while two discharge to the tributary of the Pewaukee River. The slopes of the sewers range from approximately 0.0005 feet per foot to about 0.0929 feet per foot. There are no major stormwater pumping facilities in the storm sewer system.

The system contains one engineered detention basin, located within the Village industrial park in the northwest one-quarter of Section 25, Township 8 North, Range 19 East. Pertinent information concerning the surface area and storage volume of this basin is given in Table 15. This detention basin has a maximum storage capacity of about 5.2 feet. Stormwater storage is also provided by some natural wetlands located within the study area. These are further described in a succeeding section. In addition to the storm sewers within the Village, there are approximately 3,350 feet of engineered open surface drainage channels, all of which are unpaved.

The storm sewer system is maintained by the Public Works Department of the Village of Sussex. In 1981, the cost of maintaining the storm sewer system was approximately $5,000. Maintenance activities include sewer, culvert, and

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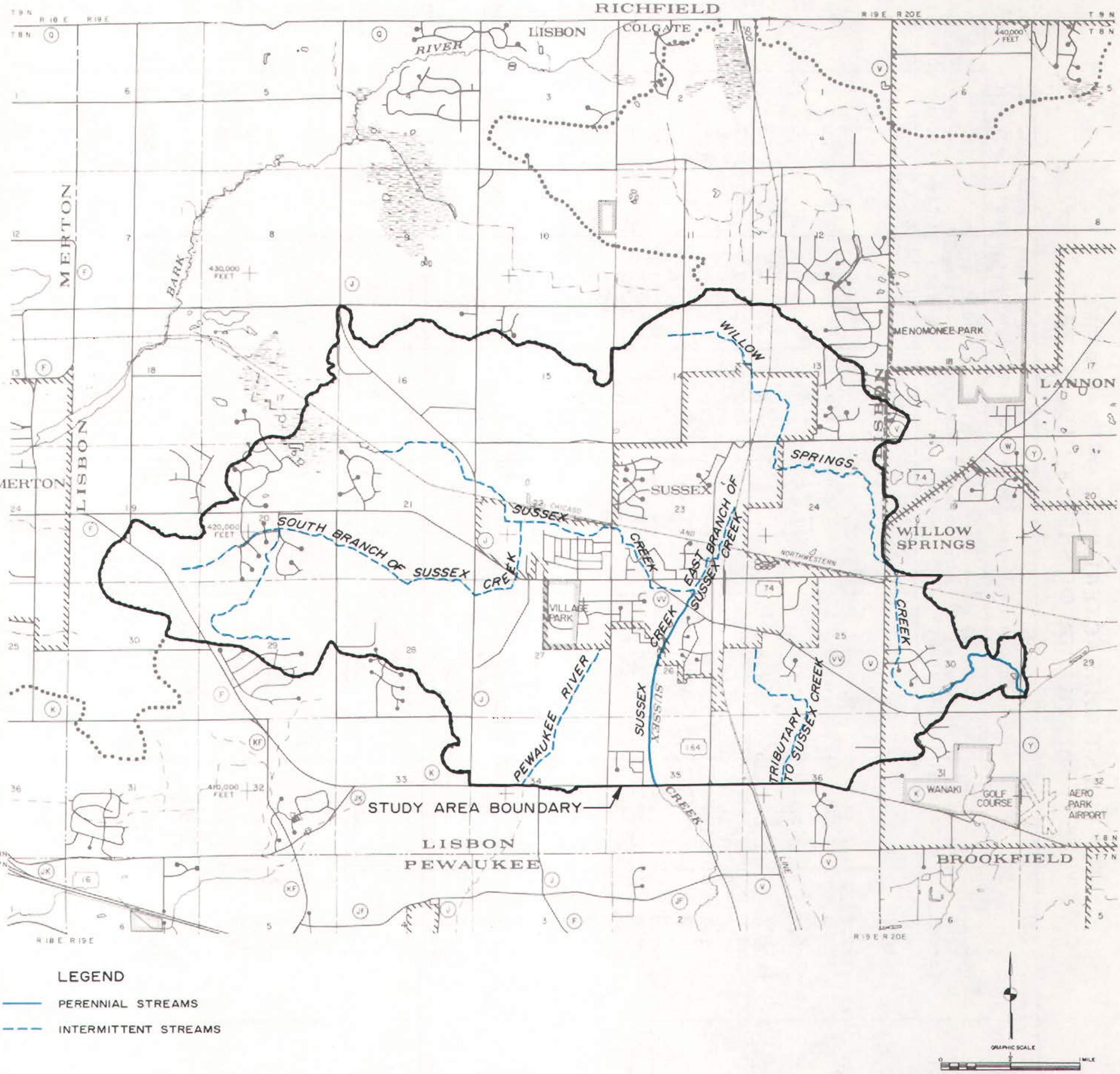
[1]Manning's coefficient of channel roughness "n" is a measure of the resistance to flow within a channel and typically ranges from about 0.013 for concrete lined pipes to about 0.050 for natural channels covered by dense vegetation. The coefficient is used in the computation of flow velocity and, therefore, the hydraulic capacity of channels and conduits.

Map 9

INTERMITTENT AND PERENNIAL STREAMS WITHIN THE VILLAGE OF SUSSEX STUDY AREA



Source: SEWRPC.

Table 14

PERTINENT CHARACTERISTICS OF SUBBASINS WITHIN THE VILLAGE OF SUSSEX STUDY AREA

Subbasin[a] (branch-reach)	Subbasin Area (acres)	Subbasin Drainageway and Major Storm Sewer Characteristics						
		Length (feet)	Slope (feet/feet)	Diameter (inches)	Height (feet)	Bottom Width (feet)	Side Slope (feet/feet)	Roughness Coefficient
Sussex Creek Subwatershed								
1-0	349.8	1,580	0.0022	--	1.0	10.0	0.05	0.040
1-2	399.5	1,300	0.0006	--	3.0	10.0	0.50	0.040
1-4	532.8	3,480	0.0029	--	3.0	4.0	0.30	0.040
1-6	122.2	2,080	0.0144	--	3.0	2.0	0.35	0.035
3-0	72.8	640	0.0031	--	1.0	6.0	0.50	0.035
4-0	409.0	2,080	0.0144	--	3.0	2.0	0.36	0.028
35-0	362.0	3,200	0.0156	--	2.0	5.0	0.43	0.030
4-2	171.0	2,360	0.0085	--	2.0	4.0	0.95	0.028
4-4	513.9	5,980	0.0002	--	2.0	6.0	0.63	0.032
6-0	301.0	3,700	0.0015	--	3.0	5.0	0.83	0.030
4-6	165.5	1,900	0.0021	--	4.0	5.0	0.30	0.032
4-8	55.4	2,080	0.0012	--	4.0	5.0	0.30	0.032
2-0	102.0	2,400	0.0035	--	0.5	99.0	0.40	0.035
1-8	49.2	2,288	0.0004	--	5.0	10.0	0.50	0.028
5-0	28.5	730	0.0110	--	1.0	10.0	0.20	0.035
36-0	103.2	350	0.035	--	1.0	10.0	0.30	0.045
7-0	17.0	780	0.0064	--	1.0	10.0	0.30	0.035
5-2[b]	35.7	--	--	--	--	--	--	--
8-0	29.9	1,350	0.0181	--	--	--	--	0.030
8-2	60.6	1,765	0.0094	--	1.0	10.0	0.40	0.035
9-0	27.7	1,562	0.0055	42	--	--	--	0.013
5-4	31.5	2,320	0.0024	--	0.5	20.0	0.20	0.035
10-0	159.5	1,345	0.0120	--	1.0	10.0	0.30	0.045
10-2[b]	49.6	--	--	--	--	--	--	--
10-4	31.0	1,620	0.0012	--	1.0	10.0	0.30	0.035
11-0	20.5	260	0.0050	21	--	--	--	0.013
12-0	31.8	318	0.0005	36	--	--	--	0.024
12-2	20.7	910	0.0013	36	--	--	--	0.024
1-20	17.8	1,460	0.0007	--	5.0	10.0	0.30	0.028
13-0	31.2	512	0.0071	30	--	--	--	0.035
14-0	40.5	840	0.0199	--	1.0	99.0	0.10	0.035
14-2	40.4	1,611	0.0057	42	--	--	--	0.013
15-0	6.6	164	0.0050	15	--	--	--	0.013
15-2	42.0	1,440	0.0050	--	1.0	5.0	0.10	0.035
1-22	52.9	1,790	0.0061	--	5.0	10.0	0.30	0.030
16-0	5.9	248	0.0075	15	--	--	--	0.013
1-24	7.3	800	0.0063	--	5.0	10.0	0.50	0.028
17-0	1.7	313	0.0023	18	--	--	--	0.013
18-0	3.0	42	0.0018	18	--	--	--	0.013
19-0	36.7	1,357	0.0039	42	--	--	--	0.013
1-26	19.7	1,900	0.0111	--	5.0	10.0	0.50	0.034
24-0	89.5	920	0.0228	--	1.0	50.0	0.10	0.035
24-2	41.3	1,380	0.0152	--	4.0	5.0	0.40	0.035
25-0	15.0	990	0.0254	27	--	--	--	0.013
32-0	43.6	900	0.0038	--	--	--	--	0.035
24-5	99.9	1,540	0.0032	--	0.5	99.0	0.05	0.050
26-0	4.1	527	0.0205	24	--	--	--	0.013

Table 14 (continued)

Subbasin (branch-reach)	Subbasin Area (acres)	Subbasin Drainageway and Major Storm Sewer Characteristics						
		Length (feet)	Slope (feet/feet)	Diameter (inches)	Height (feet)	Bottom Width (feet)	Side Slope (feet/feet)	Roughness Coefficient
Sussex Creek Subwatershed (continued)								
24-7	21.5	1,290	0.0054	--	0.5	40.0	0.20	0.030
27-0	73.1	500	0.0100	--	1.0	4.0	0.50	0.035
24-10	33.5	670	0.0120	--	1.0	5.0	0.20	0.030
33-0	8.6	1,071	0.0245	21	--	--	--	0.013
34-0	11.4	890	0.0148	18	--	--	--	0.013
28-0	34.3	700	0.0230	--	1.0	5.0	0.50	0.035
20-0	11.3	557	0.0141	24	--	--	--	0.013
21-0	27.3	994	0.0143	--	--	--	--	0.013
1-28	16.5	610	0.0049	--	4.0	10.0	0.50	0.035
22-0	4.0	400	0.0048	12	--	--	--	0.013
23-0	24.5	950	0.0019	36	--	--	--	0.013
1-32	59.2	2,000	0.0023	--	4.0	5.0	0.40	0.033
29-0	12.9	939	0.0123	24	--	--	--	0.013
1-34	85.3	1,440	0.0019	--	4.0	5.0	0.40	0.034
30-0	5.4	172	0.0023	24	--	--	--	0.013
1-36	196.8	3,920	0.0028	--	4.0	5.0	0.40	0.034
31-0	4.2	590	0.0048	21	--	--	--	0.013
37-0	1.2	270	N/A	18	--	--	--	0.013
Tributary to Sussex Creek								
1-0	57.4	1,960	0.0078	--	1.0	10.0	0.10	0.040
2-0	21.0	1,360	0.0055	--	0.5	10.0	0.05	0.040
2-2	1.9	760	0.0101	--	2.0	2.0	0.40	0.038
3-0	2.6	162	0.0074	27	--	--	--	0.013
1-6	12.7	1,240	0.0089	--	1.0	4.0	0.50	0.045
12-0	19.3	300	0.0033	--	1.0	2.0	0.50	0.040
1-8	11.4	800	0.0040	--	1.0	4.0	0.30	0.040
4-0	27.8	775	0.0053	36	--	--	--	0.024
5-0	6.5	260	0.0038	--	1.0	1.0	0.50	0.035
6-0	8.1	600	0.0067	--	1.0	3.0	0.50	0.035
4-1	21.6	750	0.0053	--	0.5	20.0	0.10	0.038
1-10	55.2	460	0.0016	--	2.0	4.0	0.50	0.040
7-0	30.3	330	0.0030	--	0.5	20.0	0.30	0.038
7-2	5.5	610	0.0049	--	0.8	5.0	0.40	0.038
1-12	6.8	760	0.0016	--	1.5	6.0	0.40	0.040
1-14	52.7	1,660	0.0072	--	1.5	6.0	0.50	0.040
8-0	31.1	780	0.0109	--	1.0	3.0	0.50	0.030
9-0	17.3	1,640	0.0067	--	1.0	3.0	0.30	0.038
9-4	4.2	580	0.0004	--	2.0	4.0	0.40	0.032
10-0	22.8	1,400	0.0086	--	1.0	3.0	0.30	0.038
11-0	2.1	1,300	0.0066	--	1.0	3.0	0.30	0.038
10-4	8.9	670	0.0090	--	1.5	14.0	0.20	0.038
9-8	4.1	110	0.0021	--	0.5	6.0	0.05	0.036
9-12	3.6	850	0.0165	--	1.5	3.0	0.50	0.036
1-16	66.1	1,190	0.0050	--	1.0	6.0	0.50	0.038
1-18	560.0	2,290	0.0013	--	1.0	6.0	0.20	0.038

Table 14 (continued)

Subbasin (branch-reach)	Subbasin Area (acres)	Subbasin Drainageway and Major Storm Sewer Characteristics						
		Length (feet)	Slope (feet/feet)	Diameter (inches)	Height (feet)	Bottom Width (feet)	Side Slope (feet/feet)	Roughness Coefficient
Pewaukee River Subwatershed								
1-0	25.0	440	0.0490	36	--	--	--	0.013
1-2	31.0	1,350	0.0160	--	2.0	2.0	0.65	0.032
1-4	26.1	760	0.0123	--	1.5	2.0	0.75	0.024
2-0	21.8	400	0.0150	--	1.0	15.0	0.20	0.035
2-2	17.7	604	0.0044	1.2	--	--	--	0.024
3-0	26.1	1,050	0.0100	--	1.0	5.0	0.20	0.030
2-4	29.9	1,600	0.0042	--	1.0	2.0	0.50	0.035
1-6	42.3	1,760	0.0074	--	2.0	2.0	0.75	0.036
1-8	110.3	1,190	0.0024	--	2.0	5.0	0.75	0.036
1-10	288.3	2,740	0.0022	--	0.5	10.0	0.30	0.032
1-12	293.3	2,200	0.0018	--	0.5	10.0	0.30	0.032
Willow Springs Creek Subwatershed								
1-0	466.2	5,280	0.0038	--	2.0	5.0	0.30	0.040
2-0	180.1	1,300	0.0050	--	1.0	30.0	0.10	0.045
1-2	71.2	2,640	0.0061	--	1.5	7.0	0.30	0.038
3-0	82.9	2,070	0.0101	--	1.0	15.0	0.20	0.030
1-4	129.0	3,800	0.0041	--	1.0	15.0	0.20	0.035
4-0	111.0	1,020	0.0137	--	1.0	4.0	0.40	0.040
4-2	55.2	1,440	0.0118	--	1.0	5.0	0.40	0.035
1-8	273.6	5,820	0.0081	--	1.5	10.0	0.30	0.032
5-0	137.7	2,180	0.0101	--	0.7	3.0	0.50	0.040
7-0	92.8	5,720	0.0098	--	0.5	4.0	0.20	0.038
1-12	114.9	2,920	0.0021	--	3.0	10.0	0.40	0.032
8-0	136.1	1,560	0.0090	--	1.0	5.0	0.20	0.030
9-0	148.8	--	--	--	--	--	--	--
1-16	134.8	4,020	0.0012	--	3.0	15.0	0.35	0.035
1-20	198.6	2,920	0.0031	--	3.0	20.0	0.30	0.035

NOTE: N/A indicates data not available.

[a] Identification numbers--see Map 7 for location.

[b] Agricultural drainage system without a defined surface water drainage system.

[c] This reach represents an internally drained area.

Source: SEWRPC.

Table 15

SELECT CHARACTERISTICS OF THE EXISTING STORMWATER DETENTION BASIN

Location	Recurrence Interval Design (years)	Tributary Area (acres)	Storage Volume Required (acre-feet)	Storage Volume Provided (acre-feet)	Basin Size (acres)	Maximum Water Depth (feet)	Lining Material	Outlet Capacity (cfs)	Maximum Detention Time (hours)
Sussex Industrial Park	10	38	4.0	5.2	1.5	3.8	Turf	4	12

Source: Jahnke and Jahnke Associates and SEWRPC.

channel cleaning; catch basin cleaning; and minor repair work on sewers, manholes, basins and inlets.

General estimates were prepared of the peak flows and average total annual flows discharged from the existing storm sewer system to receiving streams. The rational method, which is the most commonly used method of computing peak rates of discharge, was used to calculate peak rates of discharge during a storm event which may be expected to be reached or exceeded an average of once every 10 years. This recurrence interval was selected for use in reporting on the existing drainage system characteristics in order to conform to the design criteria presently utilized by the Village. Additional discussion of the design rainfall recurrence interval is covered in Chapter V, which discusses design criteria to be utilized in this study. Average annual runoff volumes were estimated with the use of runoff volumes from watersheds with similar characteristics as measured by the U. S. Geological Survey. Average annual unit area runoff volumes were calculated for these watersheds and then applied to the Sussex study area in order to estimate the annual flow from the study area.

The Illinois Urban Drainage Area Simulator (ILLUDAS) model was one method used to develop detailed storm sewer loadings for use in the evaluation of the adequacy of the existing system and in the design of alternative stormwater drainage systems for new urban development. The second procedure used involved the application of commonly utilized formulae and design criteria. This second method was used to verify simulation modeling and to provide supplementary information for system components not readily amenable to model application. The procedures are discussed in detail in Chapter V.

Table 16 sets forth the calculated 10-year recurrence interval peak rates of discharge and the calculated average annual discharges from each outfall in the existing storm sewer system. For the 25 storm sewer outfalls, the table indicates that average annual flow volumes range from 0.7 acre-feet for both outfalls No. 10 and 11; to 23.6 acre-feet for outfall No. 6. The total average annual flow volume discharged from the existing system is estimated at about 155 acre-feet. The peak flows for a 10-year recurrence interval storm range from 4.6 cfs for outfall No. 10, to 85.2 cfs for outfall No. 9.

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 common in a wet environment. Wetlands are usually covered by organic

Table 16

PEAK DISCHARGE RATE AND AVERAGE ANNUAL DISCHARGE VOLUME FROM THE EXISTING VILLAGE OF SUSSEX STORM SEWER SYSTEM

Outfall Number	Location	Description	Area Tributary (acres)	Estimated Average Annual Volume (acre-feet)	Estimated 10-Year Recurrence Interval Storm Peak Discharge (cfs)
1	Pride's Road and Maple Avenue; discharging to a ditch along Maple Avenue; tributary to Sussex Creek	42" RCP	14.4	6.2	22.5
2	Waukesha Avenue, 200 feet northeast of Homestead Road; discharging to a ditch that runs to Coolings Meadow; tributary to Sussex Creek	48" RCP	14.1	5.0	24.5
3	Waukesha Avenue, 1,100 feet southwest of Homestead Road; discharging to a ditch that runs to Coolings Meadow; tributary to Sussex Creek	30" RCP	5.0	1.8	8.1
4	Maple Avenue at the Chicago & North Western Railway tracks; discharging to Sussex Creek	48" RCP	78.3	18.4	67.6
5	Laurie Lane, 160 feet south of Linda Drive; discharging to a ditch and internally drained area; tributary to Sussex Creek	15" RCP	6.5	2.8	12.5
6	Locust Street, 170 feet north of Champeny Road; discharging to Sussex Creek	45" x 29" CMPA	54.2	23.6	58.2
7	Bank parking lot, 330 feet north of Main Street; discharging to Sussex Creek	18" CMP	5.9	2.5	11.1
8	Main Street at Sussex Creek; discharging to Sussex Creek	18" RCP	3.1	2.8	9.0
9	Main Street at Sussex Creek; discharging to Sussex Creek	42" RCP	8.1	3.5	85.2
10	Silver Spring Drive at north intersection with Sussex Creek; discharging to Sussex Creek	18" RCP	1.6	0.7	4.6
11	Silver Spring Drive at north intersection with Sussex Creek; discharging to Sussex Creek	18" RCP	1.7	0.7	4.9
12	Elm Drive at Waukesha Avenue; discharging to the East Branch of Sussex Creek; tributary to Sussex Creek	21" RCP	8.3	3.6	12.0
13	Kneiski Drive, 160 feet east; discharging to the East Branch of Sussex Creek; tributary to Sussex Creek	18" RCP	10.7	4.6	17.1
14	Main Street at the East Branch of Sussex Creek; discharging to the East Branch of Sussex Creek; tributary to Sussex Creek	24" RCP	11.8	5.1	20.5
15	Main Street at the East Branch of Sussex Creek; discharging to the East Branch of Sussex Creek; tributary to Sussex Creek	42" RCP	28.1	12.3	45.3
16	Silver Spring Drive at the south intersection with Sussex Creek; discharging to Sussex Creek	36" RCP	25.1	9.7	29.0
17	Silver Spring Drive at the south intersection with Sussex Creek; discharging to Sussex Creek	12" RCP	3.5	0.8	5.6
18	Tulip Lane, 180 feet west; discharging to a drainage ditch; tributary to Sussex Creek	30" RCP	12.8	5.6	21.3
19	Lilac Lane and Aster Drive, 170 feet west; discharging to a drainage ditch; tributary to Sussex Creek	24" RCP	5.7	2.5	11.1
20	Pewaukee Road, 350 feet west; discharging to the South Branch of Sussex Creek; tributary to Sussex Creek	21" RCP	4.2	1.8	12.2
21	Clover Drive at Waukesha Avenue; discharging to a ditch along Waukesha Avenue; tributary to Sussex Creek	27" x 45" CMPA	28.1	12.3	42.2

Table 16 (continued)

Outfall Number	Location	Description	Area Tributary (acres)	Estimated Average Annual Volume (acre-feet)	Estimated 10-Year Recurrence Interval Storm Peak Discharge (cfs)
22	Silver Spring Drive, 1,500 feet east of Waukesha Avenue; discharging to a ditch along Silver Spring Drive; tributary to Sussex Creek	27" RCP	2.6	1.1	11.0
23	Park Court, 250 feet south of Sumac Lane, discharging to a drainage ditch; tributary to Pewaukee River	12" CMP	19.7	8.6	36.9
24	Main Street at Locust Street, 340 feet south of the intersection; discharging to a ditch along the abandoned Chicago, Milwaukee, St. Paul & Pacific railroad; tributary to Pewaukee River	30" CMP	22.1	9.6	63.6
25	Champeny Road and Westhaven Road, 140 feet north of intersection; discharging to Sussex Creek	21" RCP	20.3	8.9	23.3

Source: SEWRPC.

soils, silts, and marl deposits. Wetlands support valuable ecological habitats, enhance water quality conditions by trapping pollutants, 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 management plan should utilize the stormwater storage capacity of the natural wetlands, incorporating this storage into the drainage system. Thus, wetland preservation should be an integral part of a stormwater management plan, as well as of a sound land use plan such as that recently prepared for the Village by the Commission.

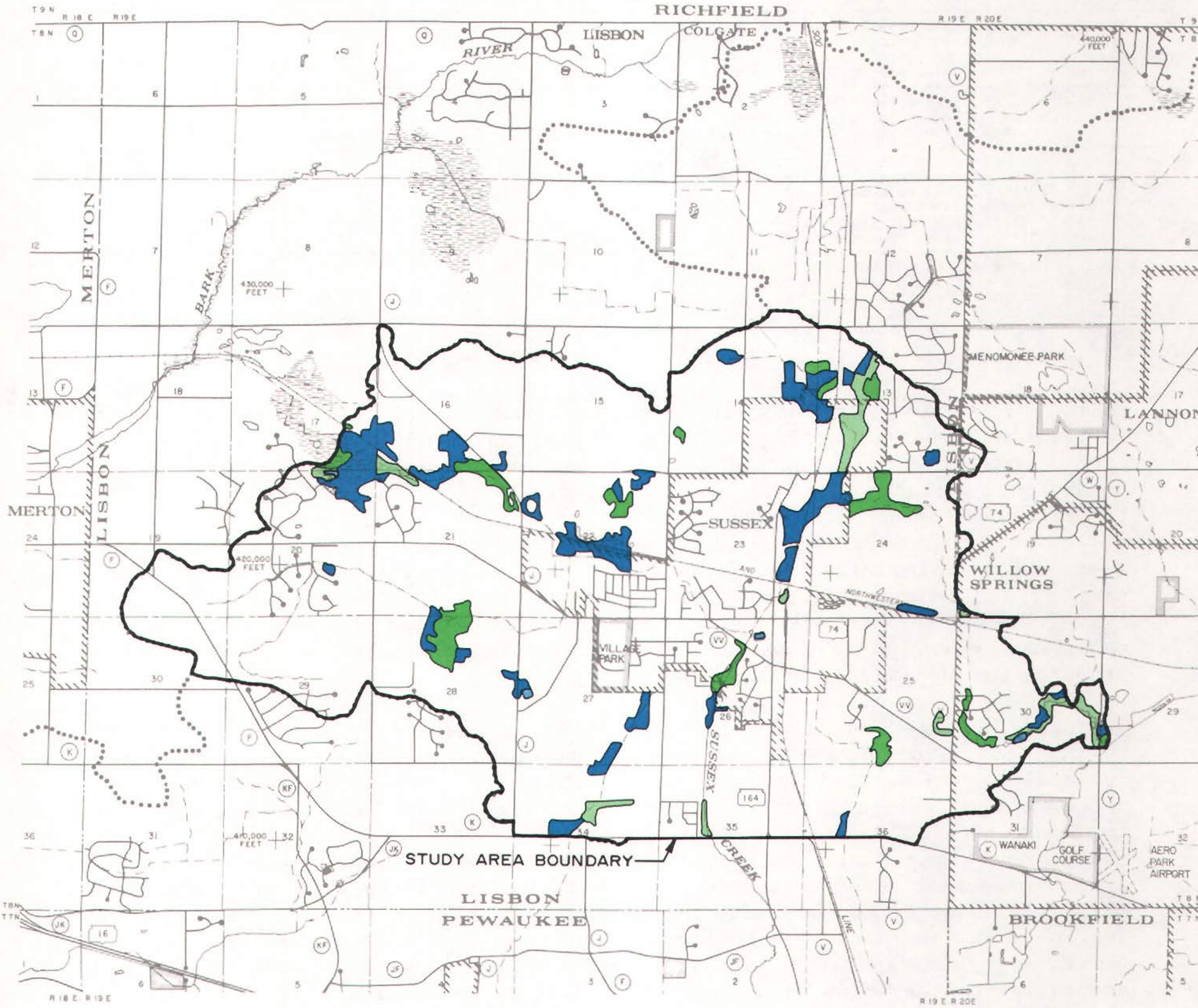
Wetlands in the study area were identified in a special inventory conducted by the Commission in 1980 using aerial photographic interpretation and field inspection supplemented by analyses of mapped soils data. The location, type, and extent of wetlands in the study area are shown on Map 10 and quantified in Table 17. In 1980, there were approximately 928 acres of wetlands in the study area, comprising about 9 percent of that area. Within the urban service area, there were about 315 acres of wetlands, comprising about 10 percent of that area. Most of the wetlands in the Village of Sussex and the Sussex urban service area, and about one-half of the wetlands in the entire study area, are dominated by emergent and submergent vegetation. These vegetation types are generally considered to be the most effective for storing surface water runoff and for trapping pollutants.

Bridges, Culverts, and Other Structures

Bridges and culverts significantly influence the hydraulic behavior of a stream system. Constrictions caused by inadequately designed bridges and culverts can, during storm events, result in large backwater effects thereby creating a floodland area upstream of the structure that is significantly larger than that which would exist in the absence of the bridge or culvert. An inventory of bridges and culverts in the Sussex area was presented in SEWRPC Community Assistance Planning Report No. 11, Floodland Information Report for Sussex Creek and Willow Springs Creek, Village of Sussex, Waukesha, County, Wisconsin (March 1977).

Map 10

WETLAND VEGETATIVE COVER TYPES AND EXTENT WITHIN THE VILLAGE OF SUSSEX STUDY AREA: 1980



LEGEND

- TREES
- SHRUBS
- EMERGENT / SUBMERGENT
- OPEN WATER

Source: SEWRPC.

Table 17

WETLAND VEGETATIVE COVER TYPES AND EXTENT WITHIN THE VILLAGE OF SUSSEX STUDY AREA: 1980

Dominant Wetland Vegetative Cover Type	Village of Sussex		Sussex Year 2000 Urban Service Area		Study Area	
	Acres	Percent of Total	Acres	Percent of Total	Acres	Percent of Total
Trees	11	8	58	19	251	27
Shrubs	27	20	41	13	191	21
Emergent/Submergent	92	69	206	65	457	49
Open Water	4	3	10	3	29	3
Total	134	100	315	100	928	100

Source: SEWRPC.

As shown on Map 11 and in Table 18, Sussex Creek and its tributaries are crossed 27 times by existing bridges for roadways and railroads in the study area; Willow Springs Creek is crossed nine times; and the tributary to the Pewaukee River is crossed once. The existing structures were examined in order to determine whether or not the structures were hydraulically significant; that is, in order to determine whether or not the structures had a significant effect on the peak discharges and stages of Sussex Creek, Willow Springs Creek, and the tributary to the Pewaukee River. Based on that examination, certain bridges and culverts were determined to be hydraulically insignificant because they were of such size or elevation as not to increase flood stages more than 0.1 foot during 10- to 100-year recurrence interval storm events. A bridge or culvert is likely to be hydraulically insignificant if it spans a stream from bank to bank, has approach roadways with little or no fill on the floodplain, and has a relatively small superstructure. Data and information such as waterway opening size, roadway profile, and channel-bottom elevation were obtained for the hydraulically significant bridges and culverts from the Commission Fox River watershed planning program, as documented in SEWRPC Planning Report No. 12, A Comprehensive Plan for the Fox River Watershed, and from the floodland report on Sussex Creek and Willow Springs Creek as documented in Community Assistance Planning Report No. 11, Floodland Information Report for Sussex Creek and Willow Springs Creek, and were used as input to the hydrologic-hydraulic computer model used to compute stream discharges and stages.

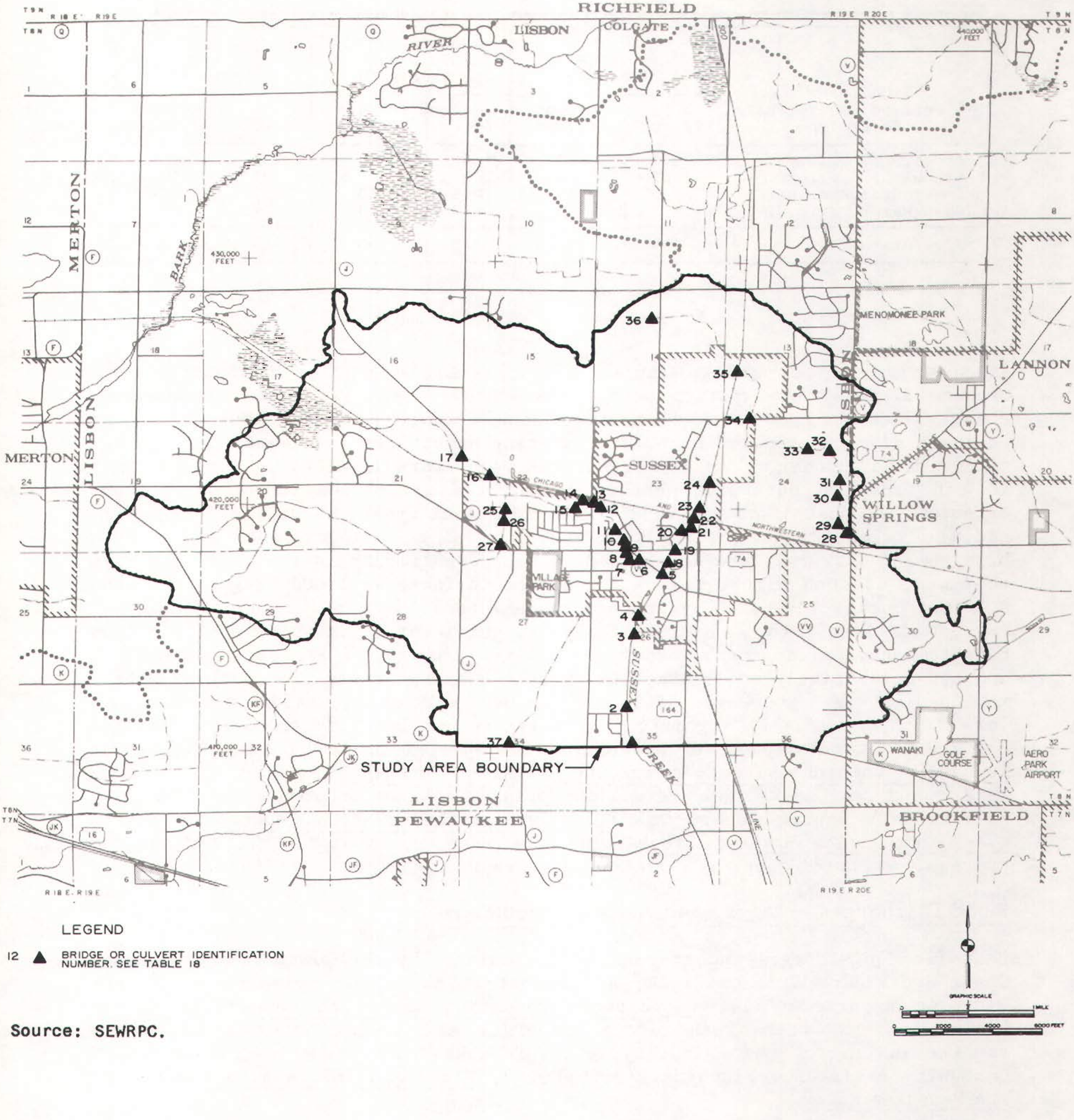
Flood Discharges, Stages, and Natural Floodlands

Peak flood discharges and stages were calculated by the Commission for Sussex Creek and Willow Springs Creek, as presented in SEWRPC Community Assistance Planning Report No. 11, Floodland Information Report for Sussex Creek and Willow Springs Creek. Peak flood discharges and stages were calculated by the Commission for the tributary to the Pewaukee River as presented in SEWRPC Community Assistance Planning Report No. 9, Floodland Information Report for the Pewaukee River.

Peak flood discharge and peak flood stages at selected structure locations for the 10-, 25-, 50-, and 100-year recurrence interval flood events under existing (1975) conditions within the study area are presented in Table 19. The 100-year

Map 11

LOCATION OF BRIDGES AND CULVERTS IN THE VILLAGE OF SUSSEX STUDY AREA: 1976



Source: SEWRPC.

Table 18

STRUCTURE INFORMATION FOR SUSSEX CREEK, WILLOW SPRINGS CREEK, AND THE TRIBUTARY OF THE PEWAUKEE RIVER: 1976

Stream	Identification Number on Map 11	Structure Name	U. S. Public Land Survey Location	Structure Type		Hydraulically Significant
				Bridge	Culvert	
Sussex Creek and Tributaries	1	CTH K bridge.................	Southeast one-quarter, northwest one-quarter, Section 35, Town of Lisbon	X		Yes
	2	Private bridge..............	Northeast one-quarter, northwest one-quarter, Section 35, Town of Lisbon		X	No
	3	Private bridge..............	Northeast one-quarter, southwest one-quarter, Section 26, Town of Lisbon		X	Yes
	4	Clover Drive bridge..........	Southeast one-quarter, northwest one-quarter, Section 26, Town of Lisbon		X	Yes
	5	Silver Spring Drive bridge...	Northwest one-quarter, northeast one-quarter, Section 26, Town of Lisbon	X		Yes
	6	Silver Spring Drive bridge...	Northeast one-quarter, northwest one-quarter, Section 26, Town of Lisbon	X		Yes
	7	Chicago, Milwaukee, St. Paul & Pacific railroad bridge............	Northeast one-quarter, northwest one-quarter, Section 26, Town of Lisbon	X		Yes
	8	Main Street bridge...........	Southeast one-quarter, southwest one-quarter, Section 23, Town of Lisbon	X		Yes
	9	Private bridge..............	Southeast one-quarter, southwest one-quarter, Section 23, Town of Lisbon	X		Yes
	10	Public foot bridge..........	Southeast one-quarter, southwest one-quarter, Section 23, Town of Lisbon	X		Yes
	11	Old Mill Lane bridge.........	Southwest one-quarter, southwest one-quarter, Section 23, Town of Lisbon	X		Yes
	12	Private bridge..............	Northwest one-quarter, southwest one-quarter, Section 23, Town of Lisbon	X		Yes
	13	Maple Avenue bridge..........	Northwest one-quarter, southwest one-quarter, Section 23, Town of Lisbon	X		Yes
	14	Private foot bridge..........	Northeast one-quarter, southeast one-quarter, Section 22, Town of Lisbon	X		No
	15	Private bridge..............	Northeast one-quarter, southeast one-quarter, Section 22, Town of Lisbon		X	Yes
	16	Chicago, Milwaukee, St. Paul & Pacific railroad bridge............	Southwest one-quarter, northwest one-quarter, Section 22, Town of Lisbon	X		Yes
	17	CTH J bridge................	Southwest one-quarter, northwest one-quarter, Section 22, Town of Lisbon		X	Yes
	18	Chicago, Milwaukee, St. Paul & Pacific railroad bridge............	Northwest one-quarter northeast one-quarter, Section 22, Town of Lisbon	X		Yes
	19	Main Street culvert..........	Southwest one-quarter, southeast one-quarter, Section 23, Town of Lisbon		X	Yes
	20	Waukesha Avenue bridge.......	Southwest one-quarter, southeast one-quarter, Section 23, Town of Lisbon		X	Yes
	21	Chicago, Milwaukee, St. Paul & Pacific railroad bridge............	Southeast one-quarter, southeast one-quarter, Section 23, Town of Lisbon		X	Yes
	22	Chicago & North Western railway bridge...........	Southeast one-quarter, southeast one-quarter, Section 23, Town of Lisbon		X	Yes
	23	Private bridge..............	Northeast one-quarter, southeast one-quarter, Section 23, Town of Lisbon		X	No
	24	Chicago, Milwaukee, St. Paul & Pacific railroad bridge...........	Southeast one-quarter, northeast one-quarter, Section 23, Town of Lisbon	X		No
	25	Private bridge..............	Southeast one-quarter, southwest one-quarter, Section 22, Town of Lisbon	X		No
	26	Chicago, Milwaukee, St. Paul & Pacific railroad bridge...........	Southeast one-quarter, southwest one-quarter, Section 22, Town of Lisbon	X		Yes
	27	Main Street bridge...........	Southeast one-quarter, southwest one-quarter, Section 22, Town of Lisbon	X		Yes
Willow Springs Creek	28	CTH V bridge................	Southeast one-quarter, southeast one-quarter, Section 24, Town of Lisbon	X		Yes
	29	St. James Parkway bridge.....	Southeast one-quarter, southeast one-quarter, Section 24, Town of Lisbon		X	Yes
	30	McLaughlin Road bridge.......	Northeast one-quarter, southeast one-quarter, Section 24, Town of Lisbon		X	Yes

Table 18 (continued)

Stream	Identification Number on Map 11	Structure Name	U. S. Public Land Survey Location	Structure Type: Bridge	Structure Type: Culvert	Hydraulically Significant
Willow Spring Creek (continued)	31	Private bridge..............	Southeast one-quarter, northeast one-quarter, Section 24, Town of Lisbon		X	Yes
	32	Private bridge..............	Northeast one-quarter, northeast one-quarter, Section 24, Town of Lisbon			
	33	Chicago, Milwaukee, St. Paul & Pacific railroad bridge............	Northeast one-quarter, northeast one-quarter, Section 24, Town of Lisbon		X	No
	34	Good Hope Road bridge........	Southwest one-quarter, southwest one-quarter, Section 13, Town of Lisbon		X	Yes
	35	Soo Line Railroad bridge.....	Northwest one-quarter, southwest one-quarter, Section 13, Town of Lisbon		X	Yes
	36	Woodside Road bridge.........	Northeast one-quarter, northwest one-quarter, Section 14, Town of Lisbon		X	Yes
Tributary to Pewaukee River	37	CTH K bridge	Southeast one-quarter, northwest one-quarter, Section 34, Town of Lisbon	X		Yes

Source: SEWRPC.

recurrence interval peak flood discharge of Sussex Creek at CTH K, located at the downstream limits of the study area, is estimated at 363 cubic feet per second (cfs). The 100-year recurrence interval peak flood discharge of Willow Springs Creek at STH 74 is estimated at 89 cfs. The 100-year recurrence interval peak flood discharge of the tributary to the Pewaukee River at CTH K is estimated at 132 cfs.

Examination of the flood stage profiles provided in SEWRPC Community Assistance Planning Report No. 11 indicated that four bridges on Sussex Creek--a private bridge, the Clover Drive bridge, the Old Mill Lane bridge, and the Maple Avenue bridge--and two bridges on the East Branch of Sussex Creek--the Main Street bridge and the Chicago & North Western Railway bridge--produced relatively large backwater effects during a 100-year recurrence interval flood event. These bridges increased immediate upstream flood stages by from one to seven feet.

The extent of the 100-year recurrence interval flood hazard area along Sussex Creek and its major tributaries, and along Willow Springs Creek in the study area, was presented in SEWRPC Community Assistance Planning Report No. 11 under planned year 2000 land use and existing channel conditions. Map 12 shows the delineated flood hazard areas. These delineated flood hazard areas serve as the basis for local floodland use regulations and thereby promote sound community development. The flood hazard areas were not delineated for the remaining stream reaches because large-scale topographic maps were unavailable at the time SEWRPC Community Assistance Planning Report No. 11 was being prepared.

STORMWATER MANAGEMENT PROBLEMS

Stormwater management problems primarily consist of stormwater drainage and flood control problems. Drainage problems may be defined as the accumulation of excess stormwater on the land surface before such water has entered stream channels. Such problems are caused by stormwater runoff attempting to reach the stream channels. Flood control problems may be defined as damage from the

Table 19

EXISTING FLOOD DISCHARGES AND STAGES FOR SUSSEX CREEK, WILLOW SPRINGS CREEK, AND THE PEWAUKEE RIVER: 1975

Stream	Structure Name	U. S. Public Land Survey Location	10-Year Recurrence Interval Flood Event		25-Year Recurrence Interval Flood Event		50-Year Recurrence Interval Flood Event		100-Year Recurrence Interval Flood Event	
			Discharge (cfs)	Stage (NGVD[a])	Discharge (cfs)	Stage (NGVD[a])	Discharge (cfs)	Stage (NGVD[a])	Discharge (cfs)	Stage (NGVD[a])
Sussex Creek and Tributaries	CTH K bridge..............	Southeast one-quarter, northwest one-quarter, Section 35, Town of Lisbon	215	875.3	272	875.5	317	875.6	363	875.7
	Private bridge............	Northeast one-quarter, southwest one-quarter, Section 26, Town of Lisbon	215	886.8	272	887.2	317	887.5	363	887.9
	Clover Drive bridge........	Southeast one-quarter, northwest one-quarter, Section 26, Town of Lisbon	215	888.8	272	890.1	317	890.4	363	890.6
	Silver Spring Drive bridge............	Northwest one-quarter, northeast one-quarter, Section 26, Town of Lisbon	215	892.3	272	892.5	317	892.6	363	892.8
	Silver Spring Drive bridge............	Northeast one-quarter, northwest one-quarter, Section 26, Town of Lisbon	203	906.8	249	907.0	283	907.1	318	907.3
	Chicago, Milwaukee, St. Paul & Pacific railroad bridge..........	Northeast one-quarter, northwest one-quarter, Section 26, Town of Lisbon	203	913.4	249	913.6	283	913.7	318	913.9
	Main Street bridge.........	Southeast one-quarter, southwest one-quarter, Section 23, Town of Lisbon	203	917.7	249	918.1	283	918.5	318	918.7
	Private bridge............	Southeast one-quarter, southwest one-quarter, Section 23, Town of Lisbon	203	919.5	249	919.7	283	919.9	318	920.1
	Public foot bridge.........	Southeast one-quarter, southwest one-quarter, Section 23, Town of Lisbon	203	919.8	249	920.1	283	920.3	318	920.5
	Old Mill Avenue bridge.....	Southwest one-quarter, southwest one-quarter, Section 23, Town of Lisbon	203	925.7	249	926.1	283	926.4	318	926.7
	Private bridge............	Northwest one-quarter, southwest one-quarter, Section 23, Town of Lisbon	203	929.2	249	929.4	283	929.6	318	929.7
	Maple Avenue bridge........	Northwest one-quarter, southwest one-quarter, Section 23, Town of Lisbon	203	932.4	249	932.7	283	932.9	318	933.0
	Private bridge............	Northeast one-quarter, southeast one-quarter, Section 22, Town of Lisbon	203	935.9	249	936.2	283	936.5	318	936.7
	Chicago & North Western Railway bridge...........	Southwest one-quarter, northwest one-quarter, Section 22, Town of Lisbon	52	938.8	65	939.0	75	939.1	85	939.2
	CTH J bridge..............	Southwest one-quarter, northwest one-quarter, Section 22, Town of Lisbon	52	943.9	65	944.2	75	944.5	85	944.7

Table 19 (continued)

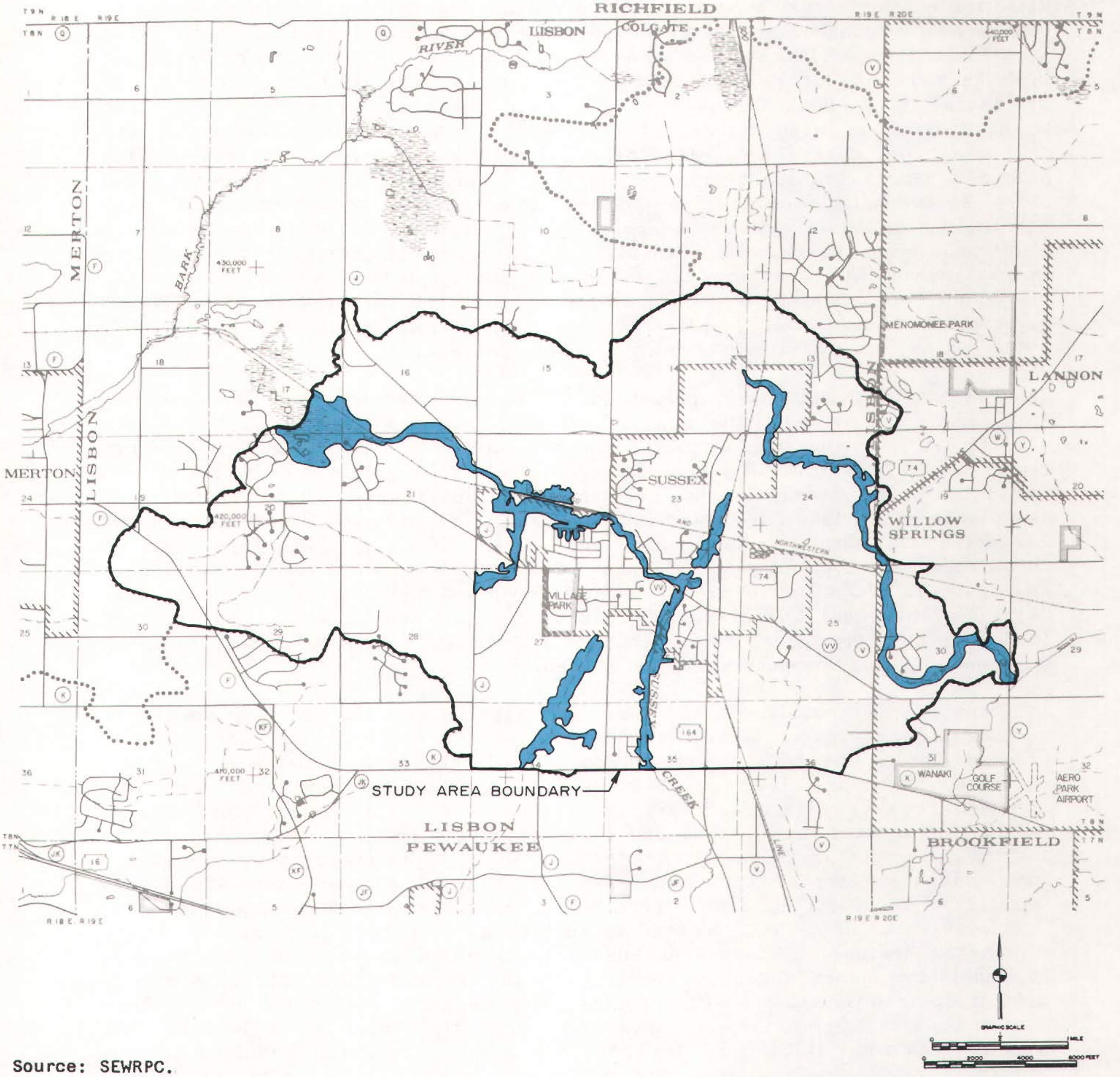
Stream	Structure Name	U. S. Public Land Survey Location	10-Year Recurrence Interval Flood Event		25-Year Recurrence Interval Flood Event		50-Year Recurrence Interval Flood Event		100-Year Recurrence Interval Flood Event	
			Discharge (cfs)	Stage (NGVD[a])	Discharge (cfs)	Stage (NGVD[a])	Discharge (cfs)	Stage (NGVD[a])	Discharge (cfs)	Stage (NGVD[a])
Sussex Creek and Tributaries (continued)	Chicago, Milwaukee, St. Paul & Pacific railroad bridge..........	Northwest one-quarter, northeast one-quarter, Section 26, Town of Lisbon	27	894.8	31	895.0	34	895.1	37	895.3
	Main Street bridge.........	Southwest one-quarter, southeast one-quarter, Section 23, Town of Lisbon	27	894.9	31	895.1	34	895.2	37	895.4
	Waukesha Avenue bridge.....	Southwest one-quarter, southeast one-quarter, Section 23, Town of Lisbon	27	897.5	31	897.6	34	897.7	37	897.7
	Chicago, Milwaukee, St. Paul & Pacific railroad bridge..........	Southeast one-quarter, southeast one-quarter, Section 23, Town of Lisbon	27	898.9	31	899.1	34	899.3	37	899.6
	Chicago & North Western Railway bridge...........	Southeast one-quarter, southeast one-quarter, Section 23, Town of Lisbon	27	907.0	31	907.1	34	907.2	37	907.3
	Chicago, Milwaukee, St. Paul & Pacific railroad bridge..........	Southeast one-quarter, southwest one-quarter, Section 22, Town of Lisbon	87	936.8	129	937.0	170	937.3	222	937.6
	Main Street bridge.........	Southeast one-quarter, southwest one-quarter, Section 22, Town of Lisbon	87	937.8	129	938.4	170	938.9	222	939.4
Willow Springs Creek	CTH V bridge..............	Southeast one-quarter, southeast one-quarter, Section 24, Town of Lisbon	69	--	78	--	84	--	89	--
	St. James Parkway bridge...	Southeast one-quarter, southeast one-quarter, Section 24, Town of Lisbon	69	--	78	--	84	--	89	--
	McLaughlin Road bridge.....	Northeast one-quarter, southeast one-quarter, Section 24, Town of Lisbon	69	--	78	--	84	--	89	--
	Private bridge.............	Southeast one-quarter, northeast one-quarter, Section 24, Town of Lisbon	69	--	78	--	84	--	89	--
	Private bridge.............	Northeast one-quarter, northeast one-quarter, Section 24, Town of Lisbon	69	--	78	--	84	--	89	--
	Chicago, Milwaukee, St. Paul & Pacific railroad bridge..........	Northeast one-quarter, northeast one-quarter, Section 24, Town of Lisbon	28	--	32	--	35	--	38	--
	Good Hope Road bridge......	Southwest one-quarter, southwest one-quarter, Section 13, Town of Lisbon	28	920.1	32	920.2	35	920.3	38	920.3
	Soo Line Railroad bridge...	Northwest one-quarter, southwest one-quarter, Section 13, Town of Lisbon	17	937.6	21	937.7	24	937.8	26	937.9
	Woodside Road bridge.......	Northeast one-quarter, northwest one-quarter, Section 14, Town of Lisbon	17	--	21	--	24	--	26	--
Pewaukee River	CTH K	Southeast one-quarter, northeast one-quarter, Section 34, Town of Lisbon	54	879.0	78	879.4	102	879.7	132	879.9

[a]Elevation in feet above National Geodetic Vertical Datum.

Source: SEWRPC Community Assistance Planning Report No. 9, Floodland Information Report for the Pewaukee River and SEWRPC Community Assistance Planning Report No. 11, Floodland Information Report for Sussex Creek and Willow Springs Creek.

Map 12

100-YEAR RECURRENCE INTERVAL FLOODPLAIN WITHIN THE VILLAGE OF SUSSEX STUDY AREA UNDER PLAN YEAR 2000 LAND USE CONDITIONS AND EXISTING (1975) CHANNEL CONDITIONS



Source: SEWRPC.

overflow of natural stream channels and watercourses. Such problems are caused by stream flow exceeding the bank full capacity and moving away from the stream channels to inundate adjacent floodlands.

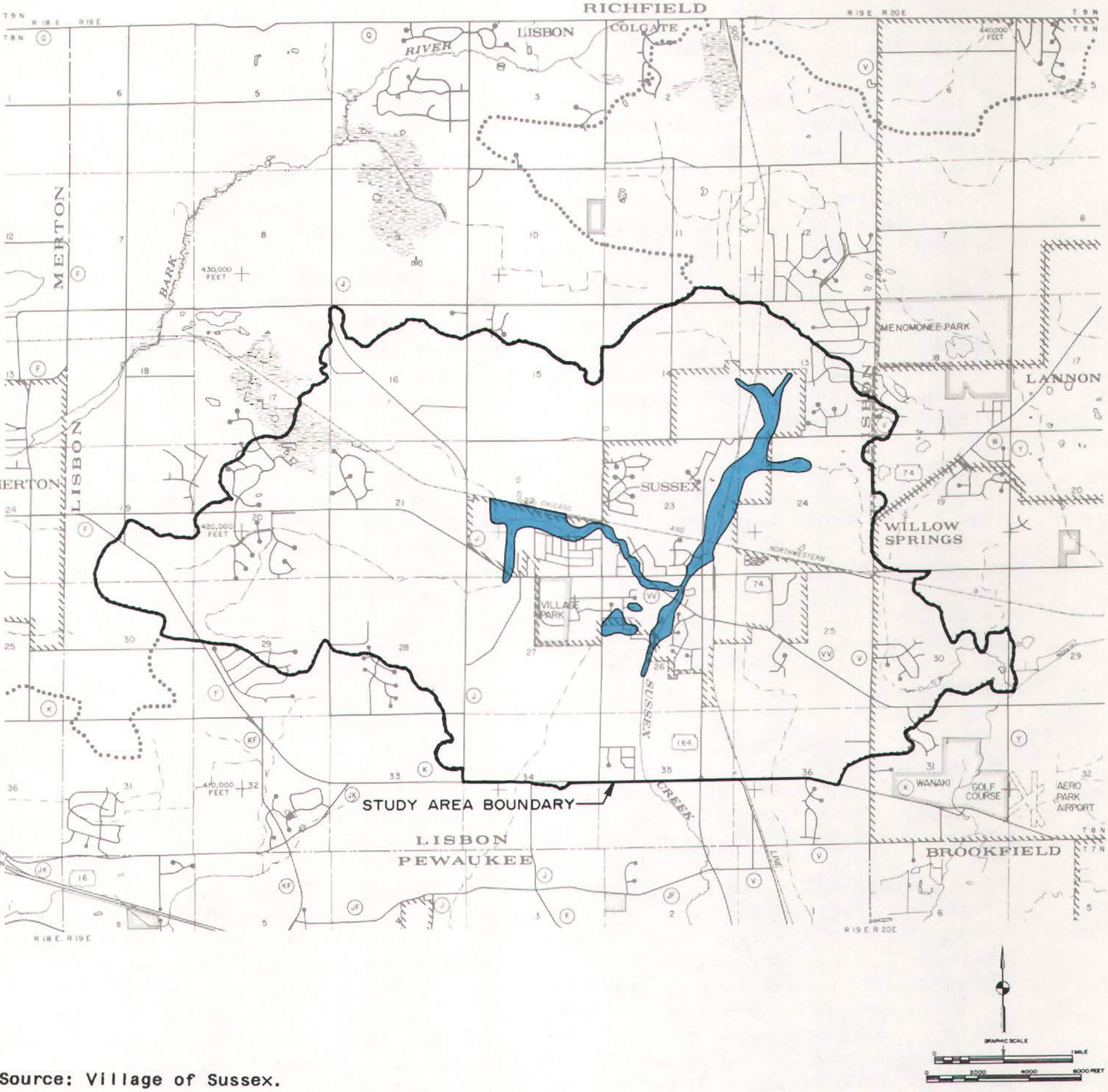
Within the study area, most drainage problems are related to the presence of wet or poorly drained soils. These poorly drained areas can constitute problems in that many of these areas cannot be developed, or can only be developed with the aid of costly special measures such as tile drainage systems and artificial fill. Sanitary sewers located in these areas may be susceptible to high rates of groundwater infiltration. Stormwater which may accumulate in these areas during and immediately following storm events may pose health hazards, hamper transportation by inundating streets, flood basements, and serve as breeding sites for mosquitoes. These areas, therefore, need to be carefully considered and, where appropriate, incorporated into the stormwater management plan in order to minimize the problems attendant to these poorly drained areas. The location and extent of poorly drained areas were illustrated on Map 5, which shows hydrologic soil groups. Areas covered by hydrologic soil groups C and D, which together cover about 31 percent of the study area, can be considered to have poor natural drainage.

The Village of Sussex has experienced at least one major flood since 1940--in April 1973--and at least one minor flood event--in September 1972. Commission studies indicate that the largest flood of record--in April 1973--had a recurrence interval of about 40 years. Based on observations made during that flood, the flood-prone areas in the Village, which have experienced flooding at least once since 1940, are shown on Map 13. The flood-prone areas cover about 285 acres, or about 14 percent of the Village of Sussex. Flood problems in the Village are located primarily along Sussex Creek downstream of Main Street and upstream of Maple Avenue and include: overland flooding along the Chicago, Milwaukee, St. Paul & Pacific railroad bridge just downstream of Main Street (STH 74); overtopping of W. Silver Spring Drive (CTH VV); and street flooding on Locust Street, Champeny Road, and Westhaven Road.

Infiltration of groundwater and inflow of stormwater into sanitary sewers is a stormwater drainage-related problem reported in the Village. The infiltration and inflow analysis report by Graef-Anhalt-Schloemer & Associates, Inc., indicated that, in 1974, 75,000 to 150,000 gallons per day (gpd) were contributed to the village sanitary sewer system via infiltration and inflow during dry weather conditions, and that during wet weather, this infiltration and inflow amount increased to about 1,200,000 gpd. By comparison, the existing village wastewater treatment plant has a total average hydraulic design capacity of 1,000,000 gpd, and a peak design capacity of 2,000,000 gpd. A major source of this inflow was reported to be flooded manholes due to an inadequate stormwater drainage system. When Sussex Creek flooded, water backed up into at least two storm sewers, resulting in the inundation of street sections and inflow into sanitary sewer manholes. Groundwater infiltration and contamination occurred primarily in those areas with high water table levels. This infiltration and inflow into the sanitary sewer system has resulted in the bypassing of raw sewage into Sussex Creek because of the inability of the wastewater treatment facility to accommodate the high peak flows. In 1974, it was estimated that during peak wet weather conditions, 630,000 gpd of untreated wastewater was bypassed and discharged into Sussex Creek. The completion of the new wastewater treatment plant and the upgrading and

Map 13

AREAS WITHIN THE VILLAGE OF SUSSEX WHICH HAVE EXPERIENCED AT LEAST ONE MAJOR FLOOD SINCE 1940



Source: Village of Sussex.

rehabilitation of the storm sewer collection system has essentially eliminated any bypassing of raw sewage. No bypassing of raw sewage has occurred since 1978.

EROSION AND SEDIMENTATION PROBLEMS

Field surveys were conducted by the staffs of the Regional Planning Commission and the U. S. Soil Conservation Service in early May 1982 to identify stormwater runoff-related soil erosion and sedimentation problems in the study area. Sites of moderate and severe erosion could be readily identified at that time because the effects of sheet and gully erosion, streambank erosion, construction site runoff, and cropland runoff caused by spring rain storms were still evident. Early seasonal growth of vegetation was minimal, permitting the ready observance of exposed soil conditions. The following types of soil erosion were identified: construction site erosion in several subdivisions at various stages of development; severe and moderate erosion from croplands; and eroded gullies, streambanks, and drainage ditches. Map 14 shows the location of erosion problems identified in the study area. It should be noted that many of these problems may be of a temporary nature, particularly when associated with construction projects.

Construction site erosion was most severe at two subdivisions located within the Village in the northern portion of Section 23. The subdivision, known as Maple View exhibited several poorly vegetated lots, very little topsoil, and a rocky surface. About 12 houses were under active construction in this subdivision which has an areal extent of approximately 25 acres. The subdivision known as Pride's Crossing did not contain any houses, nor were any houses actually under construction at the time of the field inspection. The subdivision was, however, poorly vegetated and severe erosion was in evidence over a large portion of the area. This subdivision has an areal extent of about 80 acres. Both of these severely eroding subdivisions are served by storm sewers.

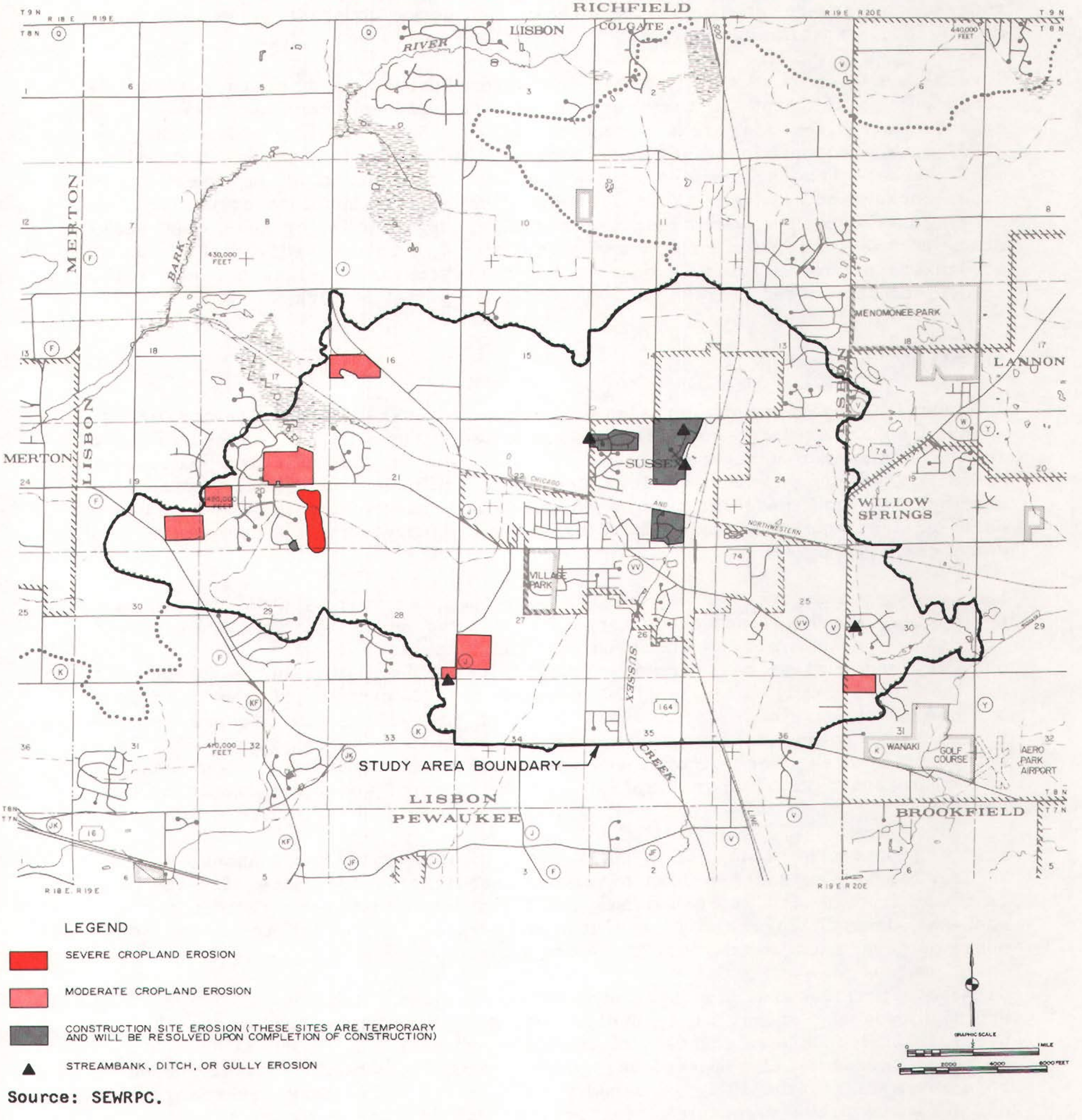
Within another subdivision, known as Stonefield, located in the central portion of the Village, over 90 percent of the lots are not yet under construction. Although these lots were vegetated severe erosion may occur when subject to development. The subdivision has an areal extent of about 30 acres.

The extent and severity of cropland erosion varies with the topography, hydrology, soils, slopes, specific crops grown, and conservation practices used. The field survey identified several cropland fields which, primarily because of the slope, crop type, and conservation practices being used, may be expected to contribute moderate amounts of sediment to surface waters. These fields, identified as moderate erosion sites on Map 14, are located on slopes of greater than 3 to 4 percent. Good soil and water conservation practices could subsequently reduce soil losses. Row crops, such as corn, are grown on most of these fields. The areas of moderate cropland erosion were located primarily in the western portion of the study area, upstream of the urban service area.

One cropland field, located in the southeast part of Section 20, Township 8 North, Range 19 East, in the Town of Lisbon, was rated as a severe erosion site having steep slopes, as shown on Map 14. In addition, if subjected to

Map 14

EXISTING EROSION AND SEDIMENTATION PROBLEMS WITHIN THE VILLAGE OF SUSSEX STUDY AREA: 1982



LEGEND

- SEVERE CROPLAND EROSION
- MODERATE CROPLAND EROSION
- CONSTRUCTION SITE EROSION (THESE SITES ARE TEMPORARY AND WILL BE RESOLVED UPON COMPLETION OF CONSTRUCTION)
- ▲ STREAMBANK, DITCH, OR GULLY EROSION

Source: SEWRPC.

urban development, this area may exhibit severe erosion during construction because of the steep slopes. About 240 acres of cropland were identified as moderate or severe erosion sites. These 240 acres comprise about 4 percent of the total existing agricultural and open land in the study area.

Several eroded streambanks and gullies were observed in the study area, as shown on Map 14. Many of these eroded gullies and banks were associated with construction sites and eroded cropland fields. Some of this erosion may be attributable to the increased peak storm flows resulting from urban development; hence, these erosion sites are a direct consequence of improper stormwater management. Streambank erosion destroys aquatic habitats at the erosion site, contributes to downstream water quality degradation by releasing sediments to the water, and provides material for subsequent sedimentation downstream which covers valuable benthic habitats, impedes navigation, and fills downstream stormwater storage basins, wetlands, ponds, and lakes.

SUMMARY

An accurate inventory of certain hydrologic-hydraulic characteristics of the study area and related natural and man-made features is an essential step in the stormwater management plan process. Data on the existing stormwater drainage system, stormwater flows, existing drainage and flooding problems, and erosion and sedimentation problems are presented. Also presented are data on land use and land use regulations, climate, soils, hydrology, and water quality.

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 cover 26 percent of the total study area, and 30 percent and 41 percent of the year 2000 planned urban service area and 1980 area of the Village of Sussex, respectively. Residential land uses comprise the largest urban category. Within the entire study area, agricultural and open land uses account for 82 percent of the rural area, with other rural areas consisting of woodlands, wetlands, and surface water.

Existing pertinent land use regulations include zoning ordinances for the Village of Sussex and the Town of Lisbon, subdivision ordinances for the Village and Town, and a shoreland and floodland protection zoning ordinance for Waukesha County. These land regulations represent important tools for local units of government for directing the use of lands.

Climatological factors affecting stormwater management include air temperature and the type and amount of precipitation. Air temperature influences whether precipitation occurs as rainfall or snowfall, whether the ground is frozen and, therefore, essentially impervious, and the rate of snowmelt. Monthly temperature means range from 19°F for January to 72°F for July. Many severe drainage and flooding problems occur during spring periods due to snowmelt, saturated or frozen soils, and heavy rains. The average monthly precipitation ranges from 1.04 inches in February to 3.74 inches in June. The average annual amount of precipitation, based on 90 years of record at the Waukesha weather station, is 30.87 inches. About 41.8 inches of snow and sleet fall per year. The amount of snow cover influences the severity of snowmelt flood events and the extent and depth of frozen soils. There is at least a 0.40 probability of snow cover during the months of December, January, and February.

The relationship between rainfall intensity, duration, and frequency is an important element in stormwater management analysis and system design. Intensity, duration, and frequency relationship equations and curves, based on 64 years of record at Milwaukee, are presented in this chapter. This information permits the estimate of peak flows and annual discharges from stormwater drainage systems.

Soil properties influence the rate and amount of runoff from land surfaces. About two-thirds of the study area is covered by soils which generate moderate amounts of runoff because of moderate capacity and generally good drainage.

The water quality impacts of stormwater management are of increasing concern. High surface runoff and erosion can result in high pollutant concentrations in surface waters which reduce the suitability of the waters for recreational uses and limit the ability of the water to support desired forms of fish and other aquatic life. Measured water quality conditions in Sussex Creek were reviewed in this chapter. An analysis of pollution sources was set forth in SEWRPC Planning Report No. 30, A Regional Water Quality Management Plan for Southeastern Wisconsin: 2000.

For planning purposes, the study area was divided into 117 drainage subbasins, of which 24, or 21 percent, are located within the service area of the existing storm sewer system. These drainage subbasins range in size from about two to 560 acres, with an average size of 85 acres. These subbasins are drained by a total of 1.6 miles of perennial streams and 14.2 miles of intermittent streams.

The existing village storm sewer system serves a tributary drainage area of about 495 acres, or 25 percent, of the 1980 village area. The system consists of approximately 30,082 lineal feet of sewers ranging in size from a 12-inch diameter circular sewer to a 29-by-45 inch pipe arch. There are a total of 262 inlets and catch basins and 25 outfalls in the system. Twenty-three of the outfalls discharge to Sussex Creek while two discharge to the tributary to the Pewaukee River.

Annual flow volumes and the 10-year peak discharge from each of the existing storm sewer outfalls were calculated. The total average annual flow volume discharged from the existing system is estimated at about 155 acre-feet, and the peak flows from individual outfalls for a 10-year recurrence interval storm range from 4.6 cfs to 85.2 cfs.

Peak flood discharges and stages have been previously calculated for Sussex Creek, Willow Springs Creek, and the Pewaukee River. Flood stage profiles indicated that four bridges on Sussex Creek produced relatively large backwater effects during the 100-year flood event.

Existing stormwater management problems consist of drainage problems and flood control problems. Most drainage problems are related to the presence of poorly drained soils. About 31 percent of the study area is covered by soils having poor drainage. The Village of Sussex has also experienced at least one major flood event since 1940 and at least one minor flood event. About 285 acres, or about 14 percent of the Village of Sussex, have experienced flooding problems. Another stormwater management problem includes excessive infiltration and inflow into the sanitary sewers with the subsequent bypassing of raw, untreated sewage into surface waters.

A field survey was conducted by the staffs of the Regional Planning Commission and the U. S. Soil Conservation Service in May 1982 to identify stormwater runoff-related erosion and sedimentation problems in the study area. The survey identified construction site erosion, cropland erosion, and eroded gullies and streambanks as existing problems. Two subdivisions were noted as having moderate to severe erosion and a third subdivision had a potential for future erosion problems. About 240 acres of cropland--about 4 percent of the existing agricultural and open land--were identified as moderate or severe erosion sites. Many of the observed eroded gullies and streambanks were associated with these construction sites and cropland areas. Other eroded channels have been subjected to higher peak flows resulting from urban development.

Chapter IV

ANTICIPATED GROWTH AND CHANGE

INTRODUCTION

The Village of Sussex stormwater management master plan is intended to identify the stormwater management needs of the Village of Sussex planned urban service area through the year 2000 and to propose the best means of meeting those needs. Pertinent information on the existing conditions in the stormwater management planning area was presented in Chapter III of this report.

Land use in the study area markedly influences the rainfall-runoff process. The conversion of the land from rural to urban use and the associated increase in impervious area will tend to increase the rate and volume of stormwater runoff for a given rainfall event and decrease the runoff time. The typical net effect of urbanization is to produce an increase, both in peak rates of runoff and in the total volume of runoff unless special stormwater management measures are taken. Stormwater runoff from urban lands also carries different types and increased amounts of pollutants as compared to runoff from rural lands. Therefore, consideration of the probable future land use pattern of an area is necessary for the effective development of alternative stormwater management plans and for the selection of a recommended plan.

Accordingly, this chapter presents information on the anticipated type, density, and spatial distribution of land uses in the stormwater management study area and on the impact of anticipated changes in land use on the stormwater management needs of the study area.

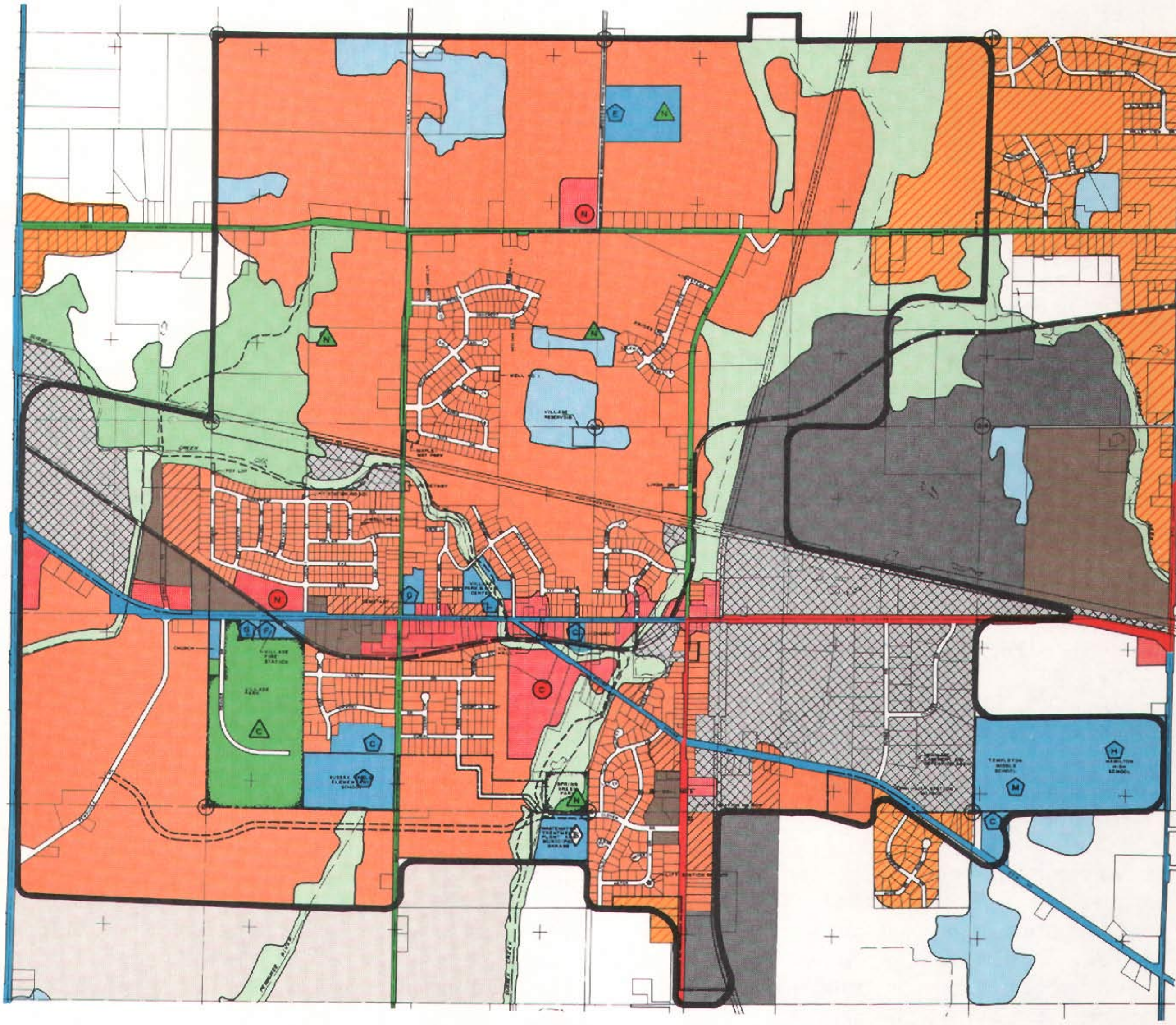
LAND USE

As already noted, land use is an important factor in determining the quality as well as the quantity of stormwater runoff. A design year 2000 land use pattern has been developed for the stormwater management planning area by the Village Plan Commission using a sound planning process which carefully considered information on the present stage of development; historic and probable future levels of population and employment; existing and proposed utility facilities; topography; soils; drainage patterns and flood hazard areas; the location, extent, and quality of woodlands, wetlands, and wildlife habitat areas; and the location and extent of prime agricultural areas and environmental corridors, all of which are important considerations in any local land use planning effort. The recommended land use plan, as well as the description of the planning process and the recommended plan implementation mechanisms, are set forth in SEWRPC Community Assistance Planning Report No. 51, A Land Use Plan for the Village of Sussex: 2000 (January 1982). The planned land use information presented herein is drawn from that report. Existing land uses and land use regulations related to development and redevelopment in the planning area were discussed in Chapter III of this report.

Proposed land use changes are presented herein for two different geographic areas. First, proposed land use changes over the plan design period are discussed within the context of the planned urban service area of the Village of Sussex, as shown on Map 15. The primary purpose of this planning effort is

Map 15

PLANNED LAND USE FOR THE VILLAGE OF SUSSEX URBAN SERVICE AREA: 2000

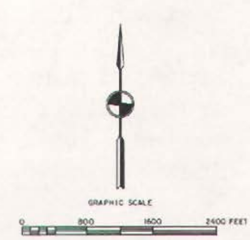


LEGEND

- LOW DENSITY RESIDENTIAL DEVELOPMENT (0.7-2.2 DWELLING UNITS PER NET ACRE)
- MEDIUM DENSITY RESIDENTIAL DEVELOPMENT (2.3-4.3 DWELLING UNITS PER NET ACRE)
- HIGH-MEDIUM DENSITY RESIDENTIAL DEVELOPMENT (4.4-6.9 DWELLING UNITS PER NET ACRE)
- HIGH DENSITY RESIDENTIAL DEVELOPMENT (7.0-17.9 DWELLING UNITS PER NET ACRE)
- COMMERCIAL DEVELOPMENT
  - N NEIGHBORHOOD RETAIL CENTER
  - C COMMUNITY RETAIL CENTER
- LIGHT INDUSTRIAL AND WHOLESALE DEVELOPMENT
- HEAVY INDUSTRIAL AND EXTRACTIVE DEVELOPMENT
- RECREATIONAL
  - N NEIGHBORHOOD PARK
  - C COMMUNITY PARK
- LOCAL PEDESTRIAN TRAIL
- WAUKESHA COUNTY HIKING AND BIKING TRAIL
- PRIMARY ENVIRONMENTAL CORRIDOR
- SECONDARY ENVIRONMENTAL CORRIDOR
- ISOLATED NATURAL AREA
- PRIME AGRICULTURAL LAND
- OTHER AGRICULTURAL AND RURAL LAND
- WATER
- GOVERNMENTAL AND INSTITUTIONAL DEVELOPMENT
  - C CHURCH
  - F FIRE STATION
  - G VILLAGE HALL AND POLICE STATION
  - L LIBRARY AND COMMUNITY CENTER
  - E ELEMENTARY SCHOOL
  - M MIDDLE SCHOOL
  - H HIGH SCHOOL
- SEWAGE TREATMENT PLANT
- LIMITS OF THE YEAR 2000 URBAN SERVICE AREA

STREETS AND HIGHWAYS

- STATE TRUNK NONFREEWAY (ARTERIAL)
- COUNTY TRUNK (ARTERIAL)
- LOCAL TRUNK (ARTERIAL)
- PROPOSED COLLECTOR



Source: SEWRPC.

to prepare a stormwater management plan for this area. Thus land use changes in this area are an important consideration in the planning effort. In addition, however, probable land use changes in the drainage areas upstream of the planned urban service area must also be considered in the plan development. Thus, the existing land use pattern and proposed changes in that pattern within the entire stormwater management study area are discussed herein.

The Village of Sussex planned urban service area for the year 2000 encompassed 3,164 acres, or about 4.9 square miles. The existing 1980 and planned year 2000 areas of land associated with each of the various land uses in this planned urban service area are set forth in Table 20. The planned year 2000 land use pattern is shown on Map 15. As indicated in the table, about 1,660 acres of rural land, or about 52 percent of the urban service area, may be expected to be converted to urban uses within the urban service area over the approximately 20-year design period. This planned conversion would increase the amount of land in urban use within the urban service area by about 176 percent. Of the total area proposed to be converted, about 1,030 acres, or 62 percent, is proposed to be converted to residential use; about 30 acres, or 2 percent, to commercial use; about 370 acres, or 22 percent, to industrial use; and about 230 acres, or 14 percent, to other urban uses.

As indicated in Table 20, under planned year 2000 land use conditions urban land uses would account for about 2,600 acres, or 82 percent of the total planned urban service area. Of these developed urban land uses, residential uses would occupy about 1,480 acres, or 57 percent, while the remaining urban land uses--governmental and institutional, commercial, industrial, transportation and utilities, and recreational--together would occupy about 1,120 acres,

Table 20

EXISTING AND PROPOSED LAND USE IN THE VILLAGE OF SUSSEX URBAN SERVICE AREA: 1980 AND PLANNED YEAR 2000

Land Use Category	Existing 1980		Planned Increment		Total 2000	
	Acres	Percent of Major Category	Acres	Percent Change	Acres	Percent of Major Category
Urban						
Residential	444	47.1	1,032	232.4	1,476	56.7
Commercial	27	2.9	32	118.5	59	2.3
Industrial	45	4.8	368	817.8	413	15.9
Governmental and Institutional	114	12.1	18	15.8	132	5.1
Transportation, Communication, and Utilities	236	25.0	202	85.6	438	16.8
Recreation	76	8.1	8	10.5	84	3.2
Urban Subtotal	942	100.0	1,660	176.2	2,602	100.0
Rural						
Agriculture and Open Lands	1,744	78.5	- 1,623	93.1	121	21.5
Wetlands and Woodlands	477	21.5	- 37	7.8	440	78.3
Surface Water	1	<0.1	--	--	1	0.2
Rural Subtotal	2,222	100.0	- 1,660	74.7	562	100.0
Total	3,164	--	--	--	3,164	--

Source: SEWRPC.

or the remaining 43 percent. Under planned year 2000 conditions, rural land uses would account for about 560 acres, or 18 percent of the planned urban area. Agricultural and other open lands would occupy about 120 acres, or 21 percent of the rural area. Other rural land uses, including wetlands, woodlands, and open water, would occupy about 440 acres, or 79 percent of the rural area.

The entire stormwater management study area encompasses about 9,820 acres, or about 15.4 square miles. The planned year 2000 land uses within the study area are shown on Map 16. The existing 1980 and planned year 2000 amounts of land associated with each of the various land uses within this study area are set forth in Table 21. As indicated in the table, about 2,210 acres of rural land, or 22 percent of the study area, may be expected to be converted to urban uses within the entire study area over the approximately 20-year design period. Thus, planned conversion would almost double the amount of land in urban use within the planning area. Of this total area to be converted, about 1,220 acres, or 55 percent, are proposed to be converted to residential use; about 30 acres, or 1 percent, to commercial use; about 500 acres, or 23 percent, to industrial use; and about 460 acres, or 21 percent, to other urban uses.

As indicated in Table 21 under planned year 2000 land use conditions, urban land uses would account for about 4,810 acres, or 49 percent of the total study area. Of these developed urban land uses, residential uses would occupy

Table 21

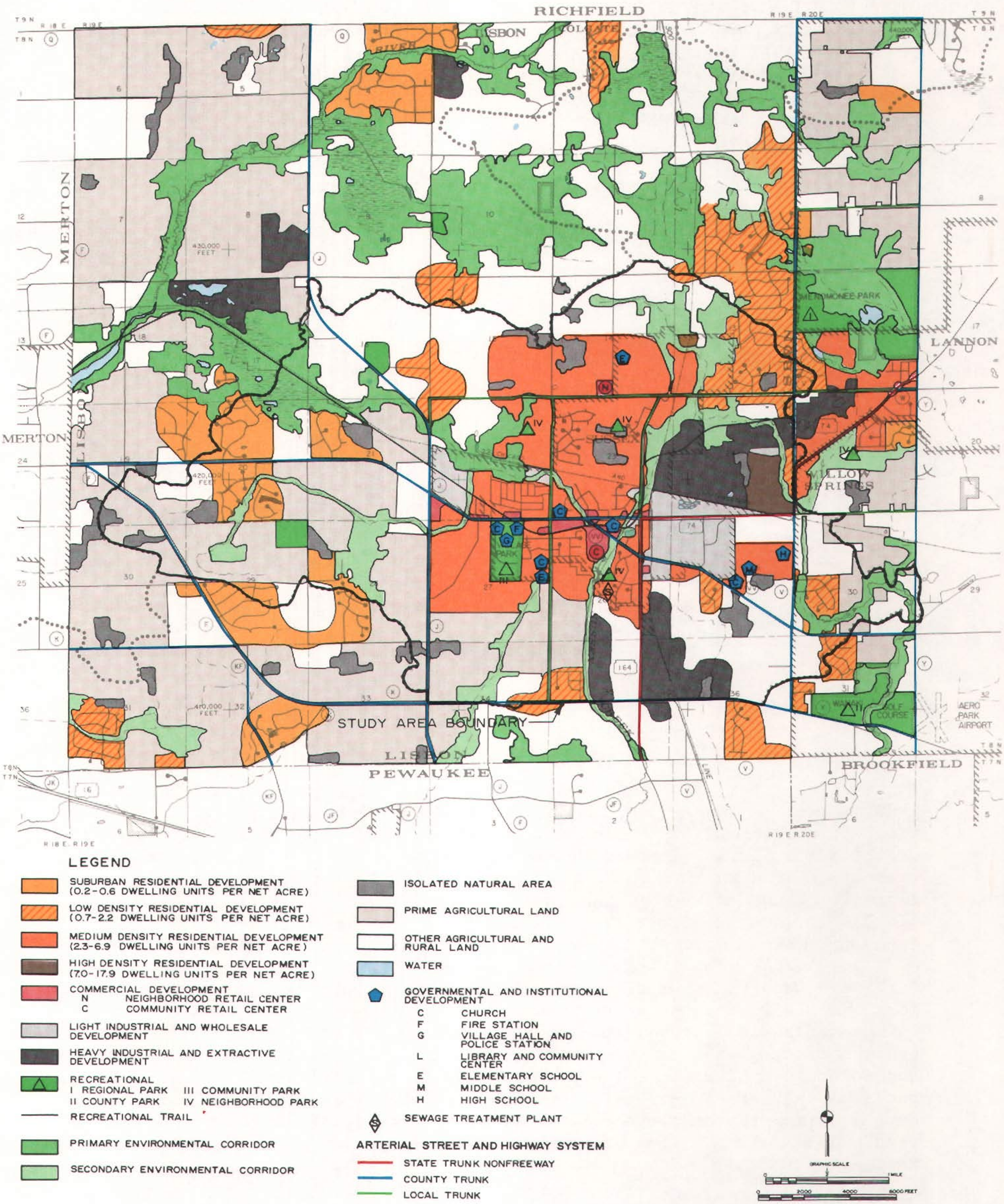
EXISTING AND PROPOSED LAND USE IN THE SUSSEX STORMWATER MANAGEMENT STUDY AREA: 1980 AND PLANNED YEAR 2000

Land Use Category	Existing 1980		Planned Increment		Total 2000	
	Acres	Percent of Major Category	Acres	Percent Change	Acres	Percent of Major Category
Urban						
Residential	1,554	59.7	1,221	78.6	2,775	57.7
Commercial	37	1.4	32	86.5	69	1.4
Industrial	397	15.2	501	126.2	898	18.7
Governmental and Institutional	125	4.8	18	14.4	143	3.0
Transportation, Communication, and Utilities	320	12.3	423	132.2	743	15.4
Recreation	171	6.6	11	6.4	182	3.8
Urban Subtotal	2,604	100.0	2,206	84.7	4,810	100.0
Rural						
Agriculture and Open Lands	5,912	81.9	- 2,187	37.0	3,725	74.3
Wetlands and Woodlands	1,291	17.9	- 19	1.5	1,272	25.4
Surface Water	17	0.2	--	--	17	0.3
Rural Subtotal	7,220	100.0	- 2,206	30.5	5,014	100.0
Total	9,824	--	--	--	9,824	--

Source: SEWRPC.

Map 16

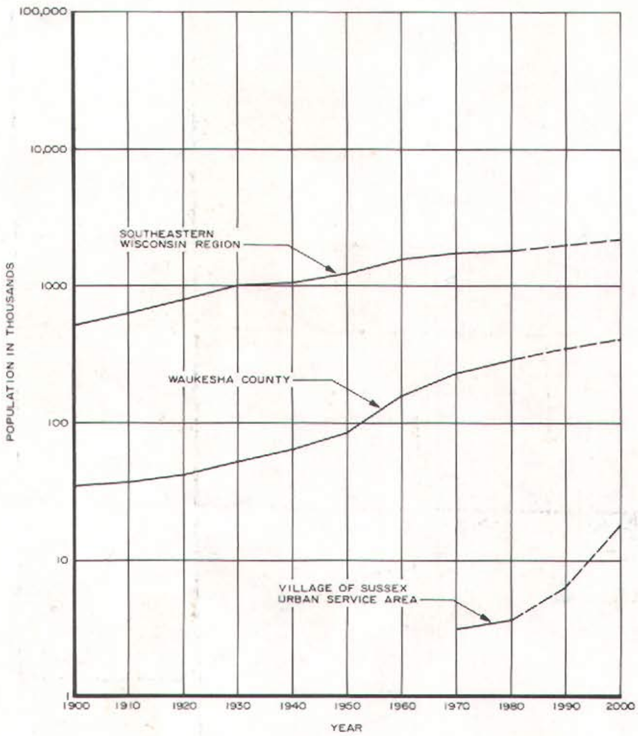
PLANNED LAND USE FOR THE STORMWATER MANAGEMENT STUDY AREA: 2000



Source: SEWRPC.

Figure 3

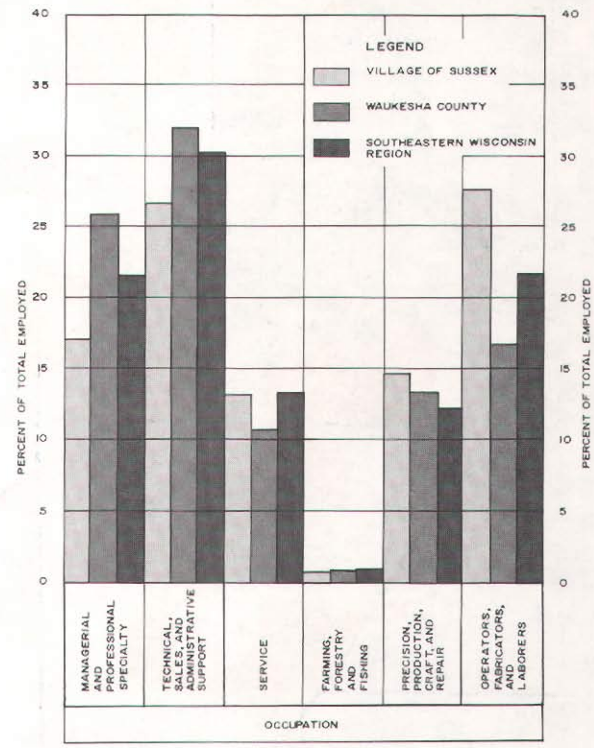
COMPARISON OF HISTORICAL, EXISTING, AND FORECAST POPULATION TRENDS FOR THE VILLAGE OF SUSSEX URBAN SERVICE AREA, WAUKESHA COUNTY, AND THE SOUTHEASTERN WISCONSIN REGION



Source: SEWRPC.

Figure 4

DISTRIBUTION OF EMPLOYMENT BY OCCUPATION FOR THE VILLAGE OF SUSSEX, WAUKESHA COUNTY, AND THE SOUTHEASTERN WISCONSIN REGION: 1980



Source: SEWRPC.

about 2,770 acres, or 58 percent of the urban area, while the remaining urban land uses--governmental and institutional, commercial, industrial, transportation and utilities, and recreational--together would occupy about 2,040 acres, or the remaining 42 percent. Under planned year 2000 conditions, rural land uses would account for about 5,010 acres, or 51 percent of the study area. Agricultural and other open lands would occupy about 3,720 acres, or 74 percent of this rural area. Other rural land uses, including wetlands, woodlands, and open water, would occupy 1,290 acres, or 26 percent of the rural area.

Pertinent demographic and economic data for the Sussex area are also set forth in SEWRPC Community Assistance Planning Report No. 51. That information which is directly related to land use planning and is indirectly related to stormwater management planning is not--with the exception of the historic and forecast population and employment levels set forth in Figures 3 and 4, and Tables 22 and 23--repeated herein. However, the demographic and economic data provided in the above-referenced report was fully and carefully considered, together with the land use data presented herein, in the stormwater management planning.

Table 22

HISTORIC AND FORECAST POPULATION LEVELS FOR THE SOUTHEASTERN WISCONSIN REGION, WAUKESHA COUNTY, THE VILLAGE OF SUSSEX, AND THE VILLAGE OF SUSSEX URBAN SERVICE AREA

Year	Southeastern Wisconsin		Waukesha County			Village of Sussex		
	Population	Percent Change	Population	Percent Change	Percent of Region	Population	Percent Change	Percent of County
1900	501,808	--	35,229	--	7.0	--	--	--
1910	631,161	25.8	37,100	5.3	5.9	--	--	--
1920	783,681	24.2	42,612	14.8	5.4	--	--	--
1930	1,006,118	28.4	52,358	22.9	5.2	496[a]	--	0.9
1940	1,067,699	6.1	62,744	19.8	5.9	548	10.5	0.9
1950	1,240,618	16.2	85,901	36.9	6.9	679	23.9	0.8
1960	1,573,620	26.8	158,249	84.2	10.1	1,087	60.1	0.7
1970	1,756,086	11.6	231,335	46.2	13.2	2,758	153.7	1.2
1980	1,873,400	6.7	292,300	26.3	15.6	3,600[b]	30.5	1.2

Year	Southeastern Wisconsin		Waukesha County			Village of Sussex Urban Service Area		
	Population	Percent Change	Population	Percent Change	Percent of Region	Population	Percent Change	Percent of County
1990	2,043,900	9.1	356,600	30.0	17.4	6,500	80.5	1.8
2000	2,219,300	8.6	420,600	17.9	18.9	10,800	66.2	2.6

[a]The Village of Sussex was incorporated from part of the Town of Lisbon in 1924.

[b]The actual U. S. Bureau of the Census total population figure for the Village is 3,482. Shortly after the 1980 census reporting period, it is estimated that about 120 additional persons were added to the village population with the occupancy of the Bristol Court residential development.

Source: U. S. Bureau of the Census and SEWRPC.

Table 23

EMPLOYED POPULATION, 16 YEARS AND OLDER, BY OCCUPATION IN THE VILLAGE OF SUSSEX, WAUKESHA COUNTY, AND SOUTHEASTERN WISCONSIN: 1980

Occupation	Village of Sussex		Waukesha County		Southeastern Wisconsin Region	
	Number	Percent of Total Employed	Number	Percent of Total Employed	Number	Percent of Total Employed
Managerial and Professional Specialty						
Executive, Administrative, Managerial	130	7.55	17,926	13.15	81,635	9.88
Professional Specialty	164	9.52	17,472	12.81	96,863	11.72
Technical, Sales, Administrative Support						
Technicians and Related Support	34	1.98	4,385	3.22	25,271	3.06
Sales	164	9.52	16,712	12.26	81,057	9.81
Administrative Support, Including Clerical	261	15.16	22,539	16.53	143,121	17.32
Service						
Private Household	5	0.29	296	0.22	2,486	0.30
Protective Service	28	1.63	1,154	0.85	11,721	1.42
Service, Except Protective and Household	194	11.27	13,207	9.63	95,816	11.59
Farming, Forestry, and Fishing	15	0.87	1,448	1.06	9,065	1.10
Precision Production, Craft, and Repair	252	14.63	18,304	13.43	100,953	12.21
Operators, Fabricators, and Laborers						
Machine Operators, Assemblers, Inspectors	273	15.85	13,136	9.64	109,787	13.28
Transportation and Material Moving	129	7.49	5,014	3.68	33,843	4.09
Handlers, Equipment Cleaners, Helpers, Laborers	73	4.24	4,734	3.47	34,838	4.22
Total Employment	1,722	100.00	136,327	100.00	826,456	100.00
Total Unemployment	89	--	6,447	--	49,696	--
Total Labor Force	1,811	--	142,774	--	876,152	--

Source: SEWRPC.

IMPACT OF CHANGED LAND USE ON STUDY AREA STORMWATER MANAGEMENT SYSTEMS

The conversion of 2,210 acres of rural land within the study area to urban land uses would result in about 4,810 acres, or about 49 percent of the study area, being devoted to urban land uses by the year 2000. This compares to the 2,600 acres, or about 26 percent of the study area, being in urban land use under existing 1980 conditions and, as already noted, indicates an approximate doubling of the amount of land in urban use. This change in land use will have a direct impact upon the quality, amount, and rate of stormwater runoff.

The combination of land use and cover is probably the single characteristic which best indicates the influence of urban development on the hydrologic processes. Both land use and land cover are largely the result of man's activities. Land cover differs from land use in that it describes the types of surface--for example, roofed, paved, grassed, and wooded--whereas land use describes the function or activity served by the land--for example, residential, commercial, and recreational. The combination of land use and cover is quantified and represented in the quantitative analyses used in the design of stormwater drainage systems. Table 24 lists the imperviousness ranges defined for various land use and land cover conditions.

The percent of impervious--or imporous--surface in a given area is an important factor in determining both the amount and rate at which stormwater runoff is generated. Industrial and commercial areas may have more than 65 percent of the total area in impervious surface, while residential areas may have from 10 to 65 percent of the total area in impervious surface, depending upon the density or intensity of the development. Rural areas generally have less than 10 percent of the total area in impervious surface. The impact of the planned changes in land use on the volume and rate of stormwater runoff from each of the drainage subbasins established for this study is set forth in Chapter VII which discusses the results of the stormwater drainage system hydrologic-hydraulic simulation modeling work.

Another important consideration in the stormwater management planning effort was the increased urban area within the village planned urban service area which must be provided with urban stormwater drainage facilities. As shown in Table 19, new stormwater drainage systems will be needed to serve about 1,030 acres of new residential land, 30 acres of new commercial land, 370 acres of new industrial land, and 230 acres of new governmental, institutional, and transportation lands. In addition, the planning effort considered the rehabilitation and improvements needed to properly maintain and, as necessary, improve the existing stormwater management system serving the 940 acres of already developed lands in the village urban service area.

SUMMARY

Future land use in the stormwater management study area directly influences stormwater management needs. Thus, consideration of expected future land use conditions is necessary for the development of alternative stormwater management plans, and for the selection of a recommended plan. Hence, this chapter presents information on the anticipated type, extent, and distribution of land uses for the year 2000 in the Sussex urban service area and in the study area.

Table 24

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.

Urban land use within the Sussex urban service area is expected to increase from about 940 acres in 1980 to about 2,600 acres in 2000, or about a 176 percent increase. The residential and industrial land use categories are expected to experience the largest increases, with the residential land area more than doubling and the industrial land area increasing eight-fold.

Within the entire study area, urban land use is expected to increase from about 2,600 acres in 1980 to about 4,810 acres in the year 2000, or about an 85 percent increase. As a result of this urbanization, the area covered by rural land uses, primarily agricultural and open lands, is expected to decrease by about 30 percent.

Attendant to this rapid increase in urbanization is an increase in the population level. The 1980 population of the Village of Sussex of 3,600 persons is expected to increase to a level of about 10,800 persons within the urban service area by the year 2000.

The anticipated change in land use will directly impact the amount, and particularly the rate, of stormwater runoff. In addition, urbanization frequently has an adverse effect on the quality of stormwater runoff. Urban areas require the provision of engineered stormwater management systems to safely and efficiently accommodate the increased runoff. The increased rates of runoff result from the higher proportion of impervious areas--such as streets, parking lots, and rooftops--and the more efficient drainage systems which generally convey the runoff to the receiving watercourse as soon as possible, unless special stormwater storage provisions are incorporated into the engineered drainage system. Impervious surfaces generally cover from 30 to more than 65 percent of urban areas, compared to typically less than 10 percent of rural areas.

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Chapter V

STORMWATER MANAGEMENT OBJECTIVES, STANDARDS, AND DESIGN CRITERIA

INTRODUCTION

Planning is a rational process for formulating and meeting objectives. Accordingly, the formulation of objectives is an essential task which must be undertaken before plans can be prepared.

Sound stormwater management objectives should be formulated within the context of broad community development objectives which reflect the basic values and needs of the community concerned. In the case of the Village of Sussex stormwater management study area, these broad community development objectives were provided by the adopted village land use plan and the land use development objectives and standards explicitly set forth in that plan. By preparing the stormwater management objectives and plan within the context of, and in a manner fully consistent with, the adopted land use development objectives and plan, the need to reconcile potentially competing objectives relating to economic and associated land use development, transportation improvement, environmental enhancement, and general social well-being with objectives relating to stormwater management was avoided, and the formulation of the required stormwater management objectives greatly simplified. Thus, the adopted village land use plan became the basis for determining stormwater management needs in the study area, and for providing for the wise use and conservation of the land and water resources of the planning area in the stormwater management system plan. It should be noted, in this respect, that the village land use plan was in turn set within the context of adopted areawide land use, transportation, park and open space, sanitary sewerage, flood control, and water quality management plans.

This chapter sets forth a number of stormwater management objectives and supporting standards as a basis for the design and evaluation of alternative stormwater management system plans for the Village of Sussex stormwater management study area, and for the selection of a recommended plan from among those alternatives.

In addition, this chapter also discusses certain engineering design criteria and analytical procedures which were used in the preparation and evaluation of the alternative stormwater management system plans. These engineering design criteria and analytic procedures include the engineering techniques used to design the alternative plan elements, test the physical feasibility of those elements, and make necessary economic comparisons between the alternative plan elements. The description of these criteria and procedures in this chapter is intended to document the degree of detail and level of sophistication employed in the preparation of the recommended stormwater management plan and thereby provide a better understanding by all concerned, of the plan and of the need for refinements of some aspects of that plan prior to and during implementation. It should be noted that, while the design criteria and analytic procedures, as described herein, were used in the preparation of the recommended stormwater management plan and alternatives thereto, these criteria and procedures do not comprise standards as heretofore defined. These criteria and procedures relate to the technical methods used in the analytical phases of the planning work, rather than to relating alternative plans to specific development objectives.

STORMWATER MANAGEMENT OBJECTIVES AND STANDARDS

The following five specific stormwater management objectives were established to guide the design, test, and evaluation of alternative stormwater management plans for the Sussex stormwater management planning area and to select a recommended plan from among the alternatives considered:

1. The development of a stormwater 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 inadequate stormwater drainage and inundation.

2. The development of a stormwater management system which will effectively serve existing and planned land uses and promote implementation of the adopted land use plan.

3. The development of a stormwater management system which will minimize soil erosion, sedimentation, and attendant water pollution.

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

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

Complementing each of the foregoing specific stormwater management development objectives is a set of quantifiable standards which can be used to evaluate the relative or absolute ability of alternative stormwater management plan designs to meet the stated development objective. These standards are set forth in Table 25 and serve to facilitate quantitative application of the objectives in plan design, test, and evaluation. 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 management development objectives and standards, and in the preparation, test, and evaluation of stormwater management plan elements, several overriding considerations must be recognized. First, it must be recognized that any proposed stormwater management facilities must constitute integral parts of a total system. It is not possible from

Table 25

STORMWATER MANAGEMENT OBJECTIVES AND STANDARDS FOR THE VILLAGE OF SUSSEX STORMWATER MANAGEMENT PLAN

OBJECTIVE NO. 1

The development of a stormwater 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 inadequate stormwater drainage and inundation.

STANDARDS

1. In order to prevent significant property damage and safety hazards, the major components of the stormwater 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 component 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 arterial streets, and one clear 10-foot lane for moving traffic on collector and land access streets during storm events up to the 10-year recurrence interval event.

4. When functioning as a part of the minor stormwater drainage system--i.e. to accommodate flows during a storm event with a recurrence interval of up to 10 years--flow across arterial, collector, and land access streets should not be allowed, and inlets and storm sewers should be located and sized accordingly.

5. When functioning as a part of the major stormwater drainage system--i.e. to accommodate flows during a storm event with a recurrence interval of up to 100 years--uncontrolled flow across collector and land access streets is acceptable; and controlled flow across arterial streets will be determined by the traffic-carrying importance of the arterial and the availability of convenient alternative arterial routes.

OBJECTIVE NO. 2

The development of a stormwater management system which will effectively serve the existing and planned land uses and promote implementation of the adopted land use plan.

STANDARDS

1. Stormwater drainage systems should be designed assuming that the layout of collector and land access streets for all 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 drainage and storage capabilities of the site, and to provide the most economical installation of a gravity flow 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 assume that midblock sags in street grades will be avoided and street grades will generally parallel storm sewer gradients.

3. Engineered stormwater management systems utilizing urban street cross-sections and storm sewers should be provided only in areas recommended for urban development in the adopted land use plan for the Village of Sussex.

4. Stormwater drainage systems for planned new urban development should minimize the creation of new drainage or flooding problems, or the intensification of existing problems both at the development site and at downstream locations.

OBJECTIVE NO. 3

The development of a stormwater management system which will minimize soil erosion, sedimentation, and attendant water pollution.

STANDARDS

1. Flow velocities which cause streambank erosion and channel sediment scouring should be avoided.

2. Storm sewer outfalls should be so located and designed so as to prevent stream bank erosion and channel sediment scouring.

3. Both urban and rural nonpoint source abatement measures, as recommended in the adopted regional water quality management plan, should be incorporated, wherever appropriate, into the stormwater management system.

OBJECTIVE NO. 4

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

STANDARDS

1. Larger, less frequent storm events should be used to design and size those site-specific elements of the stormwater drainage system for which it would not be economically feasible to provide flow relief and repairs during and following a major storm event.

2. Larger, less frequent storm events should be used to design and size special structures, such as roadway underpasses, requiring pumping stations.

OBJECTIVE NO. 5

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

STANDARDS

1. The sum of storm sewerage system capital investment and the operation and maintenance costs should be minimized.

2. Maximum feasible use should be made of all existing stormwater 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 management needs generated by implementation of the adopted land use plan.

3. Stormwater management facilities should be designed for staged or incremented construction, where feasible and economical, so as to limit the total investment in such facilities at any one time and to permit maximum flexibility to accommodate changes in urban development, economic activity growth, changes in the objectives or standards, or changes in the technology of stormwater management.

4. 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.

5. 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 immediately downstream of these potential storage sites.

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 facilitates such quantitative tests and the adjustment of the configuration and capacity of the system to the existing and future runoff loadings, as derived from the land use plan. 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 specific objectives which the given standard complements. Third, it must be recognized that certain objectives and standards may be in conflict and require resolution through compromise, such compromise being an essential part of any design effort.

ENGINEERING DESIGN CRITERIA AND ANALYTICAL PROCEDURES

Introduction

Certain engineering criteria and procedures were used in the design of alternative stormwater management plan elements, and in the making of the necessary economic evaluations. While these engineering criteria and procedures are widely accepted and firmly based in current engineering practice, it is, nevertheless, believed 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 specifically considered in this stormwater management plan. In addition to serving as a basis for the quantitative sizing and analysis of stormwater management facilities at the systems planning level, these criteria and procedures can also serve as a basis for the more detailed design of stormwater management system components which are related directly to those 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 stormwater management plan.

System Components and Associated Analytic Procedures

There are two distinct drainage systems to be considered in the development of a stormwater management plan for the Village of Sussex: the minor system and the major system. The minor stormwater drainage system is intended to minimize the inconveniences attendant to inundation from more frequent storms, generally up to the 10-year recurrence interval storm event. The minor drainage system consists of sideyard and backyard drainage swales, street curbs and gutters, roadway ditches, storm sewers, and some storage facilities. It is composed of the engineered paths provided for the stormwater runoff to reach the receiving streams and watercourses during these more frequent storm events.

The major stormwater drainage system is designed for conveyance of stormwater runoff during major storm events--that is, generally, for storms exceeding the 10-year recurrence interval--when the capacity of the minor system is exceeded.

The major stormwater drainage system consists of the entire street cross-section and interconnected drainage swales, watercourses and stormwater storage facilities. Portions of the streets, therefore, serve as components of both the minor and major stormwater drainage systems. When providing transport of overland runoff to the piped storm sewer system, the streets function as a part of the minor drainage system; when utilized to transport overflow from surcharged piped storm sewers, the streets function as a part of the major drainage system. Major drainage system components must be carefully studied to identify areas subject to inundation during major storm events.

Two different procedures were used to analyze flows in, and design system components of, the minor stormwater drainage system. One method used was the application of a mathematical simulation model: the Illinois Urban Drainage Area Simulator (ILLUDAS). This model uses discrete rainfall patterns for the selected recurrence interval design storms. The rainfall patterns used for the 10- and 100-year recurrence interval storms are shown in Figures 5 and 6 as the primary input. The study area is divided into catchment areas and hydrographs are produced for the pervious and impervious portions of each catchment area by applying the rainfall pattern to the contributing areas. These hydrographs are combined and routed downstream from one critical location in the system to the next to provide system loadings in the form of peak flow rates and total flow volumes. This model was used in both of its two potential operational modes, the evaluation mode and the design mode. In the evaluation mode the model routes hydrographs through a specified drainage system and is used to calculate needed hydraulic capacity at each critical location in the system. In this mode of operation undersized components can be identified, and the effects of detention storage on peak flow rates and, therefore, on required hydraulic capacities can be analyzed. In the design mode the model is used to calculate the pipe sizes at specified slopes needed to carry the hydraulic loadings. The simulation model application results are presented in Chapter VII.

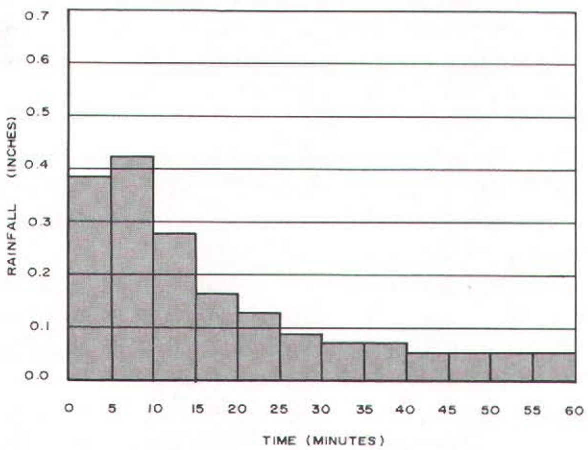
The second procedure used in the analyses of flows and the design of system components involved the application of commonly used formulae and design criteria. This second procedure was used to verify the simulation modeling results and to provide supplementary information for system components not readily amenable to model application. Peak rates of flow for selected recurrence interval storms were calculated at critical locations in the minor stormwater drainage system using the Rational Method, and peak flows and total volumes were calculated using the U. S. Soil Conservation Service TR 55 Method. The hydraulic capacities required to carry the peak flows were computed utilizing the Manning formula, and the cross-sectional areas and slopes of the pipes and channels concerned.

Stormwater Flow Rate and Volume

The quantification of the stormwater flow rates and volumes 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, and storage and pumping facilities. The techniques used to quantify

Figure 5

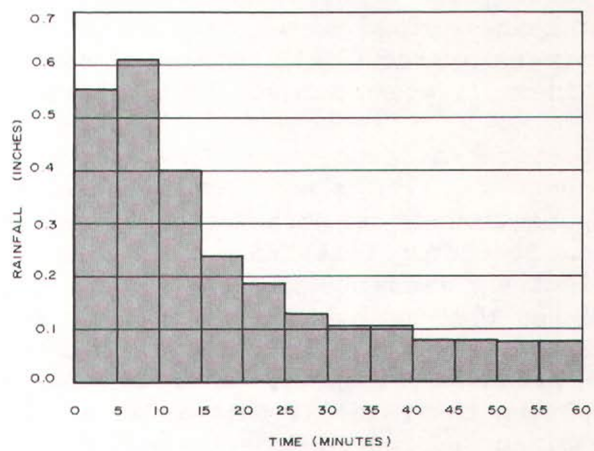
RAINFALL PATTERN FOR 10-YEAR RECURRENCE INTERVAL, ONE-HOUR STORM



Source: SEWRPC.

Figure 6

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



Source: SEWRPC.

stormwater flow rate and volume in both the minor and major drainage systems have been briefly described above. These techniques provide the basic quantitative data needed to locate, configure, and size drainage facilities, and are needed to determine surface water flows, velocities, and volumes at the inlet and outlet points of each catchment area, and to determine the hydrologic and hydraulic characteristics of the catchment areas.

To insure that the stormwater system is able to effectively facilitate the control of the stormwater runoff in a cost-effective manner, storm events of specified magnitudes and 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 properly made by the responsible local officials involved.

The average frequency of the rainfall occurrence used for design determines the degree of protection afforded by the stormwater management system. This protection should be consistent with the damage prevented. In practice, however, benefit-cost analyses are not deemed to be warranted for ordinary urban drainage facilities, and the selection of a design storm recurrence interval is made on the basis of 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 the design storm frequency; with facilities designed for 10-year recurrence interval storms costing relatively little more than facilities designed for five-year recurrence interval storms. Accordingly a 10-year recurrence interval storm event was selected for use in the design of the minor elements of the stormwater management system for the Village of Sussex stormwater management study area, including the design of most conveyance and some storage facilities. This recurrence interval has been applied historically in the Village of Sussex to size storm sewerage facilities, as well as in many other communities in the Southeastern Wisconsin Region.

A 100-year recurrence interval storm event was used to delineate areas of potential inundation along, and to size major elements of, the stormwater management system. This recurrence interval--which is also used by the Regional Planning Commission in its flood control planning efforts, and by federal and state agencies for floodland regulation, was selected because the 100-year recurrence interval event approximates, with respect to the amount of land area inundated, the largest known flood levels that have actually occurred in the Region, thereby providing a conservatively safe level of property damage and hazards to human health and safety from surcharge of the major, as opposed to the minor, stormwater management system.

Rainfall data, including rainfall intensity-duration-frequency relationships, were available from the files of the Regional Planning Commission as input to various methods used to compute stormwater runoff rates and volumes. These rainfall data are described in Chapter III. Data on the hydrologic and hydraulic characteristics of the study area were also from the files of the Regional Planning Commission, including data on soils, topography, drainage of natural streams and watercourses, and related bridges and culverts, and flood hazard areas, wetlands, and areas with existing drainage problems. Topographic maps prepared to Regional Planning Commission specifications at a scale of 1" = 200' with two feet interval contours, and Commission ratioed and rectified aerial photographs at a scale of 1" = 400',were used in the analyses.

The data noted above were utilized to estimate hydraulic loads--stormwater runoff rates and volumes--under existing and planned future land use conditions in the study area. These methods included, as already noted, the ILLUDAS mathematical simulation model and manual methods, including the Rational method, and the U. S. Soil Conservation Service TR 55 method.

Criteria and Assumptions Relating to Street Cross-Sections, Related Site Grading, and Inlets

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 level, only recommendations concerning the approximate elevations and gradients of existing and proposed streets are provided. Pertinent aspects of the details of the curbs and gutters, roadside ditches, and street crowns are assumed based upon cross-sections and must be further addressed in subsequent project development engineering.

The location and size of inlets, as a part of the minor stormwater drainage system, is dictated by the allowable stormwater spread and depth of flow in streets, and attendant interference with the safe movement of traffic. A commonly used street cross-section in the Village of Sussex has a parabolicly shaped pavement, with one inch of vertical drop across the 24-inch gutter pan area, and five inches of vertical drop between the centerline and the beginning of the gutter pan of a 36-foot wide pavement. Additional vertical drop is provided for wider streets.

Sidewalks can be placed against the curb or, as is more common and more desirable in southeastern Wisconsin, can be separated from the curb by a planting area or curb lawn. The sidewalks and curb lawn are normally sloped toward the curb at a rate of one-quarter inch per foot with any grading beyond the sidewalk being at a slope of three on one. A street cross-section with road ditches or drainage swales replacing curb and gutter, and often with no sidewalks, is currently being used in a few selected locations in the Village of Sussex and in many other areas in southeastern Wisconsin. This type of street cross-section is not, however, expected to be utilized in portions of the Village of Sussex urban service area except in special situations.

Given the standards formulated under the study, only two assumptions concerning site grading and one assumption concerning inlets were required. It was assumed that all new urban development and redevelopment will be designed to facilitate good site drainage to abutting streets, with slopes away from all sides of buildings of at least one-quarter inch per foot to provide positive drainage to streets or to interior drainage swales. It was assumed that interior drainage swales along side or back lot lines will have a minimum slope of one-quarter inch per foot, and will provide positive drainage to streets.

With regard to inlets, it was assumed that each inlet would be designed to provide sufficient capacity to intake, at the locations shown on the system plan, all flow in the tributary gutters from storms up to and including the 10-year recurrence interval event. In the system planning, the location of the inlets was selected to maintain the specified overland and gutter flow depths. Inlet capacities were not specifically calculated. However, it was assumed that combination inlets would be used except in special cases. Flow diagrams for depressed and undepressed combination inlets are shown in Figures 7 and 8, respectively. A chart for calculating flows intercepted by inlets is set forth in Figure 9.

Criteria and Assumptions Relating to Storm Sewers

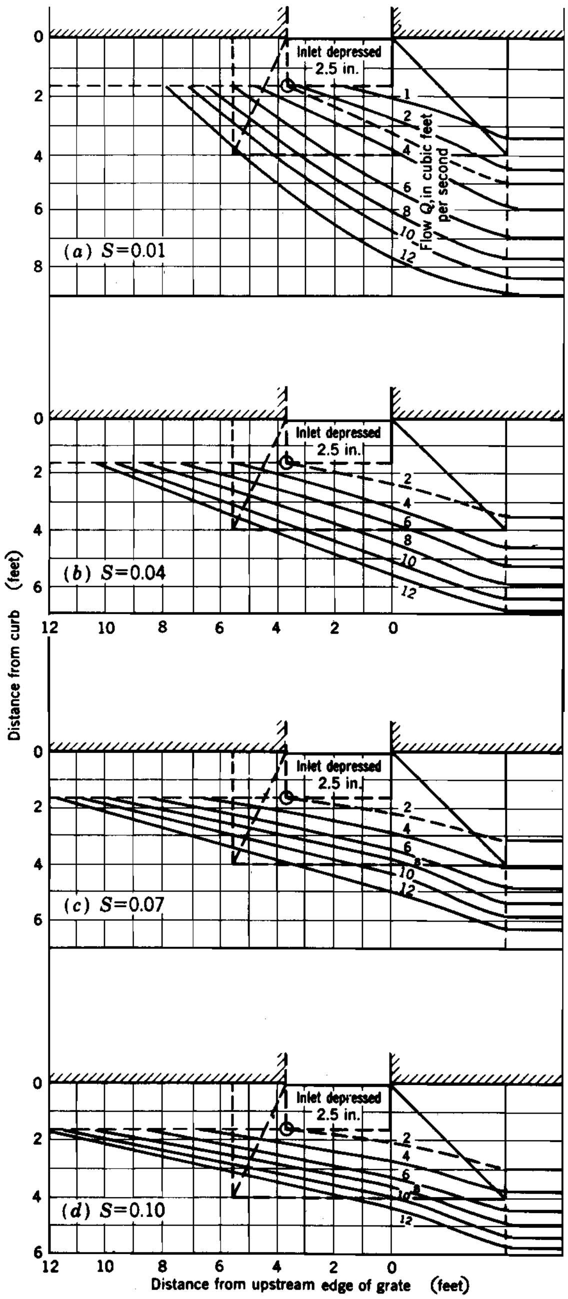
At the systems planning level, only recommendations relating to the general configuration, size, approximate invert elevation, slope, and type of storm sewer facilities are provided. More detailed engineering at the project development level will be needed to determine precise depth location and horizontal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

In the system planning, the Manning's equation was used together with the cross-sectional area of flow to determine the hydraulic capacity of sewers. 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, reinforced concrete pipe sewer lines. Sewer capacities and flow velocities were determined accordingly from either the monograph set forth in Figure 10, or calculated directly in the simulation model.

Where the analyses indicated the sewers would flow less than full at design loading, the hydraulic element chart set forth in Figure 11 was used to determine the critical characteristics; or those characteristics were computed directly in the simulation model.

Figure 7

DEPRESSED COMBINATION INLET FLOW DIAGRAM FOR A TYPICAL ROADWAY SECTION

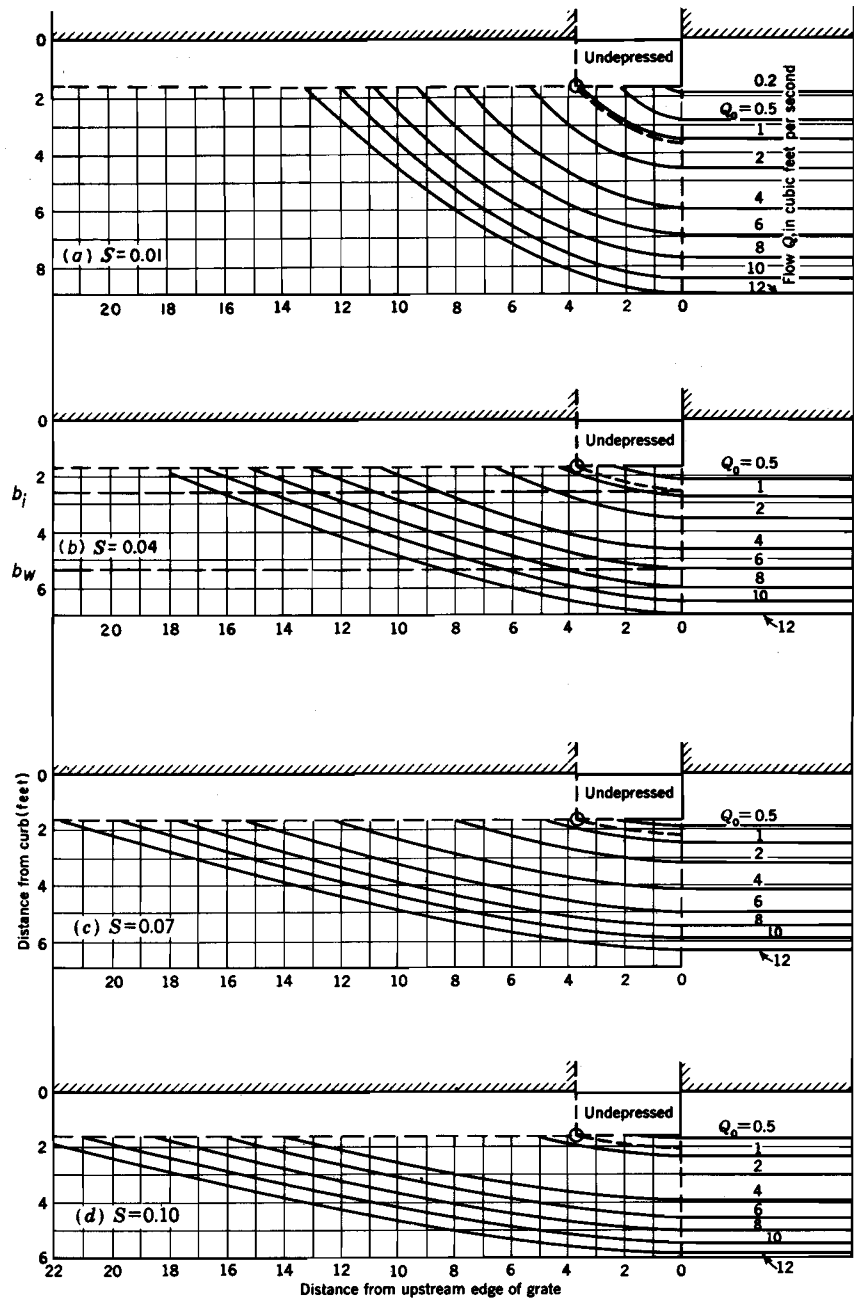


NOTE: DIAGRAM ASSUMES A CROWN SLOPE OF 1:18 AND A MANNING "n" COEFFICIENT OF 0.013. DASHED LINES REPRESENT SAMPLE DATA POINTS FOR A 3.67 FT. LONG-BY-1.67 FT. WIDE INLET GRATE. THIS FIGURE IS USED ALONG WITH FIGURE 9 TO DETERMINE THE INTERCEPTED GUTTER FLOW FOR THE CONDITIONS DESCRIBED ABOVE.

Source: American Society of Civil Engineers, Manual and Reports on Engineering Practice, No. 37.

Figure 8

UNDEPRESSED COMBINATION INLET FLOW DIAGRAM FOR A TYPICAL ROADWAY SECTION



NOTE: DIAGRAM ASSUMES A CROWN SLOPE OF 1:18 AND A MANNING "n" COEFFICIENT OF 0.013. DASHED LINES REPRESENT SAMPLE DATA POINTS FOR A 3.67 FT. LONG-BY-1.67 FT. WIDE INLET GRATE. THIS FIGURE IS USED ALONG WITH FIGURE 9 TO DETERMINE THE INTERCEPTED GUTTER FLOW FOR THE CONDITIONS DESCRIBED ABOVE. LONGER DASHED LINES IN FIGURE 8b ARE FOR EXAMPLE NOTED IN FIGURE 9.

Source: American Society of Civil Engineers, Manual and Reports on Engineering Practice, No. 37.

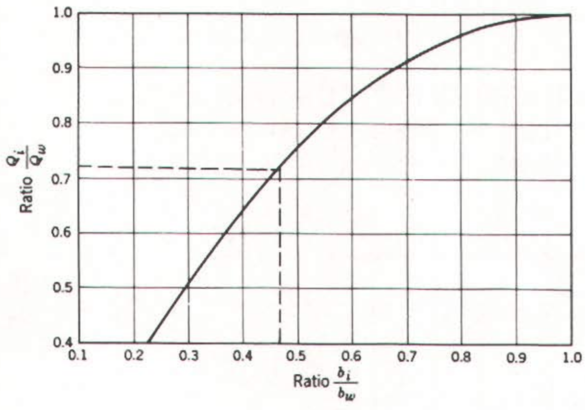


Figure 9

THE RATIO OF INTERCEPTED FLOW TO THE TOTAL GUTTER FLOW VS. THE RATIO OF INTERCEPTED WIDTH OF FLOW TO THE TOTAL WIDTH OF FLOW

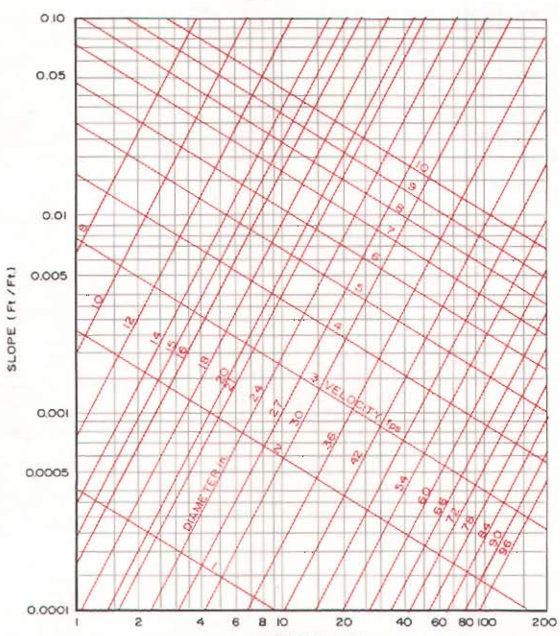
NOTE: Qw = Total Gutter Flow;
Qi = Intercepted Gutter Flow;
bw = Total Width of Flow;
bi = Width of Intercepted Flow.

<u>EXAMPLE</u>
Given: Qw = 6 cfs, S = 0.04 (use Figure 8b)
Find: Qi (intercepted gutter flow)
bi = 2.5 feet (see Figure 8b)
bw = 5.3 feet (see Figure 8b)
$\frac{bi}{bw}$ = 0.47 , $\frac{Qi}{Qw}$ = 0.72 , Qi = 4.3 cfs

Source: American Society of Civil Engineers, <u>Manual and Reports on Engineering Practice</u>, No.37.

Figure 10

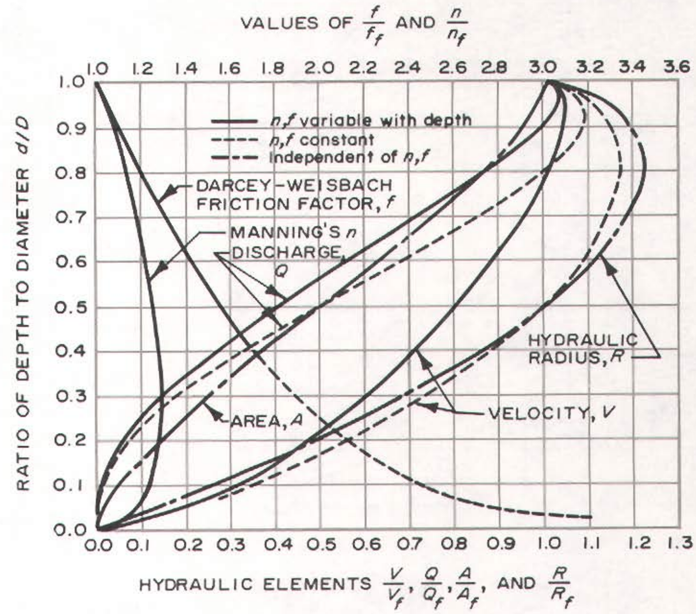
CAPACITY AND VELOCITY OF FLOW IN CIRCULAR STORM SEWERS FLOWING FULL



Source: Metcalf and Eddy, Inc., <u>Wastewater Engineering: Collection, Treatment, Disposal</u>, 1972.

Figure 11

HYDRAULIC ELEMENTS OF CIRCULAR SEWERS



NOTE: n, V, Q, AND R REPRESENT PARTIAL FLOW CONDITIONS. n_f, V_f, Q_f, AND R_f REPRESENT FULL FLOW CONDITIONS.

Source: American Society of Civil Engineers and the Water Pollution Control Federation, <u>Design and Construction of Sanitary and Storm Sewers</u>, 1969.

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

1. It was assumed that the sewer pipes would be located in the street rights-of-way and would generally follow the street alignments and gradients.

2. All storm sewers should be designed to accommodate the peak runoff expected from a minor storm when flowing full.

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

4. The minimum velocity during the design storm event should be two feet per second; while the maximum velocity during the design storm event should be 10 feet per second.

5. At all junctions and changes in pipe size, the top of the pipes should be aligned.

6. At all changes in direction of 45° or more a slope increase should be provided to compensate for associated energy losses.

7. The radius of the centerline of a bend should be at least one and one-half times the diameter of the sewer.

8. The minimum depth of cover over the top of the sewer should be three feet, while the maximum depth of cover should not exceed 15 feet.

Criteria and Assumptions Relating to Open Drainage Channels

At the systems planning level only recommendations relating to the general location cross-section, including bottom widths and side slopes, bottom elevation, slope, and type of open drainage channels, are provided. 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 buildings, other utilities, and street layout.

Although it is the general practice in the Village of Sussex for all urban streets to be constructed with curb and gutter and storm sewers, open drainage channels are a necessary and appropriate component of the total stormwater drainage system. Such channels may in certain areas serve as part of the minor drainage system, as for example in parks and cemeteries, in some industrial areas, and in some low-density residential areas. Such channels inevitably form part of the major stormwater drainage system as well. Within the Village of Sussex stormwater management study area, but outside the urban service area, open drainage channels together with road ditches may serve as the sole component of the engineered stormwater drainage system which conveys surface runoff to the receiving natural stream system.

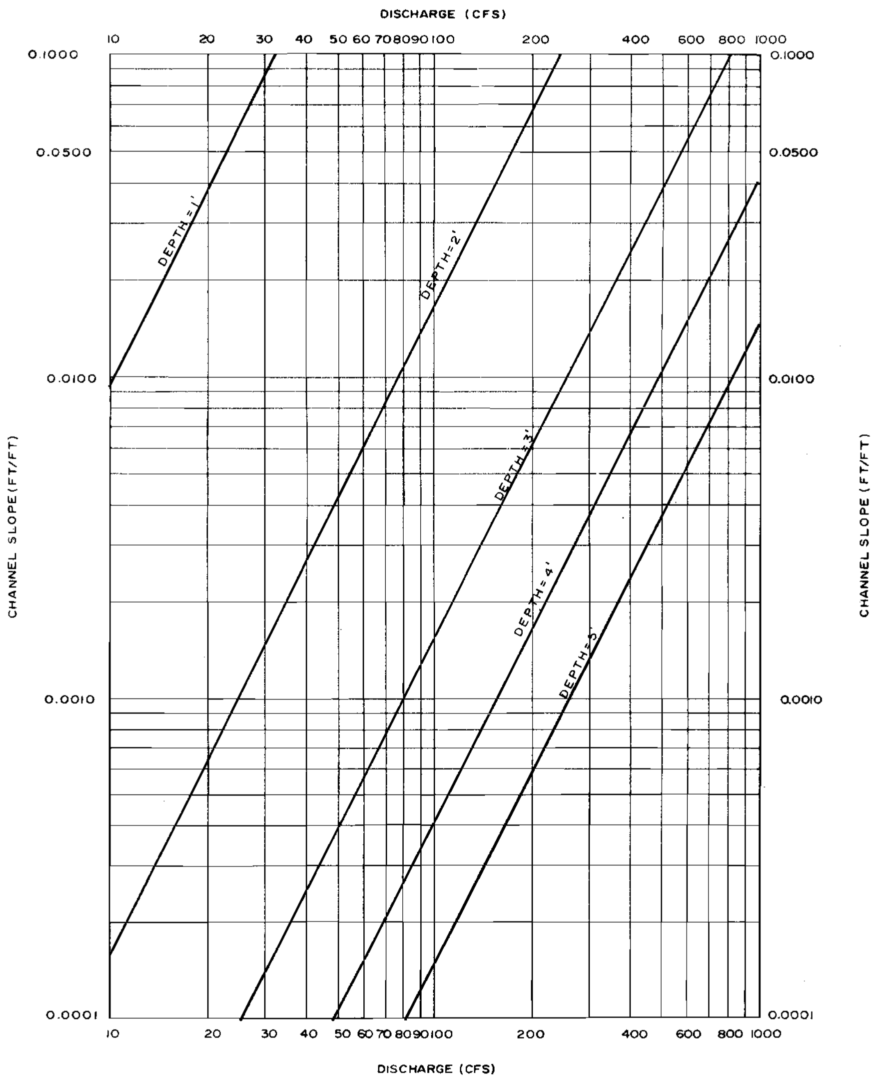
In the system planning, the Manning's equation was used together with the cross-sectional area of flow to determine the hydraulic capacity of open channels. A Manning's "n" value of 0.035 was assumed for all turf-lined channels, and a value of 0.013 for all concrete-lined channels. Receiving natural stream channels were analyzed using the U. S. Army Corps of Engineers' HEC-2 step backwater simulation model. Slope-discharge relationships for open channel flow for various channel cross-sections are shown in Figures 12 through 15.

The following criteria and assumptions relating to the details of the open drainage channels were used in the development of the stormwater management plan:

1. All open drainage channels should be designed to accommodate the peak runoff from a major storm when flowing with no freeboard.

Figure 12

SLOPE DISCHARGE RELATIONSHIP FOR OPEN CHANNEL FLOWS FOR A CHANNEL BOTTOM WIDTH OF FIVE FEET

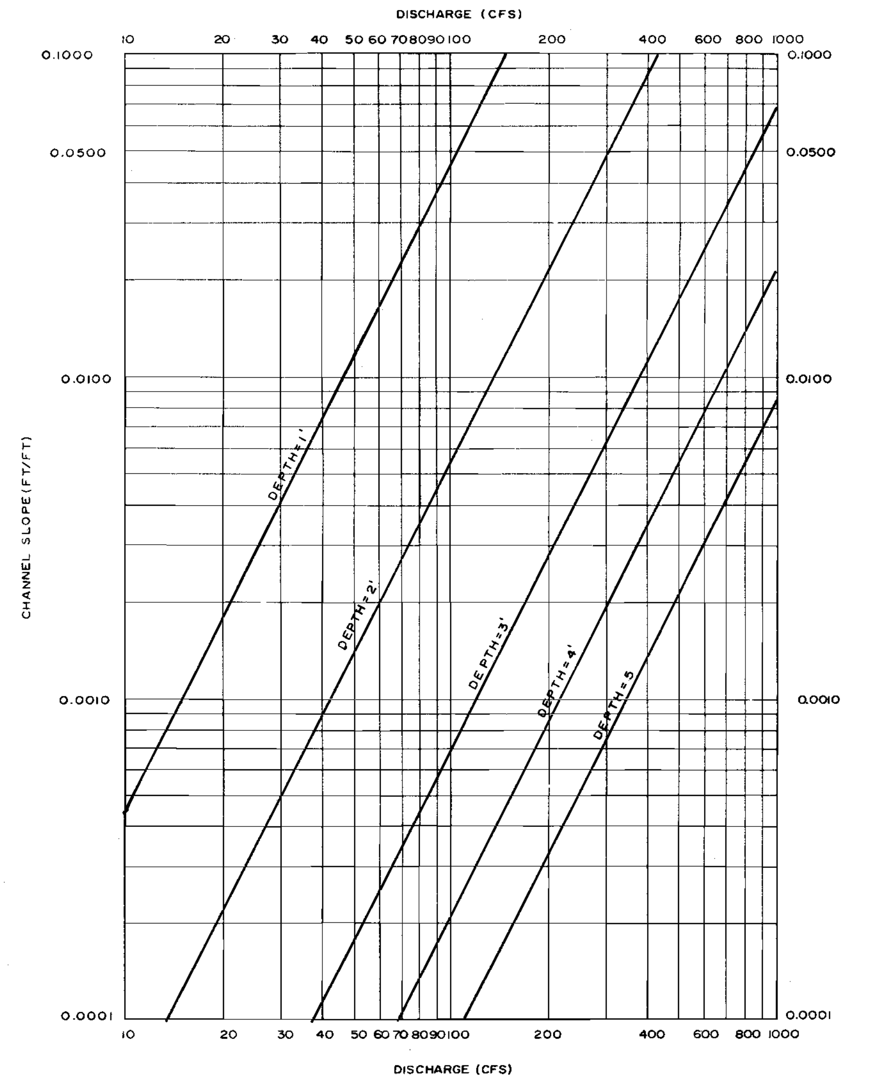


NOTE: BASED ON THE MANNING EQUATION.
MANNING "n" = 0.035
CHANNEL SIDE SLOPE = ONE ON THREE

Source: SEWRPC.

Figure 13

SLOPE DISCHARGE RELATIONSHIP FOR OPEN CHANNEL FLOWS FOR A CHANNEL BOTTOM WIDTH OF 10 FEET

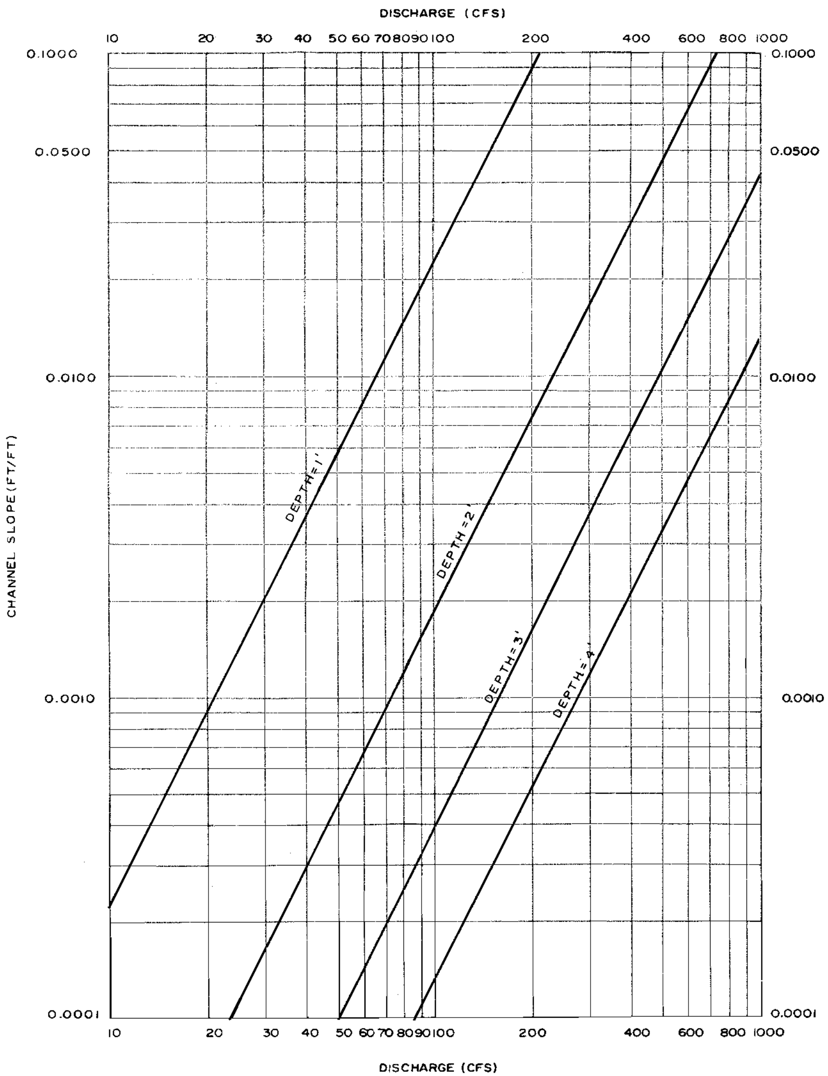


NOTE: BASED ON THE MANNING EQUATION.
MANNING "n" = 0.035
CHANNEL SIDE SLOPE = ONE ON THREE

Source: SEWRPC.

Figure 14

SLOPE DISCHARGE RELATIONSHIP FOR OPEN CHANNEL FLOWS FOR A CHANNEL BOTTOM WIDTH OF 15 FEET

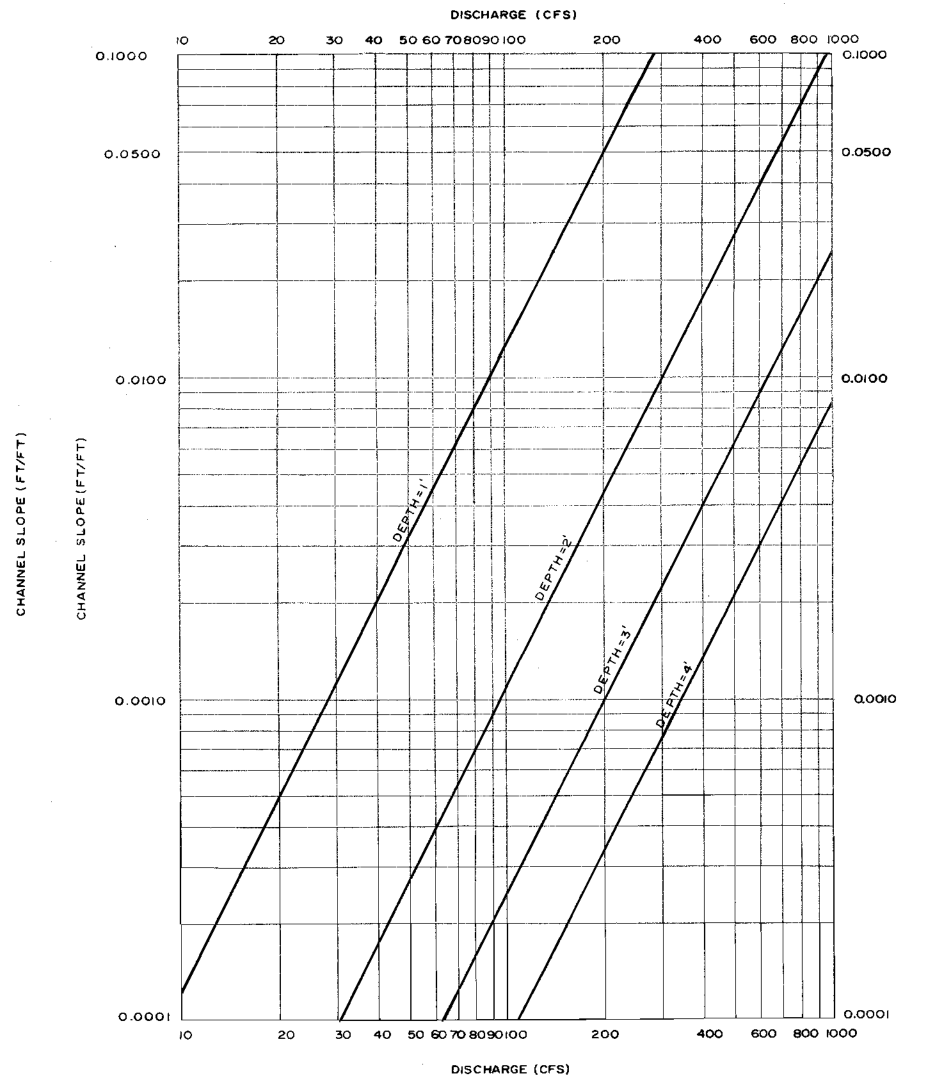


NOTE: BASED ON THE MANNING EQUATION.
MANNING "n"= 0.035
CHANNEL SIDE SLOPE = ONE ON THREE

Source: SEWRPC.

Figure 15

SLOPE DISCHARGE RELATIONSHIP FOR OPEN CHANNEL FLOWS FOR A CHANNEL BOTTOM WIDTH OF 20 FEET



NOTE: BASED ON THE MANNING EQUATION.
MANNING "n"= 0.035
CHANNEL SIDE SLOPE = ONE ON THREE

Source: SEWRPC.

2. Turf-lined side slopes should not exceed one on two and one half.

3. The minimum gradient of all turf-lined open channels should be 0.010 foot per foot, and of concrete-lined channels 0.005 foot per foot.

4. To prevent excessive streambank erosion and channel scouring, maximum flow velocities during the design storm should not exceed five feet per second for turf-lined channels, and 10 feet per second for concrete-lined channels.

Stormwater Storage Facilities

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

At the system planning level, only recommendations concerning the location, type, approximate size, and capacity of storage facilities are provided. 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. In planning the system required storage volumes were calculated using a modification of the Rational Method or the ILLUDAS simulation model. The following criteria and assumptions related to storage facilities were used in the development of the stormwater management system plan:

1. Storage facilities should be sized to accommodate a minor design storm up to and including the 10-year recurrence interval event. This criteria does not apply to storage facilities designed as components of the downstream floodland management system which should be sized to accommodate a major design storm.

2. In newly developing areas, storage facilities should be designed to limit the peak stormwater flow rates after development to predevelopment levels.

3. In existing developed areas, storage facilities should be considered to achieve reductions in peak runoff rates to eliminate identified site-specific problems.

4. In order to minimize maintenance, storage should be provided through the use of detention basins unless retention basins are specifically justified on a site-specific basis by recreation, aesthetic, water supply, or other considerations.

5. To effectively trap sediments, storm runoff should be stored when and where practical for at least 45 minutes during the design storm, thus allowing about 70 percent of the incoming sediments to settle out.

6. Where practical, the length of the storage facility, as measured from the inlet to the outlet, should be at least twice the width. Such ponds should, where possible, be wedge-shaped, with the apex, or narrow end, containing the inlet, and have side slopes not to exceed one on three. The minimum length of the pond should be about three feet for each acre of tributary watershed area.

7. Storage depths on parking lots, truck stopping areas, and similar open spaces should not exceed six inches during the design storm event.

Stormwater Pumping

The purpose of stormwater pumping is to remove stormwater from low-lying areas that cannot be effectively drained by gravity. Stormwater pumping stations are commonly associated with stormwater storage facilities that have limited land surface available and are restricted to deep storage. Pumping was not included as a component of the stormwater management plan when another alternative providing gravity drainage was practical.

At the system 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 combine any required pumping or lift stations which are relatively complex engineered facilities, including determination of the type of pump, type of drive, and motor requirements, and size and configuration of dry and wet wells.

The following criteria and assumption related to stormwater pumping facilities were used in the development of the stormwater management system plan:

1. Pumping stations should be designed with sufficient capacity to handle the estimated flows from a minor storm event with one pump out of service.

2. The pumping station should be designed with an overflow to the major drainage system.

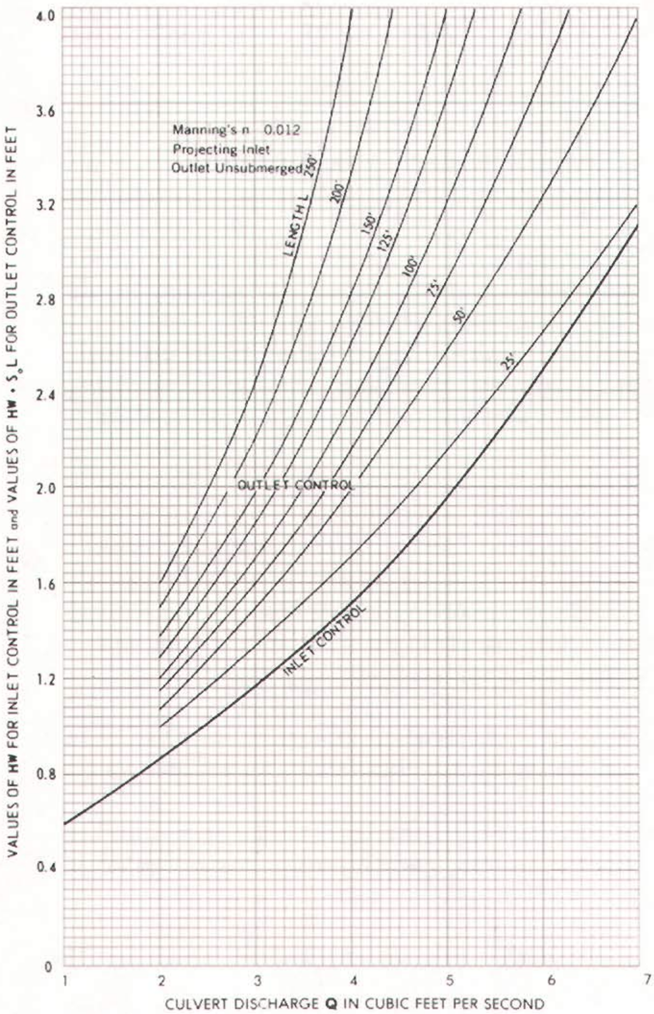
3. For planning the system it was assumed that the pumps would be high capacity, low head centrifugal pumps with constant speed motors designed for intermittent service.

Culverts

Culverts, which are a common feature of open drainage systems, are used to convey stormwater under a highway, railroad, canal, or embankment. At the systems planning level, recommendations concerning the location and size of culverts are provided. The hydraulic design of any culvert is affected by its cross-sectional area, shape, entrance geometry, length, slope, construction material, and the depth of ponding at the inlet and outlet, details which must all be addressed at the project development level. In planning the system, required culvert sizes were determined from capacity charts for circular section concrete sewers, as given in Figures 16 through 26, under minor storm event conditions. Similar design information is available for oval, pipe arch, or box sections and for other materials such as standard corrugated metal or structural plate corrugated metal. Hydraulic conditions under major storm event conditions should be evaluated on a case-by-case basis.

Figure 16

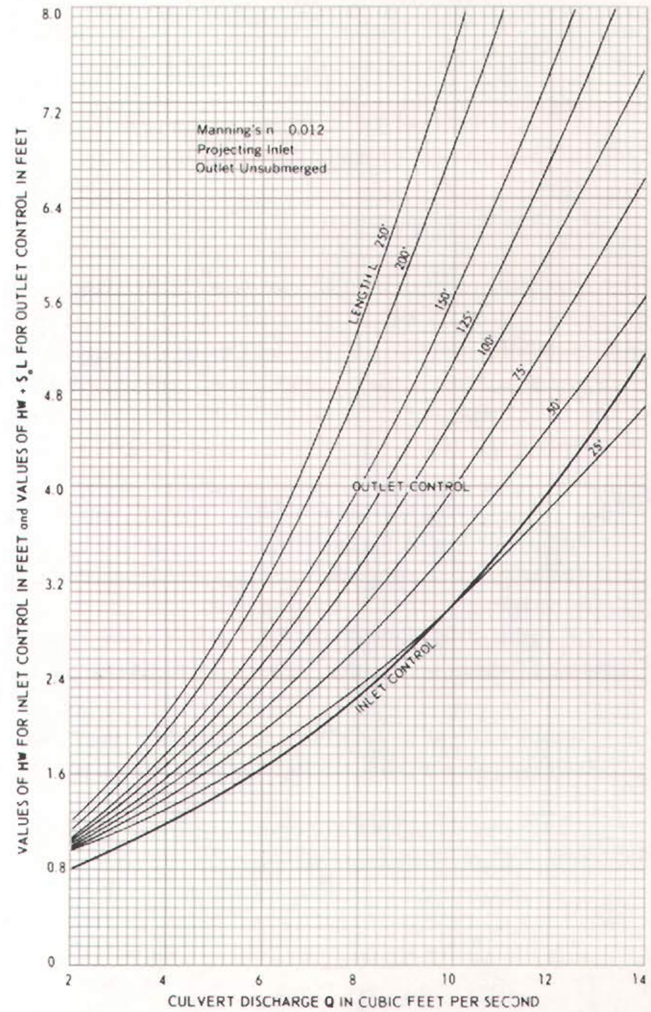
CULVERT CAPACITY 12-INCH-DIAMETER PIPE



Source: American Concrete Pipe Association, Concrete Pipe Design Manual, 1978.

Figure 17

CULVERT CAPACITY 15-INCH-DIAMETER PIPE



Source: American Concrete Pipe Association, Concrete Pipe Design Manual, 1978.

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

1. The culvert location should provide a direct entrance and exit avoiding an abrupt change in direction at either end.

2. The culverts should be laid on a slope of no less than 0.01 foot per foot.

3. Culverts were assumed to be circular, constructed of concrete pipe with a projecting inlet, and to have an unsubmerged outlet during minor storm events.

Figure 18

CULVERT CAPACITY
18-INCH-DIAMETER PIPE

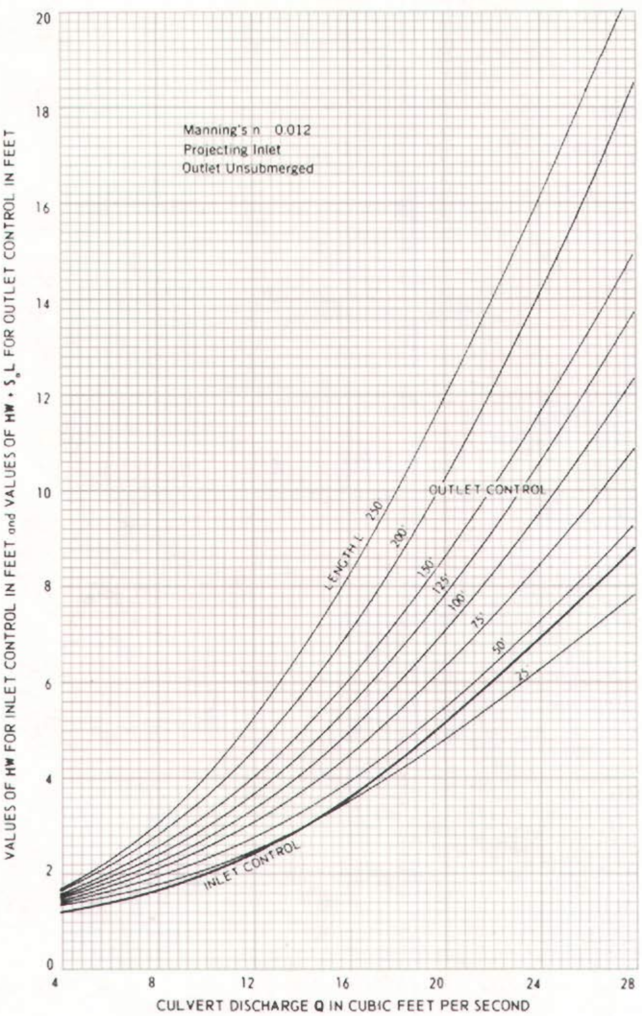
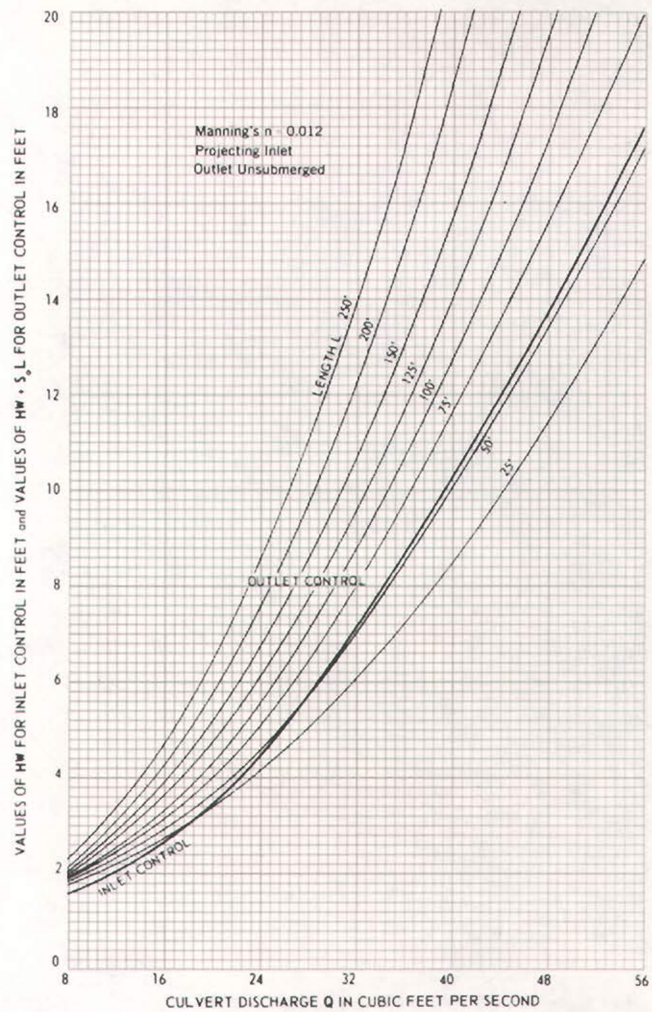


Figure 19

CULVERT CAPACITY
21-INCH-DIAMETER PIPE



In addition, several computer and hand calculator programs are available as design aids. Design procedures for use of Figures 16 through 26 are as follows:

Required Design Data

a. Design discharge Q, in cubic feet per second.

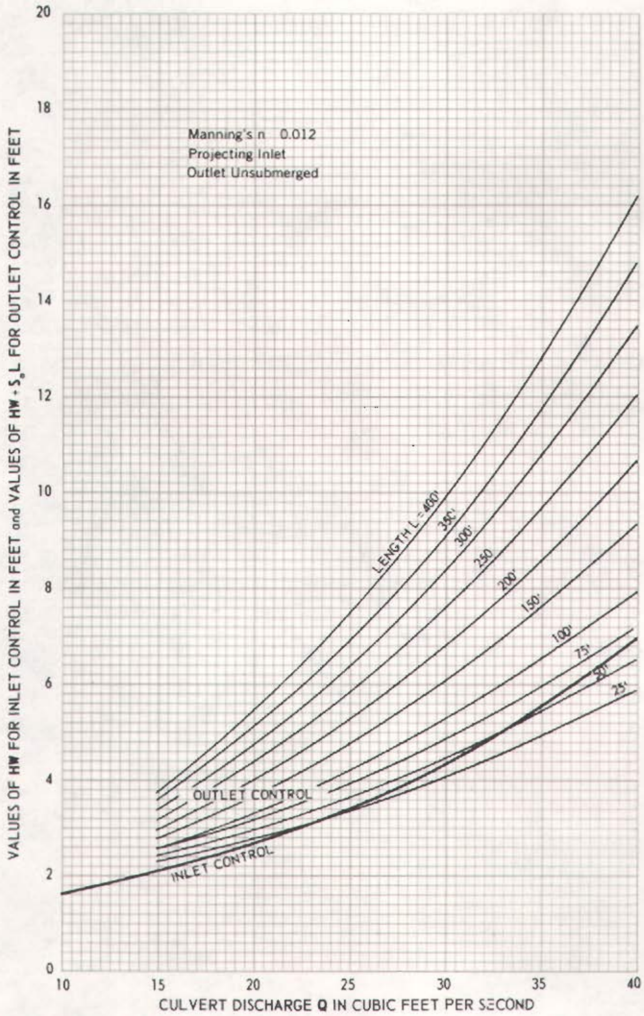
b. Approximate length L of culvert, in feet.

c. Slopes of culvert, in foot per foot.

d. Allowable headwater depth, in feet, defined as the vertical distance from the culvert invert (flow line) at the entrance to the water surface elevation permissible in the headwater pool or approach channel upstream from the culvert.

Figure 20

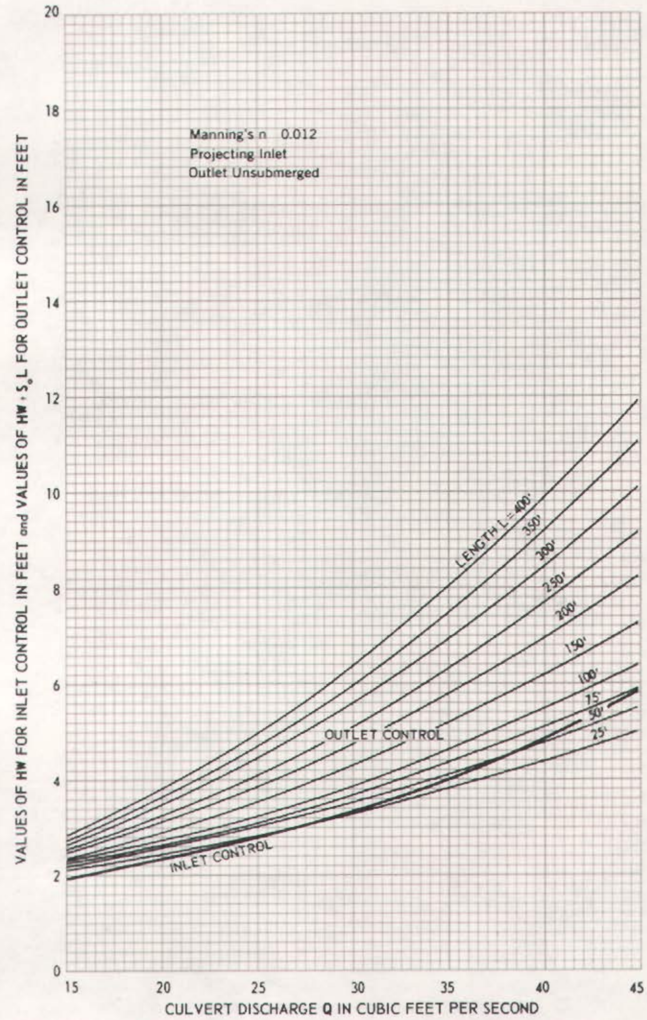
CULVERT CAPACITY
24-INCH-DIAMETER PIPE



Source: American Concrete Pipe Association, Concrete Pipe Design Manual, 1978.

Figure 21

CULVERT CAPACITY
27-INCH-DIAMETER PIPE



Source: American Concrete Pipe Association, Concrete Pipe Design Manual, 1978.

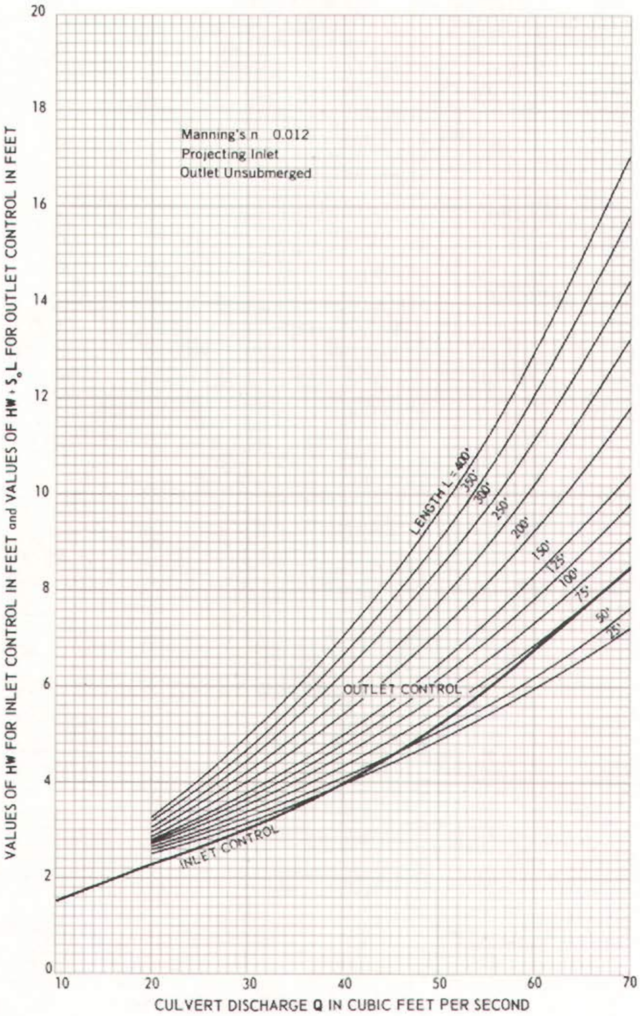
Procedure to Determine Culvert Size

a. Select the appropriate capacity chart, Figures 16 through 26, for a culvert size approximately equal to the allowable headwater depth divided by two.

b. Project a vertical line from the design discharge Q to the inlet control curve. From this intersection project a line horizontally and read the headwater depth on the vertical scale. If this headwater depth is more than the allowable, try the next larger size pipe. If the headwater depth is less than the allowable, check the outlet control curves.

Figure 22

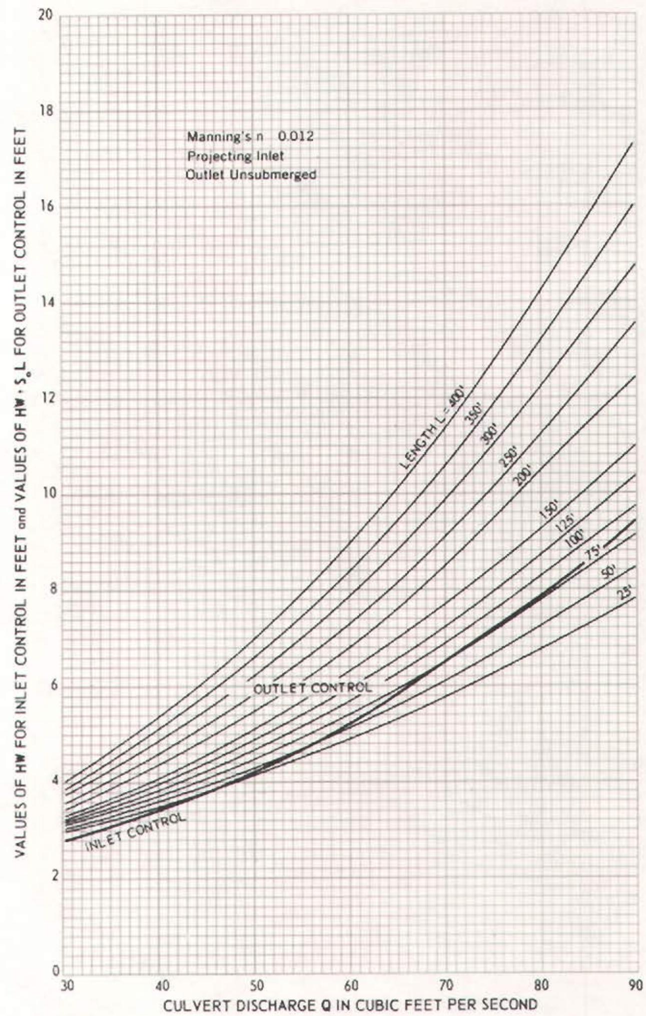
CULVERT CAPACITY 30-INCH-DIAMETER PIPE



Source: American Concrete Pipe Association, Concrete Pipe Design Manual, 1978.

Figure 23

CULVERT CAPACITY 33-INCH-DIAMETER PIPE



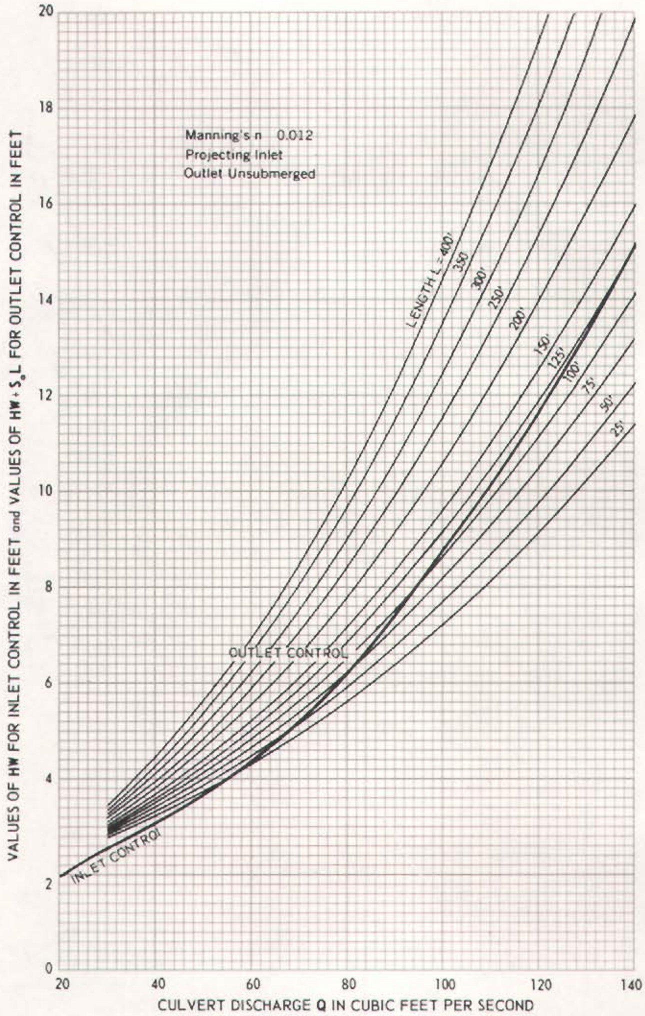
Source: American Concrete Pipe Association, Concrete Pipe Design Manual, 1978.

c. Extend the vertical line from the design discharge to the outlet control curve representing the length of the culvert. From this intersection, project a line horizontally and read the headwater depth plus SoL on the vertical scale. Subtract SoL from the outlet control value to obtain the headwater depth. If the headwater depth is more than the allowable, try the next larger size pipe. If the headwater depth is less than the allowable, check the next smaller pipe size following the same procedure for both inlet control and outlet control.

d. Compare the headwater depths for inlet and outlet control. The higher headwater depth indicates the governing control.

Figure 24

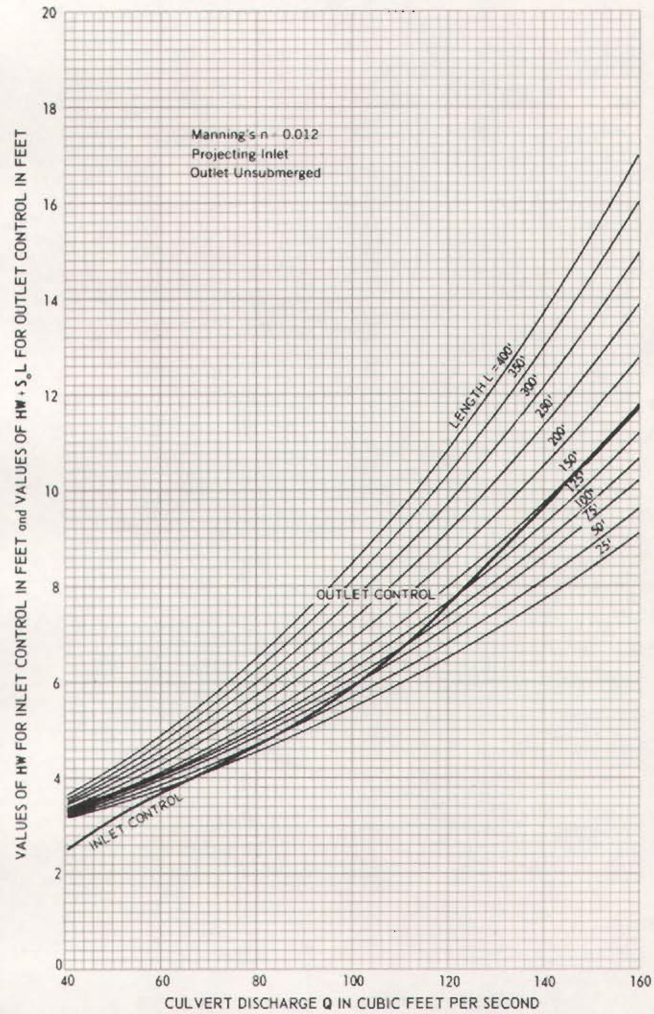
CULVERT CAPACITY 36-INCH-DIAMETER PIPE



Source: American Concrete Pipe Association, Concrete Pipe Design Manual, 1978.

Figure 25

CULVERT CAPACITY 42-INCH-DIAMETER PIPE



Source: American Concrete Pipe Association, Concrete Pipe Design Manual, 1978.

Water Quality Management Measures

Stormwater quality management measures include stormwater treatment techniques and nonpoint source pollution abatement measures. Stormwater treatment techniques, as discussed in Chapter VI, are costly and generally not warranted in the Sussex study area. Thus, criteria for treatment techniques are not presented below. Nonpoint source pollution abatement measures help protect water quality by reducing the rate and amount of storm runoff which transports pollutants to a receiving stream, by controlling pollutants at their source before transport by runoff, and by removing pollutants in runoff with sedimentation as a secondary function in detention facilities. This chapter presents criteria for urban nonpoint pollution abatement measures.

At the system planning level only the type, location, and general water quality benefits expected from urban nonpoint source pollution abatement measures are provided. The detailed design of a nonpoint source pollution abatement program will require a site-specific inventory of nonpoint pollution problems, the determination of the exact sizing and extent of application of measures, an identification of which measures are publicly acceptable and can be incorporated into the existing public works programs of the Village, and the physical detailed design of any structural measures.

The following criteria and assumptions were used in the development of this stormwater management plan:

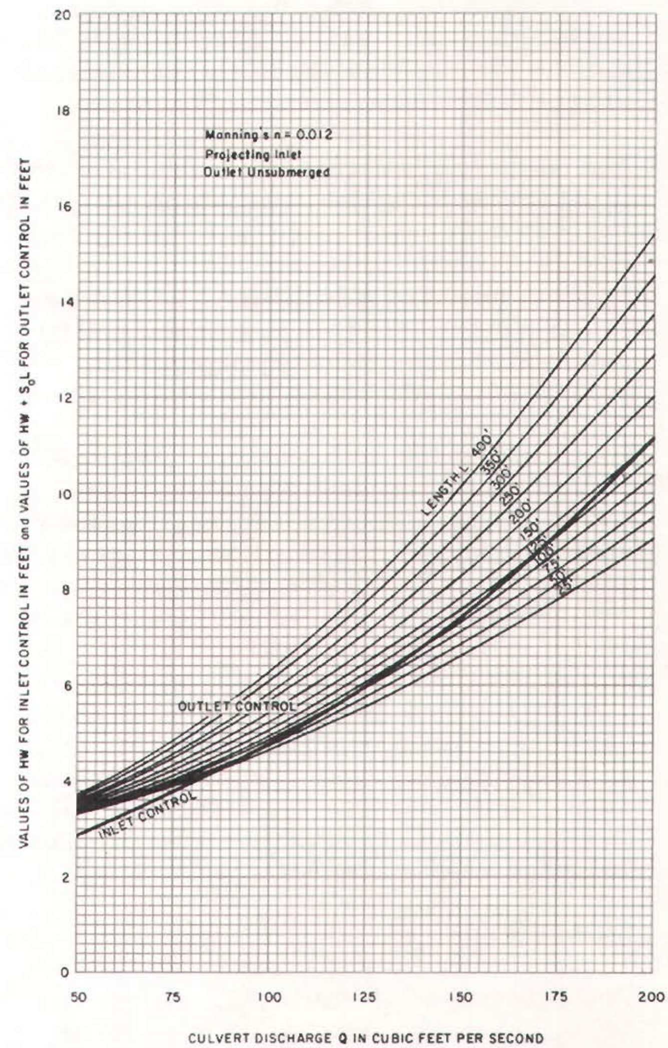
1. Where large amounts of settleable solids are generated, such as from construction sites, a combination of onsite source controls and sedimentation basins should be applied. Where pollutant contributions consist primarily of small clay-sized particles which resist settling or dissolved pollutants, such as nitrates, onsite source controls should be emphasized.

2. Temporary erosion control and sedimentation measures, such as those which should be applied at construction sites, should be designed to provide adequate protection from runoff for up to a two-year recurrence interval design event.

3. Vegetative cover should be installed as soon as possible on land disturbed for construction activity, agricultural production, and industrial uses.

Figure 26

CULVERT CAPACITY
48-INCH-DIAMETER PIPE



Source: American Concrete Pipe Association, Concrete Pipe Design Manual, 1978.

ECONOMIC EVALUATION DATA

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 that the alternative of investment in another economic sector does not exist. Accordingly, it is assumed that the least costly alternative system that meets the stormwater management objectives set forth in this chapter will be economically the most desirable alternative.

The economic evaluations conducted under this stormwater management planning program include the estimation of capital and annual operation and maintenance costs. All costs were estimated from a series of cost curves presented in SEWRPC Technical Report No. 18, State of the Art of Water Pollution Control in Southeastern Wisconsin, Volume One, Point Sources, and Volume Three, Urban Storm Water Runoff, supplemented by cost information obtained about local stormwater management projects in the Region; and from standard construction cost guides. All costs are presented in 1982 dollars.

Cost curves for manholes are presented in Volume One of SEWRPC Technical Report No. 18, and curves and related data for stormwater pumping stations, gravity storm sewers, open channels, surface and subsurface storage facilities, and onsite storage facilities are presented in Volume Three of SEWRPC Technical Report No. 18. Costs for storm sewers, culverts, manholes, inlets, catch basins, open channels, surface storage basins, and pumping stations are presented in Table 26.

The unit costs presented in the referenced cost curves and in Table 26 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, and labor costs. Land and improvement purchase costs are not included in the economic evaluations.

SUMMARY

The process of formulating objectives and standards for stormwater management is an essential part of the planning process. To reflect the basic needs and values of the community, it is necessary that these stormwater management objectives and standards be prepared within the context of, and be fully consistent with, the land use and development objectives and standards set forth in the Village's adopted land use plan.

The following five stormwater management objectives were established to guide the design and evaluation of alternative stormwater management plans:

1. The development of a stormwater 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 inadequate stormwater drainage and inundation.

2. The development of a stormwater management system which will effectively serve existing and planned land uses and promote implementation of the adopted land use plan.

Table 26

UNIT COSTS FOR SELECTED STORMWATER MANAGEMENT COMPONENTS

Component	Description	Unit Cost
Reinforced Concrete Storm Sewers--Seven-Foot Cover	12-inch diameter 15-inch diameter 18-inch diameter 24-inch diameter 30-inch diameter 36-inch diameter 42-inch diameter 48-inch diameter 60-inch diameter 72-inch diameter 84-inch diameter	$ 30 per linear foot 40 per linear foot 50 per linear foot 70 per linear foot 90 per linear foot 105 per linear foot 130 per linear foot 180 per linear foot 210 per linear foot 290 per linear foot 370 per linear foot
Reinforced Concrete Culverts	12-inch diameter 15-inch diameter 18-inch diameter 24-inch diameter 30-inch diameter 36-inch diameter 42-inch diameter 48-inch diameter 60-inch diameter	$ 9 per linear foot 11 per linear foot 13 per linear foot 20 per linear foot 34 per linear foot 48 per linear foot 57 per linear foot 68 per linear foot 100 per linear foot
Inlet	Combination Type	$ 400 each
Catch Basins	4 feet deep 6 feet deep 8 feet deep	$ 800 each 1,100 each 1,400 each
Open Channels	Grass-lined; bottom width of about six feet and top width of 50 to 80 feet; depth of 4 feet	$ 15 per linear foot
Manholes	For 12- to 30-inch pipe For 36-inch pipe For 48-inch pipe For 60-inch pipe For 72-inch pipe For 84-inch pipe	$ 800 each 900 each 1,200 each 1,500 each 2,200 each 2,700 each
Surface Storage Basins	Storage volume: 5 million gallons 10 million gallons 20 million gallons 100 million gallons	 $ 170,000 each 310,000 each 560,000 each 2,500,000 each
Pumping Stations	1 million gallons per day 5 million gallons per day 10 million gallons per day 25 million gallons per day	$ 200,000 each 310,000 each 450,000 each 740,000 each
Maintenance	Catch basin cleaning Storm sewer maintenance Open channel maintenance	$ 32 each 1,000 per mile per year 2,000 per mile per year

Source: Building Construction Cost Data 1982, 40th Annual Edition, Robert Snow Means Company, Inc.; 1982 Dodge Guide to Public Works and Heavy Construction Costs, McGraw-Hill Information Systems Company; and SEWRPC.

3. The development of a stormwater management system which will minimize soil erosion, sedimentation, and attendant water pollution.

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

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

Complementing each of the foregoing specific stormwater management development objectives is a set of quantifiable standards which can be used to evaluate the relative or absolute ability of alternative stormwater management plan designs to meet the stated development objective.

In addition to presenting and discussing the objectives and standards established for the Sussex stormwater management plan, this chapter also presents the engineering design criteria and analytical procedures which were used to design and size the alternative plan elements and which will also serve as a basis for the more detailed design of stormwater management system components. Criteria and procedures were developed for estimating stormwater flow rate and volume and for designing street cross-sections, storm sewer inlets, storm sewers, open channels, storage facilities, pumping facilities, culverts, and water quality management measures. Criteria are also presented for developing and evaluating economic data for the system components.

Chapter VI

EVALUATION OF STORMWATER MANAGEMENT SYSTEM COMPONENTS

INTRODUCTION

The development of a stormwater management system for the Sussex area requires the combination of certain system components in an effective and efficient manner to meet the overall system objectives. The design of a stormwater management system plan requires consideration of the system components. This chapter describes to the extent required for system planning purposes, six stormwater management system components and associated elements and the relationship of these components and elements to the overall system objectives. Each component or element is defined, its purpose described, and its relationship to the overall stormwater management system discussed. It should be noted that this chapter discusses general applications of individual system components and associated elements. Development of the overall stormwater management system plan requires the detailed evaluation of system components as they relate to individual drainage basins within the urban service area for the Village of Sussex. That more detailed analysis is described in the following chapter. Detailed design criteria for the components and associated elements are provided in Chapter IV of this report.

SYSTEM COMPONENTS

Traditional urban stormwater management systems may be thought of as consisting of three basic components: 1) collection; 2) conveyance; and, in some cases, 3) storage. Due to the more comprehensive objectives set forth for the Village of Sussex stormwater management plan, the stormwater management system may include two additional components--4) treatment; and 5) nonpoint source water pollution control. In addition, overland flow, while not a structural component of the system per se, must be considered in the design of the system as such flow may affect the amount and quality of the runoff reaching the system proper. Accordingly, overland flow is herein considered as a sixth basic component of the overall stormwater management system.

Overland Flow

Stormwater from precipitation and snowmelt are dispersed over the land surface often in amounts that exceed the capacity of the ground surface to absorb it. The stormwater accumulates on the ground surface filling the depression storage, and begins to flow in the direction of greatest slope. In an area served by a traditional urban stormwater management system, this overland flow carries the stormwater runoff to a collection facility. Thus, overland flow serves to concentrate stormwater from its initially more diffuse form as precipitation. In an urban area, the pattern of overland flow can be determined by the siting of buildings and the grading of the surrounding sites, so that such siting and grading becomes an important part of the design of the stormwater management system.

Overland flow may develop relatively high velocities if it occurs on a smooth paved surface such as a rooftop, driveway, or parking lot, or at considerably lower velocities if it occurs on rough surfaces such as heavily vegetated areas. In addition, stormwater may either accumulate pollutants as overland flow occurs, such as in flow across a parking lot; or may actually lose pollutants, such as in flow over a vegetated area where sediment may be precipitated.

The effect of urbanization generally is a shift from rough vegetated surfaces with water absorbing and energy dissipating characteristics to smooth paved surfaces with significantly reduced water absorbing and energy dissipating characteristics. This change in the surface configuration will produce a greater quantity and generally a lower quality of stormwater at higher velocities for a given storm. This, in turn, makes it necessary to significantly improve natural drainage systems following urbanization by providing artificial stormwater collection and conveyance facilities.

Overland flow is an important component of the overall stormwater management system, and has a direct and significant relationship to several of the overall system objectives. Overland flow patterns in urbanizing areas should be designed to maximize the inlet time of stormwater runoff without adversely affecting urban structures or interrupting human activity. Thus, while providing adequate urban drainage, overland flow patterns should be designed to minimize the total volume of stormwater runoff by allowing maximum infiltration of the stormwater; to reduce the peak rate of discharge of stormwater to the collection and conveyance facilities; and to reduce the velocity of overland flow thereby reducing the energy level of flowing stormwater and its ability to disturb sediment particles and surface pollutants.

The velocity during overland flow can be controlled by minimizing the amounts of paved surfaces and, where possible, draining paved surfaces to pervious grassed areas rather than directly to drainage gutters. Various detention and retention storage techniques are also effective in reducing the velocity of overland flow. Such systems are discussed later in this chapter. These management techniques can also reduce the overall volume of stormwater runoff by increasing infiltration and thereby reducing downstream stormwater management requirements.

Because overland flow has a broad impact on the overall system objectives, it was considered as an important and essential component of the stormwater management system for the Sussex area.

Arrangements for overland flow cannot be specifically addressed at the systems level of planning. The design of such arrangements must be done on a site-specific basis as urban development or redevelopment take place. However, overland flow is considered in the system planning process through the development of general guidelines, as set forth in Chapter V, which include a description of practical techniques for minimizing the rate and volume of runoff. In the evaluation of alternatives, it is assumed that these general guidelines will be followed to the extent practicable.

Collection

Stormwater collection is the process of further concentrating stormwater flowing overland and transmitting it to conveyance facilities. Stormwater collection facilities may include drainage swales, road ditches, roadway gutters, stormwater inlets, and catch basins in which stormwater is collected and then transmitted to surface or subsurface conveyance systems.

The stormwater collection system may also provide some conveyance and storage functions in the stormwater management system. For minor precipitation events swales, road ditches and roadway gutters collect and transmit stormwater to the stormwater conveyance facilities. The subsurface conveyance facilities are designed to accommodate minor runoff events only, constituting the minor conveyance system referred to in Chapter V. During major runoff events, the stormwater collected will, by design, exceed the capacity of the subsurface conveyance facilities with the excess stormwater being temporarily stored on and conveyed over collector and land access roadways, and interconnected surface drainageways--the major conveyance system also referred to in Chapter V.

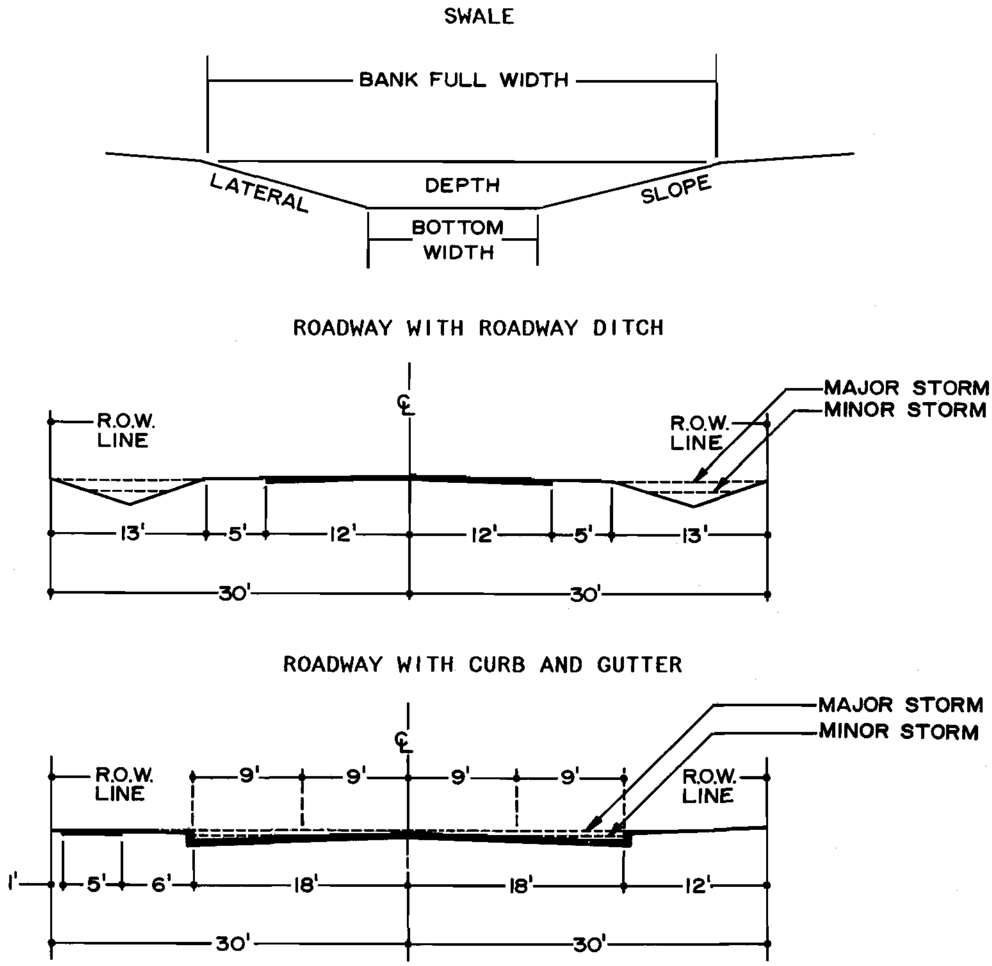
Drainage Swale: A stormwater drainage swale is defined as a sloping depression in the land surface. The purpose of a drainage swale is to collect overland flow from areas such as front, side, and backyards and transmit it to larger, open stormwater drainage channels or to subsurface conveyance facilities. Drainage swales are generally grass lined, but may be paved to prevent erosion on steep slopes, or to avoid standing water on flat slopes. A typical drainage swale is shown in Figure 27.

Drainage swales cannot be specifically addressed at the systems level of planning. The design of such components must be done on a site-specific basis as urban development or redevelopment take place. However, design of swales is considered in the system planning process through the development of criteria which are provided in Chapter V as guidelines for detailed design.

Roadway Ditch: A roadway ditch is defined as a long, narrow excavation running parallel and adjacent to a roadway providing longitudinal drainage. Roadway ditches in urban areas are generally grass lined, but also may be paved to prevent erosion on steep slopes, or to avoid standing water on flat slopes. For the purposes of this report the roadway ditch is considered as a collection component of the stormwater management system. However, the roadway ditch is also a conveyance component of the stormwater management system. A typical residential roadway and ditch combination is shown in Figure 27. The ditch collects stormwater runoff from the roadway surface and the tributary overland flow areas of abutting lands. The collected stormwater is then transmitted to open channel or subsurface conveyance facilities. Roadway ditches are generally less expensive than curb-and-gutter collection systems. They also provide lower runoff velocities and can provide for stormwater infiltration and for storage capacity. Nonpoint source water pollution loadings carried by stormwater are generally reduced as flows and are collected in ditches. More importantly, through the use of road ditches, stormwater

Figure 27

TYPICAL SWALE AND ROADWAY CROSS-SECTIONS SHOWING WATER COLLECTION AREAS



Source: SEWRPC.

runoff can be managed entirely in a surface drainage system, and the construction of storm sewers can be avoided. Such surface drainage systems are most practical only in relatively low-density areas since each intersecting private driveway, as well as public roadway, must be provided with a culvert pipe to carry the drainage. As densities increase and lot sizes decrease, a point is reached where the provision of a storm sewer becomes cheaper than the provision of culverts. The use of road ditches provides a "rural" or "suburban" appearance and is desired by some communities for this reason.

Recommendations relating to the shape, alignment, and type of roadway ditch will be included in the stormwater management plan. Additional details and refinement must be addressed in the detailed design phase preceding construction. Roadway ditches located within individual subareas and used for local area stormwater collection and conveyance would not be specifically designed in the stormwater management plan and should be designed on a site-specific basis. Criteria in Chapter V are provided as guidelines for the detailed design of all drainage ditches which may be part of the stormwater drainage system. Typically, these roadway ditches are designed using open channel flow hydraulic equations such as Manning's equation and consider such variables as: an allowable depth of flow in each area to prevent unacceptable velocities and damage to facilities and adjacent land uses; available slope; and available right-of-way. In areas with limited right-of-way, a rectangular, reinforced concrete channel may be required. In other reaches the channel is more typically trapizoidal in shape with grassed side slopes.

Roadway Gutters: A roadway gutter is defined as a depression in the roadway surface adjacent to the curb line. A typical residential roadway configuration with curb and gutter is shown in Figure 27. Typical curb-and-gutter sections that are recommended for use in the Village of Sussex are shown in Figure 28. The roadway gutter collects stormwater from the roadway surface and from the tributary overland flow areas of abutting lands. The collected stormwater is typically discharged from the roadway gutters into stormwater inlets or catch basins that transmit the stormwater to subsurface conveyance facilities. Curbs and gutters are required in higher density urban areas where the use of road ditches and culverts becomes impractical. The use of curbs and gutters reduces the potential for stormwater infiltration, increases stormwater runoff flow velocity, and limits the removal of nonpoint source water pollution loadings.

Roadway gutters are not specifically addressed at the systems level of planning. Such design should be done in accordance with the Village of Sussex design policy for roadway and sidewalk systems. The drainage plan has assumed the use of a roadway gutter with a cross section similar to that shown in Figure 27.

Stormwater Inlets: The stormwater inlet is defined as a device through which stormwater is transmitted from the surface collection facilities to subsurface conveyance facilities. Stormwater inlets are placed at strategic locations along swales, roadway ditches, and gutters for the purpose of transmitting collected stormwater into subsurface conveyance facilities. Typical stormwater inlet structures are shown in Figure 29. The inlet structure includes a stormwater inlet, drop structure and connection to the underground conveyance facility.

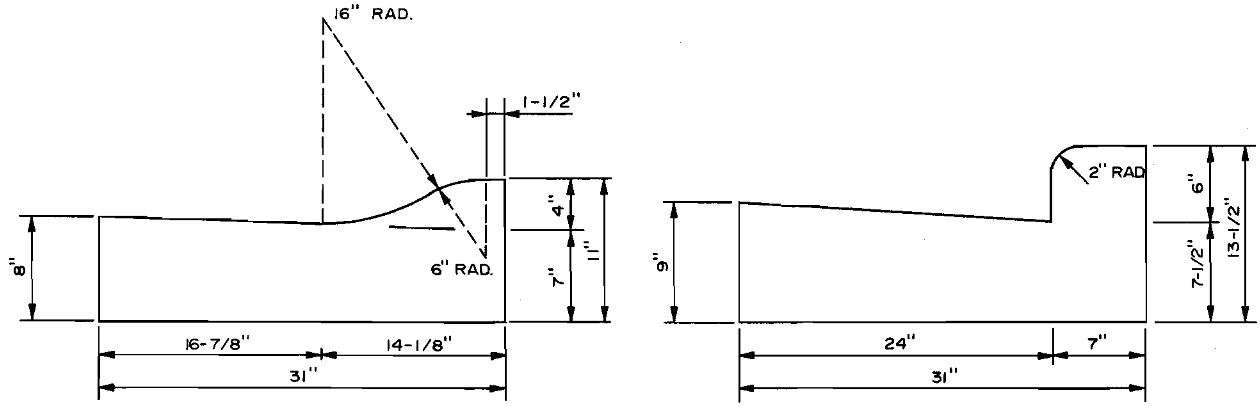
The three basic types of inlets commonly used in stormwater management systems are:

1. The curb inlet, which consists of a relatively large, vertical opening in the curb face extending up from the base of the curb face or gutter line through which stormwater can flow (Figure 30).

2. The gutter inlet, which consists of an opening in the roadway gutter that is covered by a cast iron grate (Figure 30). Stormwater is allowed to flow into the gutter inlet while sticks and large debris are trapped by the iron grate, which also prevents pedestrian and vehicular traffic from dropping into the inlet.

Figure 28

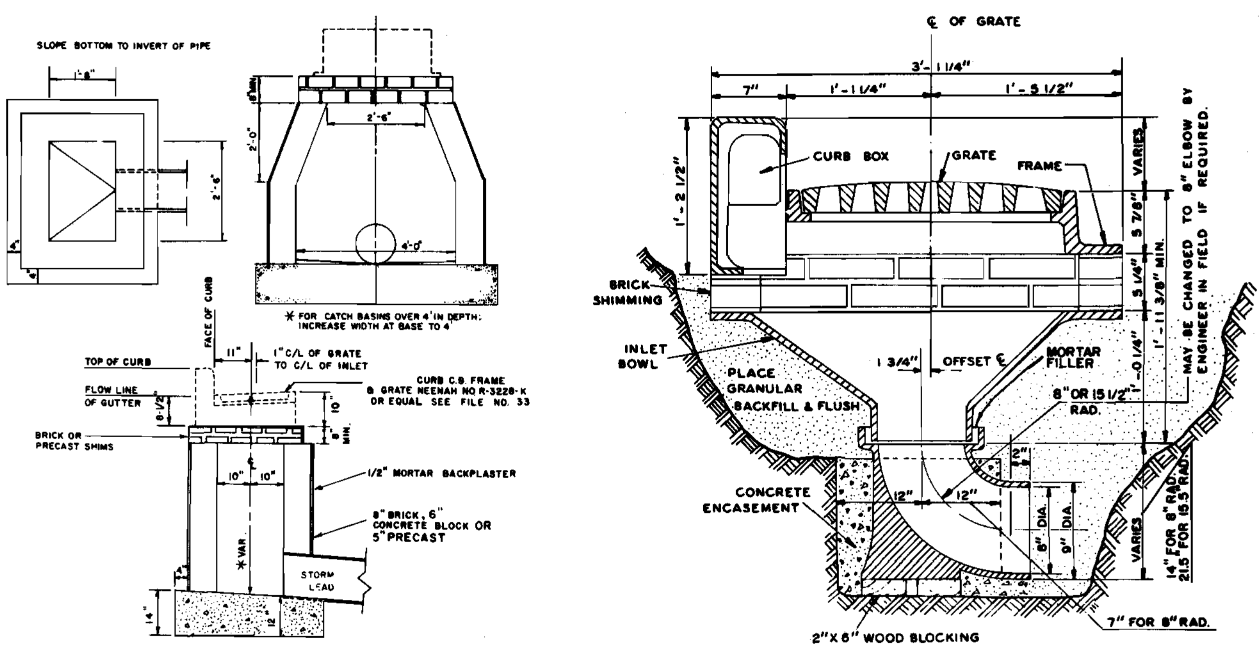
VERTICAL-FACED CURB AND MOUNTABLE CURB SECTIONS RECOMMENDED BY THE VILLAGE OF SUSSEX



Source: Robert Hutter, Engineer, Village of Sussex.

Figure 29

TYPICAL STORMWATER INLET STRUCTURES



Source: <u>Standard Specifications for Sewer and Water Construction in Wisconsin,</u> second and third editions.

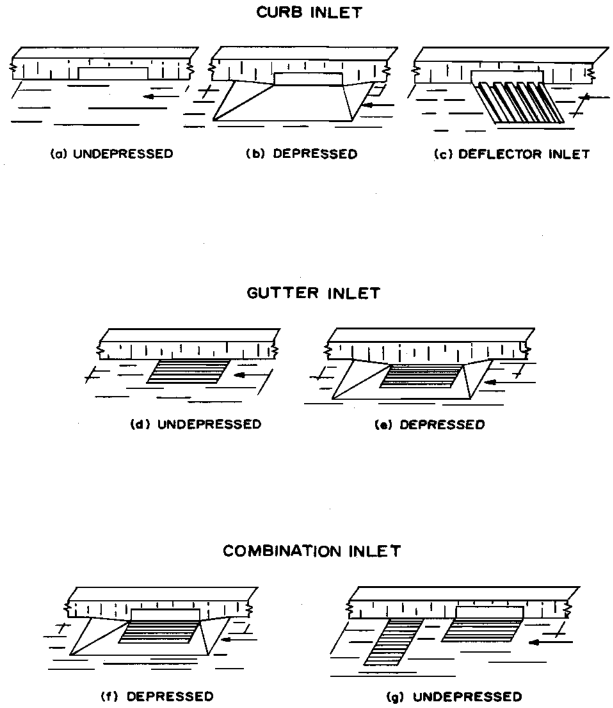
3. The combined curb inlet and gutter inlet, which is referred to as a combination inlet. (Figure 30)

Many variations of these basic inlet designs are used in stormwater management systems. For example, the three basic inlet types may be either set at grade in the gutter line, shown as an undepressed inlet in the figure, or set slightly below grade in the gutter line shown as a depressed inlet in the figure. Inlet cover types are shown in Figures 31 and 32.

Recommendations relating to the location of inlets and catch basins are included in the stormwater management plan. The inlet type, flow capacity, related street grades, types of street crowns, and the expected depth of flow must be addressed in subsequent engineering for project development.

Figure 30

TYPICAL STORMWATER INLET DESIGNS



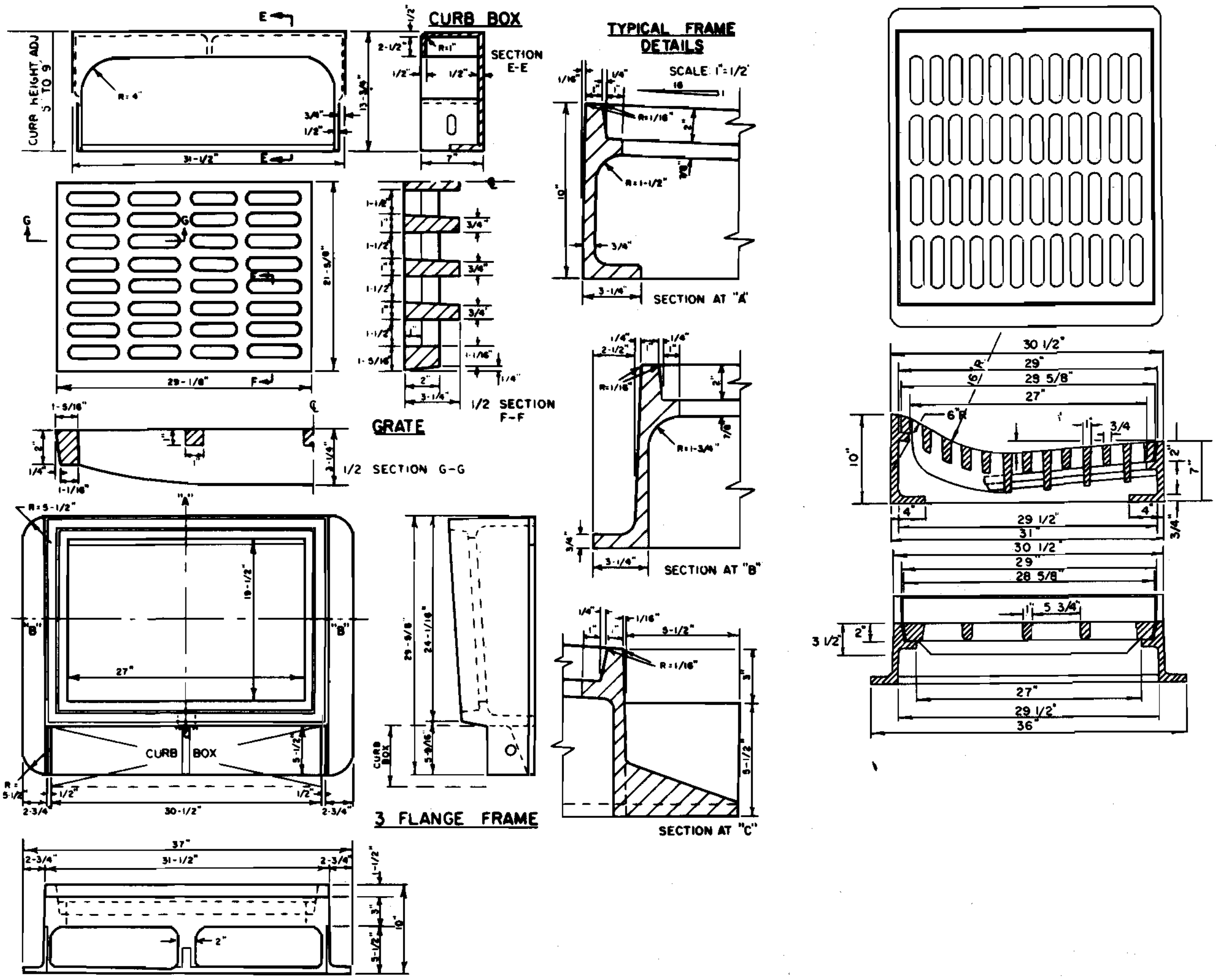
Source: American Society of Civil Engineers.

Catch Basin: A catch basin is defined as a stormwater inlet equipped with a small sedimentation basin or grit chamber. The purpose of a catch basin is to remove sediment and debris from stormwater before it is transmitted to the subsurface conveyance facilities. A typical catch basin is shown in Figure 33. Stormwater enters through the surface inlet and drops to the lower basin area. Heavy sediment particles and other debris are collected in the basin area. This debris is then removed during maintenance operations. The catch basin is designed to reduce the maintenance requirements for the underground conveyance system, particularly in areas where heavy sediment loads may otherwise be carried into the conveyance system. Catch basins also provided a form of nonpoint source water pollution abatement in the period before the automobile when large quantities of horse manure were deposited on street surfaces. The use of catch basins fell into disfavor because of the cost associated with the periodic cleaning required. Nonpoint source abatement, however, may warrant the reintroduction of the catch basin in urban areas.

If properly maintained, the catch basin has been shown to be an effective sediment trap. Improperly or inadequately cleaned catch basins may have a negative impact on receiving water quality. Decaying organic material trapped in the basin may produce noxious odors or the basin water may become rich in organic material and nutrients and low in dissolved oxygen content. This basin water becomes a part of the first flush of stormwater from subsequent storm events. Basin waters may also provide a place for mosquitos to breed. Accordingly, under most circumstances, catch basins are not considered to be beneficial components of the overall stormwater management system.

Figure 31

TYPICAL CATCH BASIN OR INLET CASTING FOR
A STANDARD OR MOUNTABLE CURB SECTION

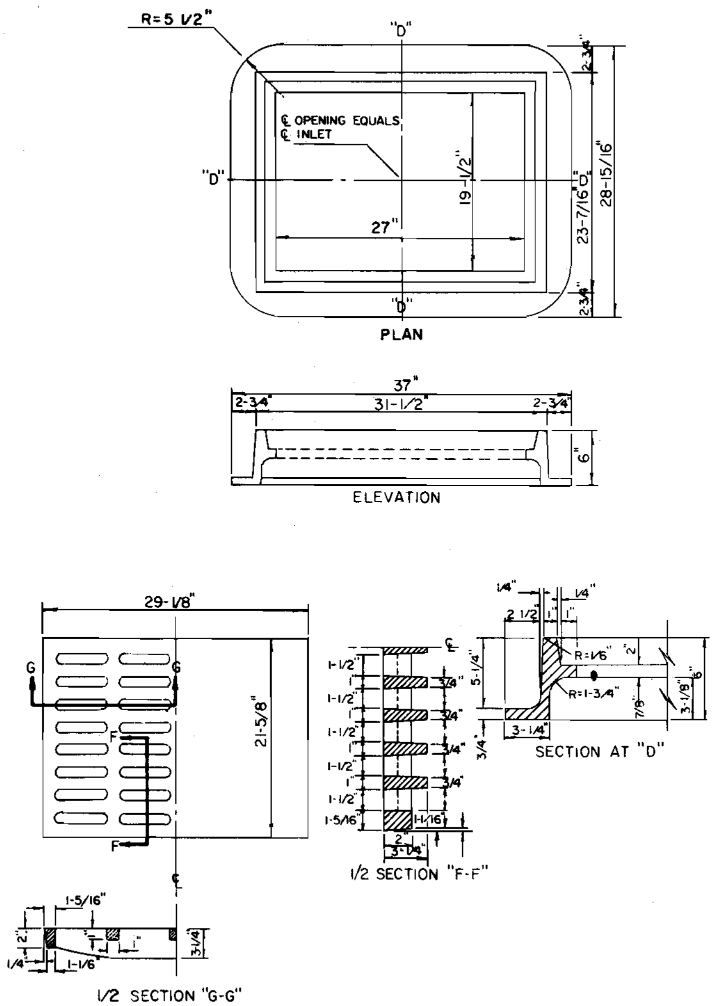


Source: Standard Specifications for Sewer and Water Construction in Wisconsin, fourth edition.

Collection Elements Applicable to the Village of Sussex Stormwater Management System: The general policy of the Village of Sussex is to provide roadway curbs and gutters and inlets for the collection of stormwater. Thus, the use of an "urban" street cross-section with curbs and gutters, inlets, and storm sewers was assumed in the preparation of the stormwater management plan. Drainage swales were also considered to be an element of the collection component since these are required in many areas to initially collect stormwater which is flowing overland. Roadway ditches were assumed to be used only in certain nonresidential areas as interim collection mechanisms prior to development and the provision of full urban services. Catch basins were assumed to be applicable for use in the Village only in special instances where stormwater runoff may be expected to carry unusual amounts of sediment and debris. Stormwater collection is an important component of the total urban stormwater

Figure 32

TYPICAL CATCH BASIN OR INLET CASTING FOR FLAT SURFACE APPLICATION



Source: Standard Specifications for Sewer and Water Construction in Wisconsin, fourth edition.

management system. The collection component serves to further concentrate stormwater runoff, conveying it as quickly as possible to subsurface conveyance facilities.

Conveyance

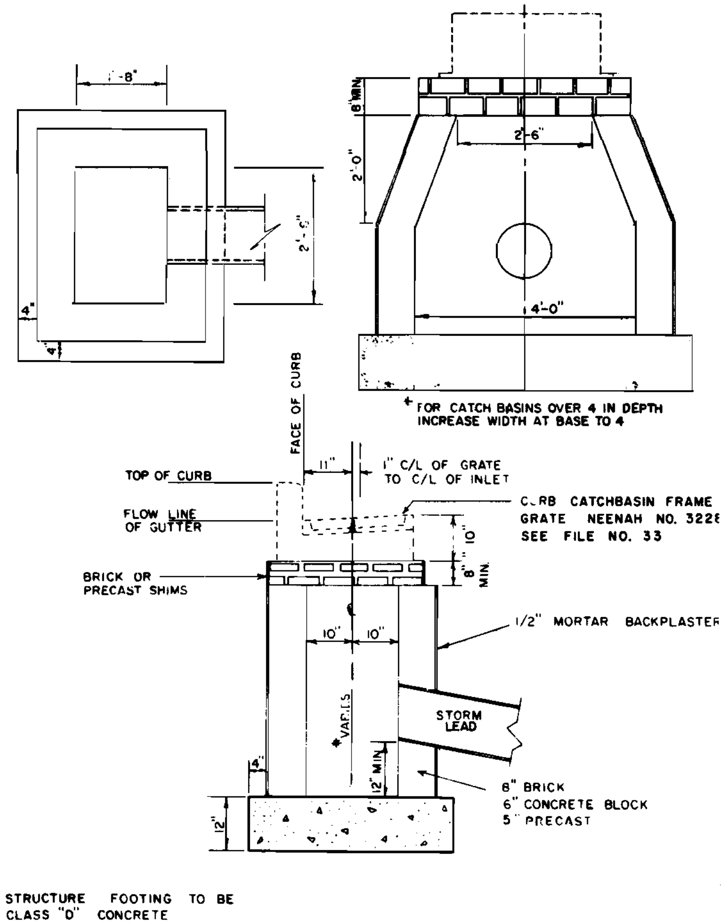
Conveyance facilities are normally the most costly component of the stormwater management system. The conveyance components of a stormwater management system may include both open channels and subsurface conduits--storm sewers--designed to receive and transport stormwater runoff from or through urban areas to a receiving stream or watercourse. Stormwater conveyance facilities may also be used to transport nonpolluted municipal or industrial wastewaters, such as spent cooling waters.

In most urban settings it is not possible to maintain the natural stormwater conveyance system due to the increase in the amount and rate of stormwater runoff attendant to the conversion of land from rural to urban use. Therefore, significant modifications are usually made to the natural drainage system to meet the increased stormwater conveyance requirements.

Open Channel Conveyance: Open channel conveyance facilities generally follow the natural surface drainage pattern. In some instances the natural channel configuration can be maintained with only minor modifications such as removing obstructions and reducing the overall channel roughness. For certain areas it may be necessary to "improve" the existing channel by widening, deepening, and realigning or to construct an entirely new channel in order to provide the required conveyance capacity. Man-made open channel conveyance facilities may be grass lined or paved, depending on the need to prevent erosion or avoid standing water. Typical open channel cross-sections are shown in Figure 34.

Figure 33

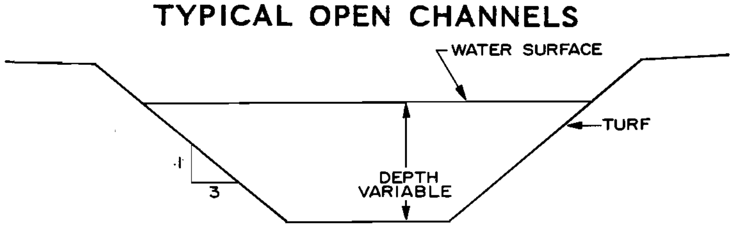
TYPICAL CATCH BASIN



Source: Standard Specifications for Sewer and Water Construction in Wisconsin, fourth edition.

Figure 34

TYPICAL OPEN CHANNELS



Source: SEWRPC.

When compared to subsurface storm sewer conveyance facilities, open channel surface conveyance facilities are generally less costly; provide a greater degree of nonpoint source water pollutant removal; and are more adaptable to providing inline storage. Grass-lined conveyance facilities reduce the overall velocity of stormwater runoff, reduce the peak discharge rate from the drainage basin, and allow stormwater to infiltrate to the groundwater. Open channel conveyance facilities may, if poorly designed, be less desirable aesthetically; may constitute a safety hazard for children; and may have higher maintenance requirements than storm sewer conveyance facilities.

Recommendations relating to the shape, alignment, and type of open channel conveyance facilities are included in the stormwater management plan. Additional details and refinement must be addressed in the detailed design phase prior to construction. Criteria for design are provided in Chapter V. Typically, the channels are designed using appropriate open channel flow hydraulic formulae such as the Manning's equation and considering allowable grades and depths of flow in each area to prevent unacceptable velocities and damage to the facilities and adjacent land uses. In areas with limited right-of-way a rectangular reinforced concrete channel may be required. In more open areas the channel is more typically trapizoidal in shape with grassed or concrete-lined bottom and side slopes.

Storm Sewer Conveyance: The storm sewer is defined as an underground conduit that transports stormwater runoff from collection facilities to an ultimate point of disposal. The purpose of a storm sewer is to receive stormwater runoff from stormwater inlets and convey that runoff to surface water drainage systems. The storm sewer provides a rapid conveyance route for stormwater to a point of disposal on a receiving watercourse or body of water. Subsurface storm sewer systems are generally more costly to construct than surface conveyance facilities; however, they are often required in order to meet overall stormwater management system objectives.

Reinforced precast concrete pipe (RCP) is probably the most common material used for the construction of storm sewers. Concrete pipe is available in lengths ranging from four feet to 24 feet and in eliptical, arch, and circular pipe sections with circular sections ranging from four inches to 144 inches in diameter. Fittings for concrete pipe such as wyes, tees, and manholes are readily available. Concrete provides a high-strength, widely used and accepted storm sewer pipe. Fabricated steel pipe such as corrugated metal pipe and corrugated metal pipe arches is also commonly used in stormwater management systems. The most common application of these materials is in culvert pipe. In some instances corrugated metal pipe is used for conventional storm sewer construction. Corrugated metal is light weight, strong, and flexible and is manufactured in generally longer lengths than concrete pipe. It is more difficult to connect inlets to corrugated metal pipe.

Other pipe materials such as asbestos-cement pipe, vitrified clay pipe, cast iron pipe, ductile iron pipe, welded steel pipe, and plastic pipe are also available. These pipe materials are not commonly applied to gravity stormwater management situations. There are limited applications for asbestos-cement pipe, metal pipe, and plastic pipe as pressure stormwater conveyance facilities.

Recommendations relating to the alignment, depth, size, slope, and type of storm sewer facilities are included in the stormwater management plan. Detailed information regarding the relative location of stormwater management facilities with respect to other underground utilities will not be addressed at this time. It is recommended, however, that stormwater management facilities be located generally as shown in Figure 35. Additional details and refinement must be addressed in the detailed design phase prior to construction. Criteria for the design are provided in Chapter V.

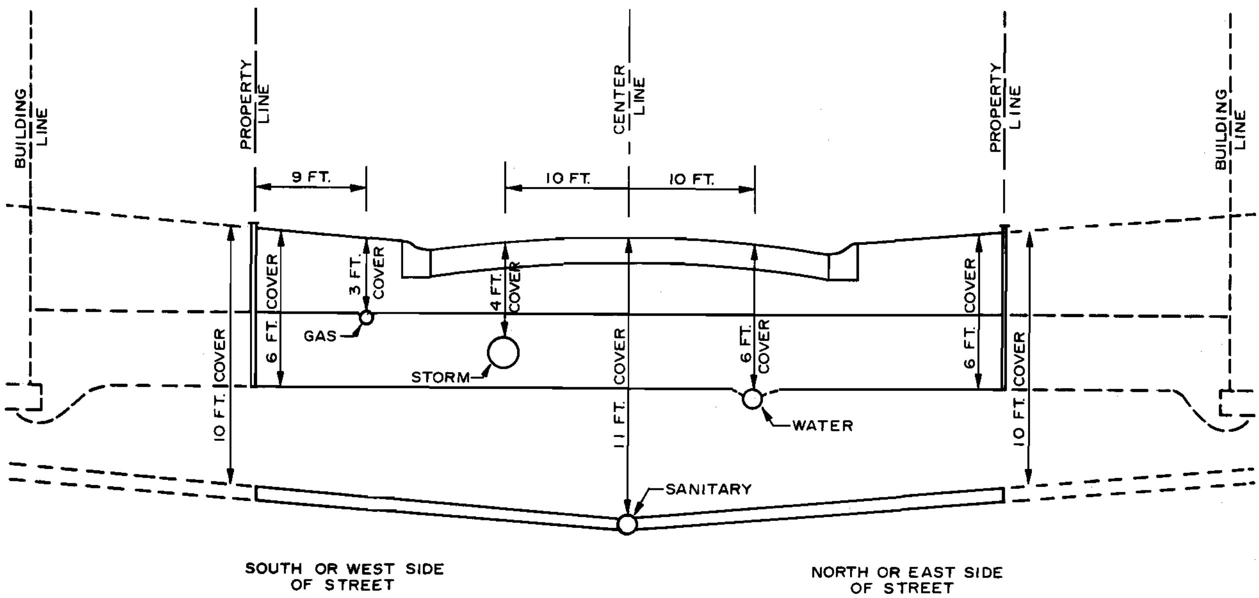
Typically, the sewers are designed to flow under gravity conditions using hydraulic formulae such as Manning's equation and considering the available slope at control points within the system. A minimum storm sewer size of 12 inches in diameter was assumed.

Stormwater Pumping Stations: A stormwater pumping station is a mechanical device that lifts and transports stormwater under pressure. The purpose of a stormwater pumping facility is to remove stormwater from a low-lying area that cannot be effectively drained by gravity. Stormwater pumping stations are commonly associated with stormwater storage facilities that have limited land surface available and are restricted to deep storage. This type of storage design requires the use of mechanical pumping to fully drain storage areas.

Pumping stormwater from storage areas is less dependable and more costly than gravity drainage. For situations where deep storage is required, or where

Figure 35

SUGGESTED UTILITY LOCATIONS IN THE VILLAGE OF SUSSEX



Source: Robert Hutter, Engineer, Village of Sussex.

there is not sufficient grade to provide adequate gravity drainage, pumped discharge is necessary.

Recommendations relating to the location, capacity, height of lift, and type of storm sewer pumping stations required are included in the stormwater management plan. Additional details and refinement will be needed in the detailed design phase prior to construction. Criteria for design are provided in Chapter V.

Manholes: A storm sewer manhole is defined as a structure which provides an access way to underground sewers. The purpose of the storm sewer manhole is to provide access to the storm sewer system for observation and maintenance purposes. Manholes are typically placed at all junctions in the sewer system and from 300 to 600 feet apart along the sewers. Smaller size sewers are normally laid in straight lines between manholes; larger sewers may be laid on curves. Greater spacing distances are allowable for sewers large enough to allow entrance by maintenance personnel. Functions for smaller size storm sewers can be accommodated within ordinary manholes. Larger sewers, however, may require the provision of special junction boxes to provide a smooth hydraulic connection. Two typical storm sewer manhole designs are shown in Figure 36.

Recommendations relating to the locations and spacing of manholes are included in the stormwater management plan. The type of manhole is a local design consideration which does not significantly affect the system plan.

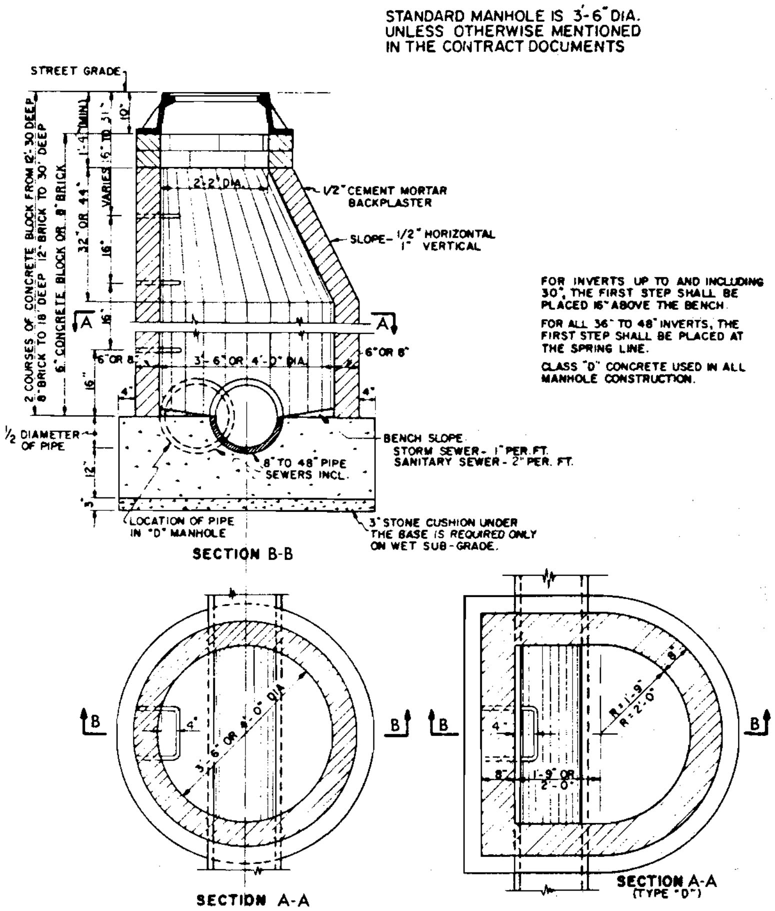
Junction Box

A junction box is defined as a structure which provides both access to an underground sewer and accommodates major changes in the size and junctions of storm sewers. The junction boxes are intended to provide smooth hydraulic transitions between differing sizes and directions of flows.

The approximate location of junction boxes in the Village of Sussex planned urban area is set forth in the stormwater management plan. The type of junction box is dependent upon the sewer sizes and alignment conditions at each point in the system.

Figure 36

TYPICAL STORM SEWER MANHOLE



Source: Standard Specifications for Sewer and Water Construction in Wisconsin, fourth edition.

Outlet Structures

An outlet structure is defined as a structure used to make the transitions from a storm sewer or channel into a receiving watercourse. The primary purpose of an outlet structure is to dissipate the velocity discontinuity and turbulence at the outfall which can cause scour or erosion in the receiving stream system. In many cases the receiving water is not uniformly deep enough to provide an effective cushion against the relatively high velocities in the incoming pipe or channel. Thus, some energy dissipation is needed. Examples of two types of outlet structures are shown in Figure 37.

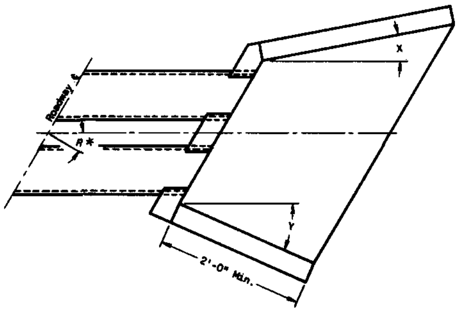
The approximate location and type of outlet structure in the Village of Sussex planned urban area are set forth in the stormwater management plan. Design criteria are set forth in Chapter V.

Culverts

A culvert is defined as a closed conduit used to convey stormwater under a highway, railroad, canal, or embankment. Culverts are a common and hydraulically important feature of open drainage channels.

Figure 37

OUTLET STRUCTURES



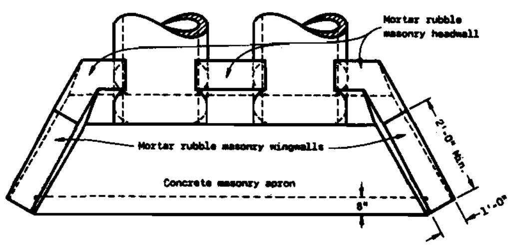
WINGWALL ANGLE DETAILS

INLET			OUTLET		
R*	X	Y	R*	X	Y
0 - 7°	30°	30°	0 - 15°	15°	15°
8 - 22°	25°	"	16 - 45°	10°	"
23 - 37°	20°	"	46 - 75°	5°	"
38 - 52°	15°	"	over 75°	0°	"
53 - 67°	10°	"			
68 - 82°	5°	"			
over 82°	0°	"			

*R = Number of degrees right or left hand forward.

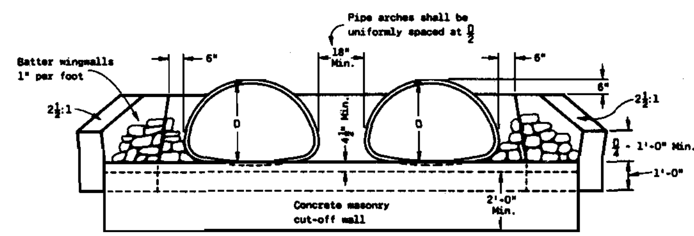
PIPE SIZE (D)	FRONT FACE ("F")	BACK FACE ("B")	"W"
24" - 48"	6" Per ft.	6" Per ft.	1.0'
60" C.M.P. 60" R.C.C.P.	6" Per ft.	3" Per ft.	2.2' 2.4'
72" C.M.P. 72" R.C.C.P.	6" Per ft.	3" Per ft.	2.4' 2.7'

All endwalls for pipe arches shall have a 6" per ft. slope on front and back face.



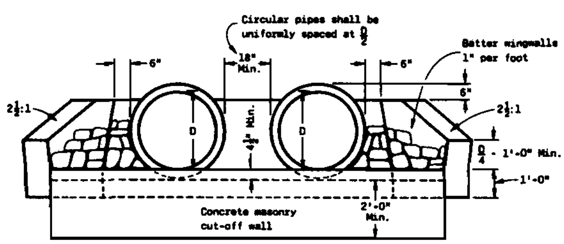
PLAN VIEW

CIRCULAR PIPE AND PIPE ARCH



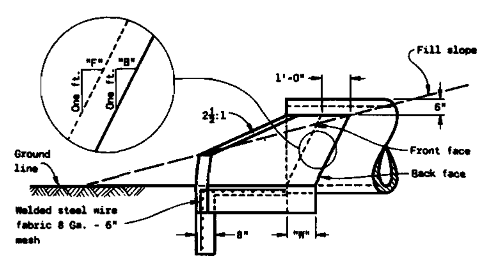
END ELEVATION

PIPE ARCH



END ELEVATION

CIRCULAR PIPE



SIDE ELEVATION

CIRCULAR PIPE AND PIPE ARCH

Source: <u>Wisconsin Department of Transportation Facilities Development Manual.</u>

The locations and sizes of culverts in the Village of Sussex planned urban area are set forth in the stormwater management plan. The hydraulic design of any culvert may be affected by its cross-sectional area, shape, entrance geometry, length, slope, construction material, and the depth of ponding at the inlet (headwater) and outlet (tailwater) to the structure.

Culvert flows are classified as having either inlet or outlet control--that is, whether the discharge capacity is controlled by either the outlet or inlet characteristics. Typical inlet control and outlet control culvert conditions are shown in Figure 38. Under inlet control, the cross-sectional area of the culvert, the inlet configuration, and the depth of the stormwater at the inlet are important. Under outlet control, the depth of stormwater in the outlet channel and the slope, roughness, and length of culvert can be important.

Storage

In order to reduce the cost of conveyance facilities, full advantage must be taken of means to reduce peak flow in the overland flow and collection system components. Stormwater storage is defined as the temporary detention, or long-term retention, of stormwater in the system. The purpose of stormwater storage is to reduce the peak stormwater discharge rates both within the stormwater management system itself and from urban areas to receiving waterways. Stormwater storage also allows greater infiltration and separation of stormwater, reduces the potential for stream erosion, enhances the removal of sediment and nutrients suspended in stormwater, and may reduce the cost of downstream stormwater conveyance and flood control facilities.

Stormwater storage may be either natural or man-made. In an undisturbed setting an abundance of natural stormwater storage areas normally exists. Stormwater is stored in natural surface depressions, in wetlands, and in the surface soils. These natural storage areas dispersed throughout a drainage area serve to significantly reduce the volume and rate of stormwater runoff, and also enhance the removal of stormwater from the surface water system by evaporation and infiltration.

In an urban area the storage capacity of the natural terrain is significantly reduced by grading to provide smooth, free-draining surfaces; by the filling of wetlands; and by the construction of impervious surfaces such as rooftops and pavements. These changes result in a significant reduction in stormwater storage capacity. In order to compensate for the loss of natural stormwater storage areas and to reduce the size and cost of conveyance facilities, it may be necessary or desirable to provide man-made storage in the stormwater management system. Such storage may be less costly than higher capacity conveyance facilities and may reduce the impact of stormwater runoff on downstream areas.

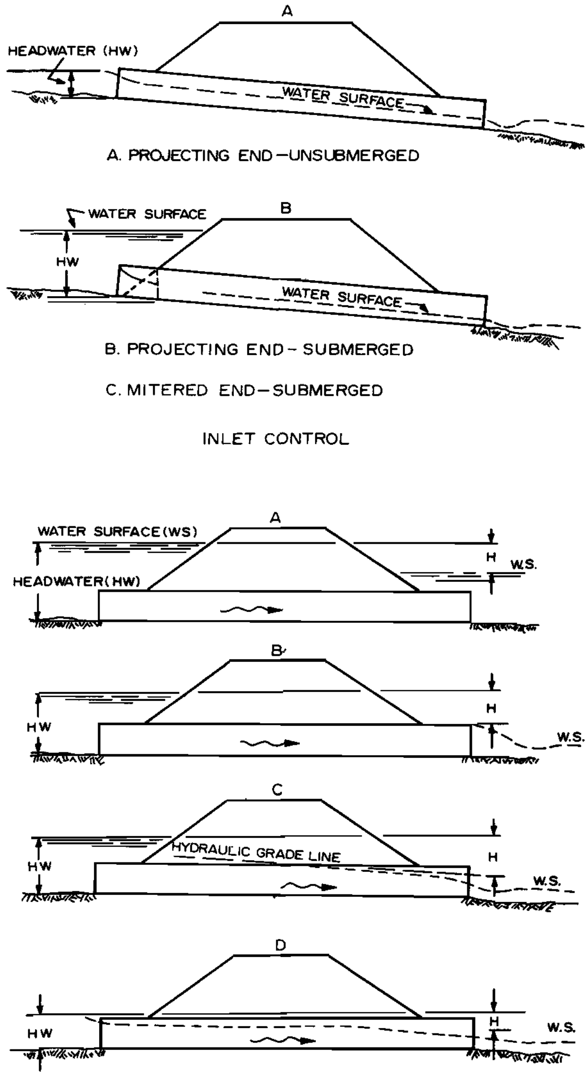
Recommendations relating to the location, size, and capacity of storage facilities are included in the stormwater management plan. Additional details and refinement must be addressed in the detailed design phase prior to construction. Criteria for design are provided in Chapter V.

Detention Storage: Detention storage is defined as temporary storage of stormwater following precipitation. The purpose of detention storage is to temporarily hold back the stormwater, increasing the overall time of concentration for the drainage area and reducing the peak rate of stormwater runoff.

There are a wide variety of passive stormwater storage techniques that can be provided in an urban setting at little or no cost. These storage techniques consist of grassed stormwater collection swales designed to flow at low velocities, thereby providing storage; small man-made depression areas designed to collect limited amounts of overland flow stormwater and permit it to infiltrate into the groundwater reservoir; stormwater conveyance ditches designed to include check dams to reduce flow velocities, thereby providing storage and berms, also used to provide increased storage volume. Stormwater storage can also be provided on rooftops, in parking lots, and in specially designed and constructed stormwater storage basins. These storage methods generally detain stormwater for short periods of time, in some cases allowing increased infiltration, evaporation, and transpiration, and significantly reducing downstream peak stormwater discharges. Stormwater detention facilities are generally completely drained between storm events. A typical stormwater detention basin is shown in Figure 39.

Figure 38

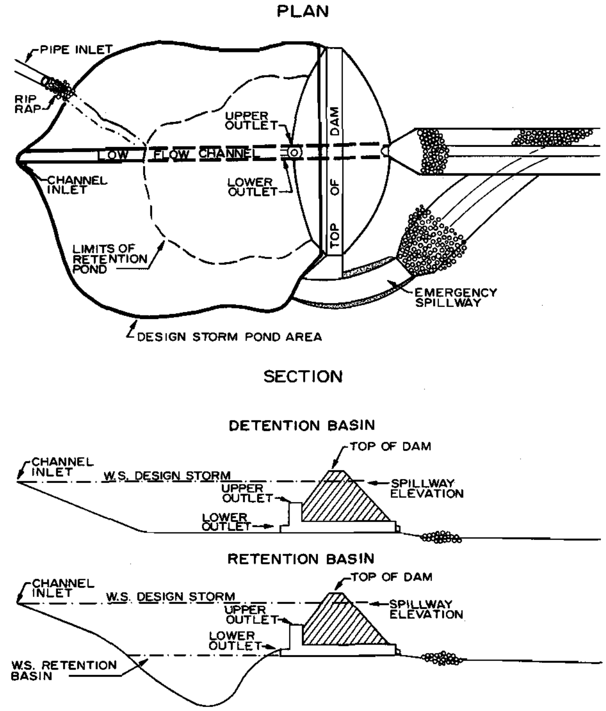
CULVERT HYDRAULIC CONDITIONS



Source: American Iron and Steel Institute, Handbook of Steel Drainage and Highway Construction Products.

Figure 39

TYPICAL STORMWATER STORAGE STRUCTURES



Source: Water Resources Research Institute and SEWRPC.

Stormwater Retention: Stormwater retention is defined as the long-term storage of stormwater following precipitation. The purpose of retention storage is to remove stormwater from the drainage system and allow stormwater to infiltrate or evaporate, reducing the overall volume of stormwater that reaches the outfall of the drainage basin.

Stormwater retention basins are often relatively shallow basins with substantial bottom area for infiltration. Stormwater retention ponds also may serve as water supply and fire protection reservoirs, and may capture stormwater for manufacturing or municipal uses. Retention ponds can also serve as recreational facilities and as aesthetic focal points in desirable "green" open spaces. Stormwater retention ponds can be designed in series to include connecting green areas that further enhance the overall stormwater management system effectiveness. A typical stormwater retention basin is shown in Figure 39.

It is not always desirable or feasible to provide storage in a stormwater management system. In most developed urban areas suitable parcels of land are not available for the construction of stormwater retention or detention basins. Other more subtle methods of onsite storage and collection system storage may be feasible but may cause objectionable disruption of urban activity.

Stormwater Treatment

Stormwater treatment may be defined as the removal of pollutants from stormwater. The purpose of stormwater treatment is to reduce the undesirable environmental impact of stormwater discharges on downstream waterways.

The natural environment contains many control mechanisms that prevent pollutants from entering the stormwater drainage system. Urban development can remove these mechanisms and cause adverse water quality impacts. In addition, new urban-related sources of surface pollutants are exposed to the surface water drainage system. The result is a considerable increase in pollutants transported to the surface water system as a result of urbanization. Control of stormwater quality from urban areas may be accomplished by providing comprehensive nonpoint source pollution control, or by removing pollutants from the stormwater after collection from the urban drainage basin. Stormwater treatment would typically consist of a stormwater detention facility to provide a constant flow rate followed by a physical treatment facility. Stormwater treatment processes may include screens, microstrainers, dissolved air flotation, swirl concentrators, high rate filtration, and disinfection or ozonization. A range of from 10 to 50 percent reduction of released pollutants may be achieved by stormwater treatment processes.

Stormwater treatment methods are costly. Less costly urban nonpoint source control measures may be a more attractive alternative in many cases. For this reason, and because there are few motivating legal requirements regarding the quality of stormwater discharged to the surface water system, municipalities have not normally pursued this component of the stormwater management system. Limited application of stormwater treatment has been effected for certain types of stormwater runoff from industrial areas.

Stormwater treatment measures are consistent with the water quality objective for the Sussex area stormwater management system. There is considerable conflict, however, with the economic objectives.

Other Nonpoint Source Pollution Control Measures

Nonpoint source pollution control may be defined as management of urban and rural land uses to reduce pollutants discharged to surface waters. For the purposes of this report, such control measures will be considered only with respect to urban nonpoint sources of pollution. Table 27 presents various nonpoint source control measures. Each of the measures listed may be utilized in both existing and newly developing urban settings. The last two measures--parking lot storage and treatment, and onsite storage--while probably more applicable to new urban development, do have limited application in existing

Table 27

GENERALIZED SUMMARY OF METHODS AND EFFECTIVENESS OF NONPOINT SOURCE WATER POLLUTION ABATEMENT MEASURES

Control Measures	Summary Description	Approximate Percent Reduction of Released Pollutants
Litter and pet waste control ordinance	Prevent the accumulation of litter and pet wastes on streets and residential, commercial, industrial, and recreational areas	2-5
Improved timing and efficiency of street sweeping, leaf collection and disposal, and catch basin cleaning	Improve the scheduling of these public works activities, modify work habits of personnel, and select equipment to maximize the effectiveness of these existing pollution control measures	2-5
Management of onsite sewage treatment systems	Regulate septic system installation, monitoring, location, and performance; replace failing systems with new septic systems or alternative treatment facilities; develop alternatives to septic systems; eliminate direct connections to drain tiles or ditches; dispose of septage at sewage treatment facility	10-30
Increased street sweeping	On the average, sweep all streets in urban areas an equivalent of once or twice a week with vacuum street sweepers; require parking restrictions to permit access to curb areas; sweep all streets at least eight months per year; sweep commercial and industrial areas with greater frequency than residential areas	30-50
Increased leaf and clippings collection and disposal	Increase the frequency and efficiency of leaf collection procedures in fall; use vacuum cleaners to collect leaves; implement ordinances for leaves, clippings, and other organic debris to be mulched, composted, or bagged for pickup	2-5
Increased catch basin cleaning	Increase frequency and efficiency of catch basin cleaning; clean at least twice per year using vacuum cleaners; catch basin installation in new urban development not recommended as a cost-effective practice for water quality improvement	2-5
Reduced use of deicing salt	Reduce use of deicing salt on streets; salt only intersections and problem areas; prevent excessive use of sand and other abrasives	Negligible for pollutants addressed in this chapter but helpful for reducing chlorides and associated damage to vegetation
Improved street maintenance and refuse collection and disposal	Increase street maintenance and repairs; increase provision of trash receptacles in public areas; improve trash collection schedules; increase cleanup of parks and commercial centers	2-5
Parking lot stormwater temporary storage and treatment measures	Construct gravel-filled trenches, sediment basins, or similar measures to store temporarily the runoff from parking lots, rooftops, and other large impervious areas; if treatment is necessary, use a physical-chemical treatment measure such as screens, dissolved air flotation, or a swirl concentrator	5-10
Onsite storage--residential	Remove connections to sewer systems; construct onsite stormwater storage measures for subdivisions	5-10

Source: SEWRPC.

urban areas. As already noted, nonpoint source control is usually a less costly method than treatment for controlling pollution from stormwater runoff. In addition, nonpoint source control measures such as parking lot storage and onsite storage provide an additional benefit in peak stormwater runoff and volume reductions. Accordingly, nonpoint source control is consistent with the water quality and hydraulic objectives of the Sussex area stormwater management plan.

SUMMARY

This chapter has presented an evaluation of six stormwater system components. The three basic components of overland flow, collection, and conveyance were presented as the traditional approach to stormwater management. The three remaining components of storage, treatment, and nonpoint source pollution control were also presented as alternative stormwater management components that may be required to meet the overall system objectives. Stormwater treatment will not be considered further in the preparation of a stormwater management plan for the Sussex area. The need for such treatment can be properly determined only as a part of a detailed urban nonpoint source water pollution abatement plan. The adopted regional water quality management plan does not indicate that the level of nonpoint source abatement in the Sussex area required to meet established water use objectives and supporting water quality standards will require such treatment. The regional plan does, however, indicate that about a 25 percent reduction in nonpoint source pollution will be required. To that end the stormwater management planning effort will consider, to the extent practicable in the absence of a detailed, second-level abatement plan, means of reducing nonpoint source pollution through the stormwater management system. In this respect, local preferences and planning with respect to land use intensity precludes the use of roadway ditches for stormwater collection or open ditches for stormwater conveyance. Accordingly, the planning effort will be based on the assumption that except in isolated cases, stormwater collection and conveyance in areas of new urban development, as well as in areas of existing urban development, will utilize curb and gutter collection facilities, along with storm sewer conveyance facilities.

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Chapter VII

EVALUATION OF EXISTING AND ALTERNATIVE FUTURE STORMWATER MANAGEMENT SYSTEMS

INTRODUCTION

This chapter presents the findings of an evaluation of the existing stormwater management system serving the Village of Sussex urban service area, together with a description and evaluation of alternative stormwater management plans designed to serve this area through the design year 2000. In order to evaluate alternative stormwater management plans, it was first necessary to characterize the existing stormwater drainage system of the urban service area. This required the collation of definitive data on the location and configuration and on the size, elevation and grade of the various components of that system; the computation of the hydraulic capacity of that system; and a comparison of that capacity to anticipated rates and volumes of stormwater runoff under both existing and planned future land use conditions. As indicated in Chapter V of this report, a 10-year recurrence interval storm event was used to evaluate and design the minor system components consisting of backyard and sideyard swales, roadway ditches and curbs and gutters, inlets, storm sewers, storage facilities, and related appurtenances. The major system components, including the entire street cross section and interconnected drainage swales, drainage ditches, and watercourses, were evaluated and designed using a 100-year recurrence interval storm event.

Following a description of the findings of the evaluation of the existing system, this chapter describes and evaluates alternative conceptual approaches to stormwater management which could be applied in the planning area to mitigate existing stormwater management problems and accommodate runoff from planned development to the design year 2000. Descriptions and evaluations of the three specific alternative stormwater management plans for the urban service area follow the general description and evaluation of alternative conceptual approaches to stormwater management.

EVALUATION OF THE EXISTING STORMWATER MANAGEMENT SYSTEM

Introduction

The characterization of the existing stormwater management system requires the definitive description of the primary components of that system. Such a description permits calculation of the hydraulic capacities of the existing conveyance and storage facilities, as well as the required capacities under the design storms and under planned future as well as existing land use development conditions in the tributary catchment areas. Those system components which are unable to accommodate the runoff expected from the design storms under either existing or future land use conditions, or both, are thus identified, and these components then can be addressed in the design of alternative stormwater management plans.

The evaluation of the existing stormwater management system conducted under the study has been directed toward the storm sewers, storage facilities, and open channels and culverts of the minor system, as defined in Chapter V of this report, and to the water courses and related bridges and culverts of the major system. In the evaluation it was assumed that the backyard and sideyard drainage swales, the roadway ditches and curbs and gutters, and the inlets have adequate capacity to convey the stormwater flows generated by storms up to and including the 10-year event to the receiving conveyance and storage facilities of the minor system. In addition, it was assumed that the capacities of the street cross-sections and interconnecting drainage swales of the major system have adequate capacity to convey the stormwater flows generated by storms in excess of the 10-year recurrence interval event and up to the 100-year recurrence interval event to the water courses of the major system. However, the system components assumed to be adequate in this chapter for the purpose of designing and evaluating alternative system plans were subject to quantitative analysis in the development of the recommended plan as set forth in Chapter VIII of this report.

Physical Characteristics

As described in Chapter III of this report, the total planning area was divided into 117 subbasins for analytical purposes, as shown on Map 8 of Chapter III. Of the total of 117 subbasins, 87 were located within the Village of Sussex urban service area. The pertinent characteristics of the stormwater drainage system of each subbasin within the urban service area, together with the pertinent characteristics of the subbasin itself, are described in Table 28. Data are provided on the subbasin size, existing and planned land use, the type and capacity of the stormwater drainage component comprising the outlet of the subbasin, and the peak stormwater flow rates expected to be generated from the subbasin.

The existing stormwater drainage system is primarily comprised of roadway ditches, roadway curbs and gutters, storm sewer inlets, storm sewers, open channels, and associated culverts, together with the streams to which the outlets of the engineered and constructed system components discharge. A description of the existing stormwater management system is provided in Chapter III of this report.

Hydraulic Capacities of Conveyance Systems and Storm Flows

The hydraulic capacity of conveyance facilities--storm sewers, culverts, and open channels--is determined by the shape and dimensions of the cross-section of the facility, its composition and lining, its elevation and slope, and the roughness of the surface--as represented by Manning's "n" value. The methods used to determine the hydraulic capacity of the system components are described in Chapter V of this report. The hydraulic capacity of the conveyance facilities at the outlet of each subbasin is presented in Table 28. In addition to the capacity at the outlet of each subbasin as presented in Table 28, the capacities of all storm sewers, storage facilities, open channels and culverts in the minor stormwater management system and for selected water courses of the major stormwater management system were calculated as part of the evaluation of the existing system.

Table 28

SELECTED CHARACTERISTICS OF THE EXISTING STORMWATER DRAINAGE SYSTEM IN THE SUSSEX PLANNED URBAN SERVICE AREA UNDER EXISTING AND PLANNED LAND USE CONDITIONS

Subwatershed and Subbasin or Special Component Identification	Area of Subbasin (acres)	Subbasin Downstream Conveyance Component		Principal Land Use In Subbasin		Peak Stormwater Flow (cfs)			
						10-Year Recurrence Interval Storm Event		100-Year Recurrence Interval Storm Event	
		Description	Hydraulic Capacity (cfs)	Existing Conditions	Planned Conditions	Existing Land Use	Planned Land Use	Existing Land Use	Planned Land Use
Pewaukee River									
PR 1-0	25.0	36-inch-diameter corrugated metal pipe	25	Commercial	Commercial and multi-family residential	11	49	22	79
PR 1-2	31.0	2-foot-deep open channel with a bottom width of 2 feet and side slopes of 2 on 3	49	Park	Park and governmental and institutional	35	60	70	86
PR 1-3[a]	--[b]	36-inch-diameter corrugated metal pipe	26	--[b]	--[b]	35	60	70	86
PR 1-4	26.1	1.5-foot-deep open channel with a bottom width of 2 feet and side slopes of 1 on 2	25	Single-family residential	Single-family residential	51	82	99	128
PR 3-0	26.1	--[c]	--[c]	Residential and commercial	Residential and commercial	14	17	20	25
PR 2-0	21.8	1-foot-deep open channel with a bottom width of 15 feet and side slopes of 1 on 5	89	Open lands	Commercial	10	63	27	104
PR 2-2	17.7	12-inch-diameter corrugated metal pipe	1	Single-family residential	Single-family residential	33	129	62	215
PR 2-4	29.9	1-foot deep open channel with a bottom width of 2 feet and side slopes of 1 on 2	8	Open lands	Single-family residential	53	166	102	268
PR 2-6[a]	--[b]	28-inch by 42-inch corrugated metal pipe arch	26	--[b]	--[b]	53	166	102	268
PR 1-5[a]	--[b]	24-inch by 48-inch corrugated metal pipe arch	26	--[b]	--[b]	110	230	220	380
PR 1-6	42.3	2-foot-deep open channel with a bottom width of 2 feet and side slopes of 1 on 2	36	Governmental and institutional lands	Governmental and institutional lands	110	230	220	380
PR 1-8	110.3	2-foot-deep open channel with a bottom width of 5 feet and side slopes of 1 on 2	38	Open lands	Parklands and single-family residential	130	260	280	440
PR 1-10	288.3	0.5-foot-deep open channel with a bottom width of 10 feet and side slopes of 1 on 3	7	Open lands	Open lands and single-family residential	170	300	380	530

Table 28 (continued)

Subwatershed and Subbasin or Special Component Identification	Area of Subbasin (acres)	Subbasin Downstream Conveyance Component: Description	Subbasin Downstream Conveyance Component: Hydraulic Capacity (cfs)	Principal Land Use in Subbasin: Existing Conditions	Principal Land Use in Subbasin: Planned Conditions	Peak Stormwater Flow (cfs): 10-Year Recurrence Interval Storm Event: Existing Land Use	Peak Stormwater Flow (cfs): 10-Year Recurrence Interval Storm Event: Planned Land Use	Peak Stormwater Flow (cfs): 100-Year Recurrence Interval Storm Event: Existing Land Use	Peak Stormwater Flow (cfs): 100-Year Recurrence Interval Storm Event: Planned Land Use
Main Branch-Sussex Creek West Agricultural Area									
SCWA 1-6	122.2	3-foot-deep open channel with a bottom width of 2 feet and side slopes of 1 on 3	219	Agriculture and other open lands	Environmental corridor	93	194	145	286
SCWA 3-0	72.8	1-foot-deep open channel with a bottom width of 6 feet and side slopes of 1 on 2	16	Agriculture and other open lands	Agriculture and other open lands	15	20	15	20
SCWA 4-6	165.5	4-foot-deep open channel with a bottom width of 5 feet and side slopes of 1 on 3	244	Agriculture and other open lands	Single-family residential	85	93	216	236
SCWA 4-8	55.4	4-foot-deep open channel with a bottom width of 5 feet and side slopes of 1 on 3	184	Agriculture and other open lands	Environmental corridor and industrial	87	95	222	242
SCWA 1-8	49.2	5-foot-deep open channel with a bottom width of 10 feet and side slopes of 1 on 2	180	Agriculture and other open lands	Environmental corridor	135	282	278	549
SCWA 31-0	4.2	21-inch-diameter concrete pipe	11	Open lands	Commercial	8	12	8	12
Main Branch-Sussex Creek North Agricultural Area									
SCNA 5-0	28.5	21-inch-diameter corrugated metal pipe	55	Agriculture and other open lands	Single-family residential	20	35	52	61
SCNA 5-1[a]	--[b]	24-inch-diameter corrugated metal pipe	9	--[b]	--[b]	20	35	52	61
SCNA 36-0	103.2	1-foot-deep open channel with a bottom width of 10 feet and side slopes of 1 on 3	90	Agriculture and other open lands	Single-family residential and isolated natural areas	5	12	13	25
SCNA 36-1[a]	--[b]	24-inch-diameter corrugated metal pipe	9	--[b]	--[b]	5	12	13	25
SCNA 7-0	17.0	1-foot-deep open channel with a bottom width of 10 feet and side slopes of 1 on 3	39	Agriculture and other open lands	Single-family residential	8	21	22	38
SCNA 7-1[a]	--[b]	15-inch-diameter corrugated metal pipe	1	--[b]	--[b]	8	21	22	38
SCNA 5-2	35.7	--[d]	--[d]	Agriculture and other open lands	Single-family residential	28	71	57	110

Table 28 (continued)

Subwatershed and Subbasin or Special Component Identification	Area of Subbasin (acres)	Subbasin Downstream Conveyance Component		Principal Land Use in Subbasin		Peak Stormwater Flow (cfs)			
						10-Year Recurrence Interval Storm Event		100-Year Recurrence Interval Storm Event	
		Description	Hydraulic Capacity (cfs)	Existing Conditions	Planned Conditions	Existing Land Use	Planned Land Use	Existing Land Use	Planned Land Use
SCNA 8-0	29.9	1-foot-deep open channel with a bottom width of 10 feet and side slopes of 1 on 3	45	Agriculture and other open lands	Single-family residential	21	100	56	160
SCNA 8-1[a]	--[b]	16-inch-diameter corrugated metal pipe	5	--[b]	--[b]	21	100	56	160
SCNA 8-2	60.6	1-foot-deep open channel with a bottom width of 5 feet and side slopes of 2 on 5	18	--[b]	--[b]	21	100	56	160
SCNA 9-0	27.7	42-inch-diameter concrete pipe	75	Residential undeveloped	Single-family residential	33	43	69	77
SCNA 9-1[a]	--[b]	42-inch-diameter concrete pipe	62	--[b]	--[b]	32	43	69	77
SCNA 8-3[a]	--[b]	25-inch high by 48-inch wide concrete box culvert	70	--[b]	--[b]	40	120	80	200
SCNA 5-4	31.5	0.5-foot-deep channel with a bottom width of 20 feet and side slopes of 1 on 5	14	Agriculture and other open lands	Agriculture and other open lands	50	150	120	260
SCNA 10-0	159.5	1-foot-deep open channel with a bottom width of 10 feet and side slopes of 1 on 3	53	Agriculture and other open lands	Single-family residential and agriculture	12	50	31	150
SCNA 10-1	--[b]	24-inch-diameter corrugated metal pipe	5	--[b]	--[b]	12	50	31	150
SCNA 10-2	49.6	--[c]	--[c]	Agriculture and other open lands	Single-family residential and environmental corridor	20	100	50	200
SCNA 10-4	31.0	1-foot-deep open channel with a bottom width of 10 feet and side slopes of 1 on 3	17	Agriculture and other open lands	Environmental Corridor	30	120	60	220
SCNA 5-6[a]	--[b]	36-inch-diameter cast iron pipe	70	--[b]	--[b]	50	180	110	320
Main Branch-Sussex Creek Mid-Town									
SCMT 11-0	20.5	21-inch-diameter concrete pipe	9	Single-family residential	Single-family residential	29	29	49	49
SCMT 12-0	31.8	24-inch by 38-inch corrugated metal pipe arch	8	Single-family residential	Single-family residential	46	48	77	81
SCMT 12-2	20.7	29-inch by 45-inch corrugated metal pipe arch	13	Single-family residential	Single-family residential	--	--	--	--

Table 28 (continued)

Subwatershed and Subbasin or Special Component Identification	Area of Subbasin (acres)	Subbasin Downstream Conveyance Component		Principal Land Use in Subbasin		Peak Stormwater Flow (cfs)			
						10-Year Recurrence Interval Storm Event		100-Year Recurrence Interval Storm Event	
		Description	Hydraulic Capacity (cfs)	Existing Conditions	Planned Conditions	Existing Land Use	Planned Land Use	Existing Land Use	Planned Land Use
SCMT 12-4[a]	--b	29-inch by 45-inch corrugated metal pipe arch	45	--b	--b	60	87	60	87
SCMT 1-20	17.8	5-foot-deep open channel with a bottom width of 10 feet and side slopes of 1 on 3	310	Agriculture and other open lands	Industrial and environmental corridor	178	373	279	551
SCMT 13-0	31.2	30-inch-diameter concrete pipe	19	Agriculture and other open lands	Single-family residential	10	39	27	66
SCMT 14-0	40.5	1-foot-deep open channel with a bottom width of 99 feet and side slopes of 1 on 10	615	Agriculture and other open lands	Single-family residential and isolated natural areas	25	46	35	65
SCMT 14-2	40.4	42-inch-diameter concrete pipe	76	Single-family residential	Single-family residential	68	107	96	150
SCMT 14-4[a]	--b	42-inch-diameter concrete pipe	32	--b	--b	68	107	96	150
SCMT 14-6[a]	--b	48-inch-diameter concrete pipe	102	--b	--b	68	107	96	150
SCMT 15-0	6.6	15-inch-diameter concrete pipe	5	Single-family residential	Single-family residential	6	6	12	12
SCMT 15-1[a]	--b	15-inch-diameter concrete pipe	3	--b	--b	6	6	12	12
SCMT 15-2	42.0	1-foot-deep open channel with a bottom width of 5 feet and side slopes of 1 on 10	32	Single-family residential and open lands	Single-family residential	13	60	30	105
SCMT 1-22	52.9	5-foot-deep open channel with a bottom width of 10 feet and side slopes of 1 on 3	915	Single-family residential and open lands	Single-family residential and environmental corridor	184	385	289	570
SCMT 1-24	7.3	5-foot-deep open channel with a bottom width of 10 feet and side slopes of 1 on 2	715	Governmental and institutional	Environmental corridor and governmental and institutional	184	385	288	569
SCMT 16-0	5.9	18-inch-diameter corrugated metal pipe	3	Single-family residential	Single-family residential	5	5	11	11
SCMT 1-25		5-foot-deep open channel with a bottom width of 10 feet and side slopes of 1 on 2	949	Commercial and open space	Commercial and open space	212	405	303	598

Table 28 (continued)

Subwatershed and Subbasin or Special Component Identification	Area of Subbasin (acres)	Subbasin Downstream Conveyance Component		Principal Land Use In Subbasin		Peak Stormwater Flow (cfs)			
						10-Year Recurrence Interval Storm Event		100-Year Recurrence Interval Storm Event	
		Description	Hydraulic Capacity (cfs)	Existing Conditions	Planned Conditions	Existing Land Use	Planned Land Use	Existing Land Use	Planned Land Use
SCMT 17-0	1.7	18-inch-diameter concrete pipe	5	Commercial	Commercial	2	7	4	11
SCMT 18-0	3.0	18-inch-diameter concrete pipe	4	Commercial and single-family residential	Commercial and single-family residential	7	7	12	12
SCMT 19-0	36.7	42-inch-diameter concrete pipe	63	Single-family residential	Single-family residential	36	36	63	63
SCMT 19-2[a]	--b	42-inch diameter concrete pipe	39	--b	--b	36	36	63	63
SCMT 1-26	19.7	5-foot-deep open channel with a bottom width of 10 feet and side slopes of 1 on 2	949	Single-family residential and commercial	Commercial and environmental corridor	203	424	318	627
SCMT 1-28	16.5	4-foot-deep open channel with a bottom width of 10 feet and side slopes of 1 on 2	403	Open lands	Environmental corridor and commercial	--	--	--	--
SCMT 20-0	11.3	24-inch-diameter concrete pipe	27	Single-family residential	Single-family residential and commercial	7	7	13	13
SCMT 20-2[a]	--b	24-inch-diameter concrete pipe	15	--b	--b	7	7	13	13
SCMT 21-0	27.3	30-inch-diameter concrete pipe	49	Single-family residential	Single-family residential	35	51	64	91
SCMT 21-2[a]	--b	42-inch-diameter concrete pipe	47	--b	--b	35	49	49	49
SCMT 22-0	4.0	12-inch-diameter concrete pipe	2	Single-family residential	Commercial	3	19	5	32
SCMT 23-0	24.5	36-inch-diameter concrete pipe	29	Single-family residential	Single-family residential and industrial	18	31	36	54
Sussex Creek East Branch									
SCEB 24-0	89.5	1-foot-deep open channel with a bottom width of 50 feet and side slopes of 1 on 10	347	Agriculture and other open lands	Single-family residential	30	120	80	200
SCEB 24-1[a]	--b	48-inch-diameter concrete pipe	551	--b	--b	30	120	80	200
SCEB 24-2	41.3	4-foot-deep open channel with a bottom width of 3 feet and side slopes of 2 on 5	541	Agriculture and other open lands	Single-family residential	40	125	110	230
SCEB 25-0	15.0	27-inch-diameter concrete pipe	49	Agriculture and other open lands	Single-family residential	12	22	26	40
SCEB 25-2[a]	--b	48-inch-diameter concrete pipe	76	--b	--b	12	20	25	37

Table 28 (continued)

Subwatershed and Subbasin or Special Component Identification	Area of Subbasin (acres)	Subbasin Downstream Conveyance Component		Principal Land Use in Subbasin		Peak Stormwater Flow (cfs)			
						10-Year Recurrence Interval Storm Event		100-Year Recurrence Interval Storm Event	
		Description	Hydraulic Capacity (cfs)	Existing Conditions	Planned Conditions	Existing Land Use	Planned Land Use	Existing Land Use	Planned Land Use
SCEB 24-4[a]	--[b]	2-foot-deep open channel with a bottom width of 5 feet and side slopes of 1 on 2	187	--[b]	--[b]	40	125	110	230
SCEB 32-0	43.6	24-inch-diameter concrete pipe	30	Open lands	Residential and open lands	16	27	23	40
SCEB 24-5	99.9	0.5-foot-deep open channel with a bottom width of 99 feet and side slopes of 1 on 10	54	Agriculture and other open lands	Single-family residential and environmental corridor	75	91	91	110
SCEB 24-6[a]	--[b]	30-inch-diameter concrete pipe	16	--[b]	--[b]	75	91	91	110
SCEB 26.0	4.1	24-inch-diameter concrete pipe	32	Agriculture and other open lands	Single-family residential	7	7	14	14
SCEB 26-1[a]	--[b]	24-inch-diameter concrete pipe	69	--[b]	--[b]	7	7	14	14
SCEB 26-2[a]	--[b]	24-inch-diameter concrete pipe	124	--[b]	--[b]	7	7	14	14
SCEB 26-3[a]	--[b]	30-inch-diameter concrete pipe	127	--[b]	--[b]	7	7	14	14
SCEB 26-4[a]	--[b]	1-foot-deep open channel with a bottom width of 99 feet and side slopes of 1 on 10	276	--[b]	--[b]	7	7	14	14
SCEB 24-7	21.5	0.5-foot-deep open channel with a bottom width of 40 feet and side slopes of 1 on 5	40	Agriculture and other open lands	Environmental corridor and single-family residential	109	132	131	160
SCEB 27-0	73.1	1-foot-deep open channel with a bottom width of 4 feet and side slopes of 1 on 2	20	Agriculture and other open lands	Industrial	30	30	82	82
SCEB 27-1[a]	--[b]	24-inch-diameter concrete pipe	32	--[b]	--[b]	30	30	82	82
SCEB 24-8[a]	--[b]	18-inch-diameter concrete pipe	184	--[b]	--[b]	109 109	132 132	131 131	160 160
SCEB 24-9[a]	--[b]	72-inch-diameter concrete pipe	568	--[b]	--[b]	131	159	160	193
SCEB 24-10	33.5	1-foot-deep open channel with a bottom width of 5 feet and side slopes of 1 on 5	35	Vacant residential lands	Single-family residential and environmental corridor	12	12	17	17
SCEB 33-0	8.6	21-inch-diameter concrete pipe	--	Single-family residential	Single-family residential	17	17	24	24
SCEB 34-0	11.4	18-inch-diameter concrete pipe	--	Single-family residential	Single-family residential	131	159	160	193
SCEB 24-11[a]	--[b]	34-inch by 56-inch corrugated metal pipe arch	55	--[b]	--[b]	13	51	35	95
SCEB 28-0	34.3	1-foot-deep open channel with a bottom width of 5 feet and side slopes of 1 on 2	37	--	Single-family residential				

Table 28 (continued)

Subwatershed and Subbasin or Special Component Identification	Area of Subbasin (acres)	Subbasin Downstream Conveyance Component		Principal Land Use in Subbasin		Peak Stormwater Flow (cfs)			
						10-Year Recurrence Interval Storm Event		100-Year Recurrence Interval Storm Event	
		Description	Hydraulic Capacity (cfs)	Existing Conditions	Planned Conditions	Existing Land Use	Planned Land Use	Existing Land Use	Planned Land Use
SCEB 24-12[a]	--[b]	Three 24-inch by 52-inch corrugated metal pipe arches	300	--[b]	--[b]	131	159	160	193
SCEB 24-14[a]	--[b]	3-foot-deep open channel with a bottom width of 5 feet and side slopes of 1 on 2	146	--[b]	--[b]	131	159	160	193
SCEB 24-16[a]	--[b]	48-inch-diameter concrete pipe	61	--[b]	--[b]	131	159	160	193
SCEB 24-17[a]	--[b]	3-foot high by 5-foot wide concrete box culvert	258	--[b]	--[b]	131	159	160	193
SCEB 24-18[a]	--[b]	44-inch by 72-inch corrugated metal pipe arch	78	--[b]	--[b]	131	159	160	193
Lower Sussex Creek									
LSC 1-32	59.2	4-foot-deep open channel with a bottom width of 5 feet and side slopes of 2 on 5	210	Agriculture and other open lands	Environmental corridor and single-family residential	205	439	325	648
LSC 29-0	12.9	24-inch-diameter concrete pipe	25	Single-family residential	Single-family residential	15	15	25	25
LSC 29-1[a]	--[b]	30-inch-diameter concrete pipe	24	--[b]	--[b]	15	15	25	25
LSC 1-34	85.3	4-foot-deep open channel with a bottom width of 5 feet and side slopes of 2 on 5	191	Agriculture and other open lands	Agriculture and single-family residential	208	463	336	679
LSC 30-0	5.4	24-inch-diameter concrete pipe	11	Single-family residential	Single-family residential	7	7	11	11
LSC 30-1[a]	--[b]	2-foot-deep open channel with a bottom width of 5 feet and side slopes of 3 on 5	56	--[b]	--[b]	7	7	11	11
Eastern Tributary to Sussex Creek									
ETSC 1-0	57.4	1-foot-deep open channel with a bottom width of 10 feet and side slopes of 1 on 10	57	Agriculture and other open lands	Industrial	28	41	149	214
ETSC 2-0	21.0	0.5-foot-deep open channel with a bottom width of 10 feet and side slopes of 1 on 20	15	Agriculture and other open lands	Industrial	12	17	63	90
ETSC 2-2	1.9	2-foot-deep open channel with a bottom width of 2 feet and side slopes of 2 on 5	64	Agriculture and other open lands	Single-family residential	13	19	69	98

Table 28 (continued)

Subwatershed and Subbasin or Special Component Identification	Area of Subbasin (acres)	Subbasin Downstream Conveyance Component		Principal Land Use in Subbasin		Peak Stormwater Flow (cfs)			
						10-Year Recurrence Interval Storm Event		100-Year Recurrence Interval Storm Event	
		Description	Hydraulic Capacity (cfs)	Existing Conditions	Planned Conditions	Existing Land Use	Planned Land Use	Existing Land Use	Planned Land Use
ETSC 1-4[a]	--b	21-inch by 35-inch corrugated metal pipe arch	9	--b	--b	35	85	160	230
ETSC 3-0	2.6	27-inch-diameter concrete pipe	23	Single-family residential	Industrial	11	15	16	21
ETSC 3-2[a]	--b	2-foot-deep open channel with a bottom width of 3 feet and side slopes of 1 on 2	106	--b	--b	11	15	16	21
ETSC 1-6	12.7	1-foot-deep open channel with a bottom width of 4 feet and side slopes of 1 on 2	19	Agriculture and other open lands	Single-family residential	40	63	180	260
ETSC 12-0	19.3	1-foot-deep open channel with a bottom width of 2 feet and side slopes of 1 on 2	7	Agriculture and other open lands	Multi-family residential	23	33	51	73
ETSC 5-0	6.5	1-foot-deep open channel with a bottom width of 1 foot and side slopes of 1 on 2	5	Single-family residential	Single-family residential	9	9	16	16
ETSC 6-0	8.1	1-foot-deep open channel with a bottom width of 3 feet and side slopes of 1 on 2	13	Agriculture and other open lands	Single-family residential	12	12	20	20
ETSC 4-0	27.8	36-inch-diameter concrete pipe	49	Single-family residential	Single-family residential	42	42	69	69
ETSC 4-1	21.6	0.5-foot-deep open channel with a bottom width of 20 feet and side slopes of 1 on 10	22	Agriculture and other open lands and industrial	Multi-family residential	49	49	80	80
ETSC 4-2	--b	33-inch reinforced concrete pipe	54	--b	--b	49	49	80	80
ETSC 1-8	11.4	1-foot-deep open channel with a bottom width of 4 feet and side slopes of 1 on 3	25	Agriculture and other open lands	Agriculture and other open lands	45	66	188	270
ETSC 7-0	30.3	0.5-foot-deep open channel with a bottom width of 20 feet and side slopes of 1 on 3	15	Agriculture and other open lands	Agriculture and other open lands	7	20	19	35
ETSC 7-2	5.5	0.8-foot-deep open channel with a bottom width of 5 feet and side slopes of 2 on 5	12	Agriculture and other open lands	Industrial	10	25	26	50
ETSC 8-0	31.1	1-foot-deep open channel with a bottom width of 3 feet and side slopes of 1 on 2	20	Single-family residential	Single-family residential	17	20	34	40

Table 28 (continued)

Subwatershed and Subbasin or Special Component Identification	Area of Subbasin (acres)	Subbasin Downstream Conveyance Component		Principal Land Use in Subbasin		Peak Stormwater Flow (cfs)			
						10-Year Recurrence Interval Storm Event		100-Year Recurrence Interval Storm Event	
		Description	Hydraulic Capacity (cfs)	Existing Conditions	Planned Conditions	Existing Land Use	Planned Land Use	Existing Land Use	Planned Land Use
ETSC 8-2[a]	--[b]	0.2-foot-deep open channel with a bottom width of 10 feet and side slopes of 1 on 2	2	--[b]	--[b]	17	20	34	40
ETSC 9-0	17.3	1-foot-deep open channel with a bottom width of 3 feet and side slopes of 1 on 3	16	Agriculture and other open lands	Industrial	11	25	24	40
ETSC 9-2[a]	--[b]	18-inch by 24-inch corrugated metal pipe arch	3	--[b]	--[b]	11	25	24	40
ETSC 9-4	4.2	2-foot-deep open channel with a bottom width of 4 feet and side slopes of 2 on 5	17	Agriculture and other open lands	Industrial	15	30	28	45
ETSC 10-0	22.8	1-foot-deep open channel with a bottom width of 3 feet and side slopes of 1 on 3	18	Agriculture and other open lands	Industrial	12	26	27	48
ETSC 10-2[a]	--[b]	Two 24-inch by 36-inch corrugated metal pipe arches	24	--[b]	--[b]	12	26	27	48
ETSC 11-0	2.1	1-foot-deep open channel with a bottom width of 3 feet and side slopes of 1 on 3	16	Agriculture and other open lands	Industrial	3	6	5	10
ETSC 10-4	8.9	1.5-foot-deep open channel with a bottom width of 14 feet and side slopes of 1 on 5	138	Agriculture and other open lands	Industrial	15	30	23	50
ETSC 10-6[a]	--[b]	12-inch-diameter corrugated metal pipe detention basin outfall	1	--[b]	--[b]	15	45	23	75
ETSC 9-6[a]	--[b]	18-inch by 24-inch corrugated metal pipe arch	6	--[b]	--[b]	16	31	30	50
ETSC 9-8	4.1	0.5-foot-deep open channel with a bottom width of 6 feet and side slopes of 1 on 20	7	Industrial	Industrial	17	32	32	55
ETSC 9-10[a]	--[b]	18-inch by 24-inch corrugated metal pipe arch	13	--[b]	--[b]	17	32	32	55

Table 28 (continued)

Subwatershed and Subbasin or Special Component Identification	Area of Subbasin (acres)	Subbasin Downstream Conveyance Component		Principal Land Use in Subbasin		Peak Stormwater Flow (cfs)			
						10-Year Recurrence Interval Storm Event		100-Year Recurrence Interval Storm Event	
		Description	Hydraulic Capacity (cfs)	Existing Conditions	Planned Conditions	Existing Land Use	Planned Land Use	Existing Land Use	Planned Land Use
Willow Springs Creek									
WSC 1-0	466.0	1-foot-deep open channel with a bottom width of 2 feet and side slopes of 1 on 3	7.7	Agriculture and other open lands	Residential, agricultural, and other open lands	17	17	26	26
WSC 1-1	--b	60-inch-diameter corrugated metal pipe	44.9	--b	--b	17	17	26	26
WSC 2-0	180.0	1-foot-deep open channel with a bottom width of 3 feet and side slopes of 1 on 5	15.4	Residential and other open lands	Residential and other open lands	10	15	12	19
WSC 1-2	71.0	1.5-foot-deep open channel with a bottom width of 3 feet and side slopes of 1 on 4	38.3	Agriculture and other open lands	Residential and other open lands	21	32	31	43
WSC 1-3	--b	48-inch-diameter corrugated metal pipe	55.4	--b	--b	21	32	31	43
WSC 3-0	83.0	2-foot-deep open channel with a bottom width of 2 feet and side slopes of 1 on 3	66.9	Residential and other open lands	Residential and other open lands	8	15	12	22
WSC 3-1	--b	21-inch-diameter corrugated metal pipe	6.1	--b	--b	8	15	12	22
WSC 1-4	129.0	2-foot-deep open channel with a bottom width of 4 feet and side slopes of 1 on 4	7.37	Open land	Residential and other open lands	28	56	38	69
WSC 7-0	93.0	1-foot-deep open channel with a bottom width of 2 feet and side slopes of 1 on 4	15.8	Open land	Light industrial	20	31	30	45
WSC 7-1	--b	32-inch by 57-inch corrugated metal pipe arch	55.4	--b	--b	20	31	30	45
WSC 8-0	136.0	1-foot-deep open channel with a bottom width of 5 feet and side slopes of 1 on 5	23.9	Institutional	Institutional	5	5	11	11
WSC 9-0	149.0	--e	--e	Agricultural, institutional, and light industrial	Agricultural, institutional, and light industrial	--e	--e	--e	--e

NOTE: Information on the Main Stem, East Branch and South Branch of Sussex Creek, and Willow Springs Creek was obtained from SEWRPC Community Assistance Planning Report No. 11, Floodland Information Report for Sussex Creek and Willow Springs Creek. More detailed information for subbasins tributary to the main stem stream reaches was obtained by utilizing the Illudas stormwater management model and the Rational method.

[a] Designation used for special component which is immediately downstream of subbasin. There is no additional subbasin area associated with this designation.

[b] No area or land use is noted since designation is for a special component rather than for a subbasin.

[c] No defined surface water drainage system.

[d] Agricultural drainage system without a defined surface water drainage system.

[e] The subbasin is internally drained.

Source: SEWRPC.

courses of the major stormwater management system were calculated as part of the evaluation of the existing system.

Peak rates of stormwater runoff, as determined by the hydrologic and hydraulic characteristics of each catchment area, were estimated utilizing the methods described in Chapter V of this report. The estimated peak rates of stormwater runoff at the outlets of each subbasin for the 10-year and 100-year recurrence interval storm events, where appropriate, also are set forth in Table 28. Peak rates of flow also were estimated for catchment areas within subbasins in order to determine the hydraulic loading, where appropriate, on each segment of the storm sewer and drainage channel. Where these stormwater flows exceed the capacities of the conveyance facilities, surface ponding, flooding, and surcharging of upstream or downstream drainage facilities may be expected to occur.

Identified Problem Areas

The calculated capacity of each of the components of the existing drainage system was compared to the anticipated stormwater flow rates to identify those areas where problems may be expected under design storm conditions. As already noted, the evaluation considered the capacity of the minor system components in relation to the stormwater flows and volumes generated by a 10-year recurrence interval rainfall event; and the capacity of the major system components in relation to the stormwater flows and volumes generated by a 100-year recurrence interval rainfall event. In identifying existing and potential problems in the existing system, consideration was given to the potential impact of excessive flows. In some cases problems were not created even though the capacity of the system component was exceeded if the areas inundated were undeveloped and no buildings, transportation facilities, or other damage-prone improvements were affected.

Map 17 shows the location of those existing system components which have inadequate hydraulic capacity and attendant problems under existing or planned land use conditions. A brief description of these problems is included in Table 29. The problems identified can be grouped into one of two general types, as follows:

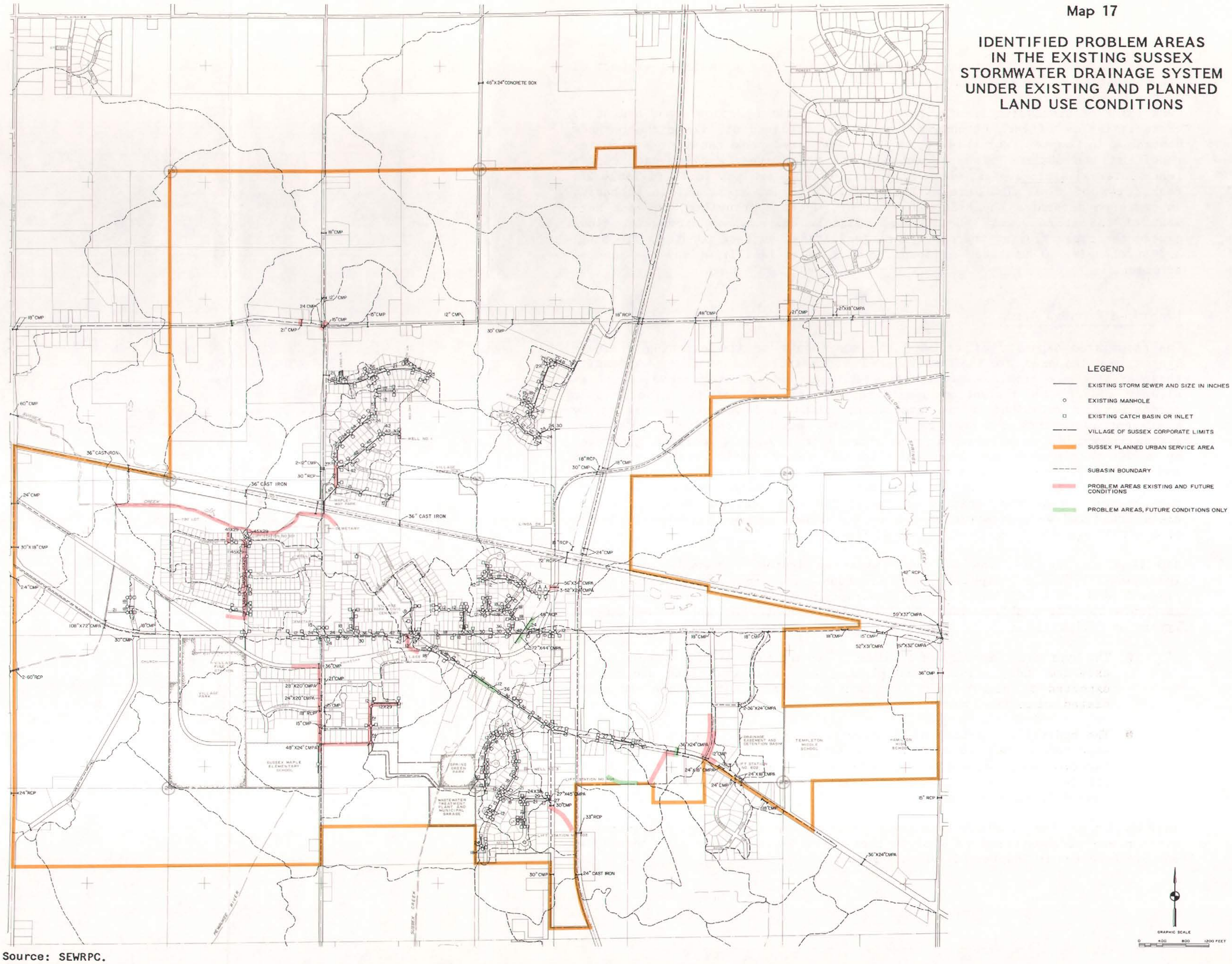
- The hydraulic capacity of a culvert, storm sewer, or open channel is exceeded under existing and planned land use conditions and may be expected to result in the inundation of adjacent streets and associated urban development.

- The hydraulic capacity of a culvert, storm sewer, or channel is not expected to be exceeded under existing land use conditions but is expected to be exceeded under planned land use conditions and may be expected to result in the inundation of adjacent streets and associated urban development.

In addition to the problems associated with inundation, areas of significant erosion and sedimentation related to stormwater drainage were also identified and are reported in Chapter III of this report.

Map 17

IDENTIFIED PROBLEM AREAS IN THE EXISTING SUSSEX STORMWATER DRAINAGE SYSTEM UNDER EXISTING AND PLANNED LAND USE CONDITIONS



Source: SEWRPC.

Table 29

IDENTIFIED PROBLEM AREAS IN THE EXISTING SUSSEX STORMWATER DRAINAGE SYSTEM UNDER EXISTING AND PLANNED LAND USE CONDITIONS

Subwatershed and Subbasin	System Component[a]	Location	Component Description	Land Use Conditions Under Which Problems Are Expected		Problem Description
				Existing Land Use	Planned Land Use	
Pewaukee River Subwatershed PR 1-0	Minor	Locust Street at Main Street	36-inch-diameter corrugated metal pipe	X	X	Hydraulic capacity of the existing pipe is exceeded. Excess stormwater is backed up onto grassed areas adjacent to a shopping center parking lot. The storage capacity of this detention area is approximately 0.8 acre-foot, which should be adequate to store excess stormwater runoff under future conditions without inundating the adjacent commercial area. Accordingly, no corrective measures are required
PR 1-2	Minor	Adjacent to railroad right-of-way upstream from Maple Avenue	2-foot-deep open channel with a bottom width of 2 feet and side slopes of 2 on 3	--	X	Hydraulic capacity of the existing open channel is exceeded. Excess stormwater inundates adjacent residential and commercial land
PR 1-3	Minor	Railroad right-of-way at Maple Avenue	36-inch-diameter corrugated metal pipe	X	X	Hydraulic capacity of the existing open channel and pipe is exceeded. Excess stormwater inundates the parking lot at an adjacent commercial establishment. A portion of the excess stormwater flows over the roadway surface and then south along Maple Street
PR 1-4	Minor	Adjacent to Maple Avenue from railroad right-of-way to Hickory Drive	1.5-foot-deep open channel with a bottom width of 2 feet and side slopes of 3 on 4	X	X	Hydraulic capacity of the existing open channel is exceeded. Excess stormwater inundates the roadway surface and adjacent yards
PR 1-5	Minor	Adjacent to Maple Avenue at Maple Avenue Elementary School	Two 24-inch by 48-inch corrugated metal pipe arches	X	X	Hydraulic capacity of the existing open channel and pipe is exceeded. Excess stormwater inundates the roadway surface, adjacent yards, and the elementary school access road
PR 1-6	Minor	Adjacent to Maple Avenue	2-foot-deep open channel with a bottom width of 2 feet and side slopes of 1 on 2	X	X	Hydraulic capacity of the existing open channel is exceeded. Excess stormwater inundates adjacent residential and institutional land
PR 2-2	Minor	Hickory Lane and Park Court	12-inch-diameter corrugated metal pipe	X	X	Hydraulic capacity of the existing pipe is exceeded. Excess stormwater inundates portions of the Hickory Lane and Park Court roadway surfaces and adjacent yards
PR 2-4	Minor	Between Park Court and Maple Avenue	1.0-foot-deep open channel with a bottom width of 5 feet and side slopes of 1 on 2	X	X	Hydraulic capacity of the existing open channel is exceeded. This drainage channel does not have sufficient slope to adequately convey stormwater

Table 29 (continued)

Subwatershed and Subbasin	System Component[a]	Location	Component Description	Land Use Conditions Under Which Problems Are Expected: Existing Land Use	Planned Land Use	Problem Description
PR 2-6	Minor	Culvert crossing Maple Avenue south of Sumac Lane	28-inch by 42-inch corrugated metal pipe arch	X	X	Hydraulic capacity of the existing pipe is exceeded
Main Branch Sussex Creek West Agricultural Area SCWA 1-8	Major	Main stem of Sussex Creek north of Sussex Estates Subdivision	5.0-foot-deep open channel with a bottom width of 10 feet and side slopes of 1 on 2	X	X	Hydraulic capacity of the existing open channel is exceeded owing to insufficient slope
Main Branch Sussex Creek North Agricultural Area SCNA 5-1	Minor	Culvert crossing Good Hope Road 400 feet west of Maple Avenue	24-inch-diameter corrugated metal pipe	X	X	Hydraulic capacity of the existing pipe is exceeded
SCNA 7-1	Minor	Culvert crossing Good Hope Road and Maple Avenue	15-inch-diameter corrugated metal pipe	X	X	Hydraulic capacity of the existing pipe is exceeded
SCNA 8-3	Minor	Culvert crossing Maple Avenue 100 feet north of Prides Road	25 inches high by 48 inches wide concrete box culvert	--	X	Hydraulic capacity of box culvert is exceeded. Excess stormwater inundates Maple Avenue right-of-way and adjacent residential land
SCNA 10-1	Minor	Culvert crossing Good Hope Road 1,700 feet west of Maple Avenue	24-inch-diameter corrugated metal pipe	--	X	Hydraulic capacity of the existing pipe is exceeded
Main Branch Sussex Creek Mid-town Area SCMT 1-20	Major	Main stem of Sussex Creek north of Sussex Estates Subdivision	5.0-foot-deep channel with a bottom width of 10 feet and side slopes of 1 on 3	--	X	Hydraulic capacity of the existing open channel is exceeded
SCMT 11-0	Minor	Storm sewer segment in Westhaven Road extended at Champeny Road	21-inch-diameter concrete pipe	X	X	Hydraulic capacity of the existing pipe is exceeded. Excess stormwater inundates the roadway surface and adjacent yards
SCMT-12-0	Minor	Storm sewer segment in Locust Street	38-inch by 24-inch corrugated metal pipe arch	X	X	Hydraulic capacity of the existing pipe is exceeded. Excess stormwater inundates the roadway surface and adjacent yards

Table 29 (continued)

Subwatershed and Subbasin	System Component[a]	Location	Component Description	Land Use Conditions Under Which Problems Are Expected: Existing Land Use	Land Use Conditions Under Which Problems Are Expected: Planned Land Use	Problem Description
SCMT 12-2	Minor	Storm sewer segment in Locust Street	45-inch by 29-inch corrugated metal pipe arch	X	X	Hydraulic capacity of the existing pipe is exceeded. Excess stormwater inundates the roadway surface and adjacent yards
SCMT 14-4	Minor	Storm sewer segment in Michell Lane north of Linda Drive	42-inch-diameter concrete pipe			Hydraulic capacity of the existing pipe is exceeded. However, the sewer segment is about 8 feet deep, allowing additional static head during surcharge to improve the flow capacity
SCMT 22-0	Minor	Storm sewer segment in Silver Spring Drive running southeast from a point 400 feet northwest of Sussex Creek	12-inch-diameter concrete pipe	--	X	Hydraulic capacity of the existing pipe is exceeded
Sussex Creek East Branch SCEB 24-11	Major	Culvert crossing abandoned railway right-of-way and Waukesha Avenue at Elm Drive	56-inch by 34-inch corrugated metal pipe arch	X	X	Hydraulic capacity of the existing pipe is exceeded. Excess stormwater flows over the Waukesha Avenue roadway surface
SCEB 24-16	Major	Northern segment of a culvert crossing Main Street 500 feet west of Waukesha Avenue	48-inch-diameter concrete pipe	--	X	Hydraulic capacity of the existing pipe is exceeded. Excess stormwater inundates a lowland area between pipe inlet and Elm Drive. Water also bypasses the 48-inch pipe by running across Main Street in the abandoned railway right-of-way
SCEB 24-18	Major	Southern segment of a culvert crossing Main Street 500 feet west of Waukesha Avenue	44-inch by 72-inch corrugated metal pipe arch	--	X	Hydraulic capacity of the existing pipe is exceeded; however, because of the restricted flow at the upstream end of the culvert, the capacity at this point will not be exceeded until the upstream culvert is improved
East Tributary to Sussex Creek ETSC 4-1	Minor	Drainage channel east of Spring Green Heights Subdivision	0.5-foot-deep open channel with a bottom width of 20 feet and side slopes of 1 on 10	X	X	Hydraulic capacity of the existing open channel is exceeded owing to insufficient slope
ETSC 9-0	Minor	Drainage channel parallel to Sussex Road	1.0-foot-deep open channel with a bottom width of 3 feet and side slopes of 1 on 3	--	X	Hydraulic capacity of the existing open channel is exceeded owing to insufficient slope

Table 29 (continued)

Subwatershed and Subbasin	System Component[a]	Location	Component Description	Land Use Conditions Under Which Problems Are Expected		Problem Description
				Existing Land Use	Planned Land Use	
ETSC 1-4	Minor	Culvert crossing Silver Spring Road 600 feet west of Sussex Road	21-inch by 35-inch corrugated metal pipe arch	--	X	Hydraulic capacity of the existing corrugated metal pipe arch is exceeded. This culvert segment is in need of repair. Excess stormwater inundates land upstream of culvert
ETSC 1-6	Minor	Drainage channel south of Silver Spring Drive from structure ETSC 1-4	The channel is a fully cultivated drainage swale	X	X	Any appreciable amount of surface water runoff would cause inundation of agricultural land
ETSC 12-0	Minor	Drainage channel south of Silver Spring Drive and east of Soo Line railway tracks	1.0-foot-deep open channel with a bottom width of 2 feet and side slopes of 1 on 2	--	X	Hydraulic capacity of the existing open channel is exceeded causing inundation of adjacent agricultural land
ETSC 9-10	Minor	Culvert crossing Silver Spring Road south of Sussex Road	18-inch by 24-inch corrugated metal pipe arch	--	X	Hydraulic capacity of box culvert is exceeded. Excess stormwater inundates adjacent industrial parking lot

[a] Anticipated exceedance of the hydraulic capacity of the system structures is based on calculated stormwater flows during a 10-year recurrence storm event for the minor system components and a 100-year recurrence interval storm event for the major system components.

Source: SEWRPC.

DESCRIPTION AND EVALUATION OF ALTERNATIVE STORMWATER MANAGEMENT APPROACHES

Introduction

As indicated in Chapter IV of this report, urban land use within the Sussex planned urban service area may be expected to almost triple between 1980 and the year 2000. Urban land use in the entire study area is expected to almost double over the same time period. This urbanization may be expected to produce an increase in the peak rate of stormwater runoff and in the volume of runoff for a given storm event. Stormwater runoff from urban land also contains different types--and, in some cases, increased amounts--of pollutants compared to stormwater runoff from undeveloped land. The potential urbanization, accordingly, may be expected to place increased demands on the existing stormwater management system, requiring additional engineered drainage facilities to accommodate the increased flows. These facilities are designed to minimize the occurrence of stormwater management problem areas and the associated disruption of the urban environment and adverse water quality impacts.

To accommodate these increased flows and to abate existing, as well as potential, future stormwater management problems, several stormwater management approaches were considered. These alternative approaches to stormwater management were first evaluated on a conceptual basis, considering the technical feasibility, applicability, and advantages and disadvantages of each alternative approach. Elements of the most feasible approaches were then incorporated into three systems level alternative stormwater management plans for the Village of Sussex urban service area as described later in this chapter.

Alternative Stormwater Management Approaches

Alternative approaches to stormwater management which have been considered for application in the Sussex planned urban service area include conventional conveyance, centralized detention, onsite detention, centralized retention, open channels, and nonstructural measures. Pertinent characteristics of each of the alternative approaches are set forth in Table 30. Based upon consideration of these characteristics, the general feasibility and applicability of each approach to the Sussex urban service area was determined.

Conveyance: The conveyance approach would utilize storm sewers and concrete-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. The major advantages of this type of system are that the onsite inconvenience is minimized because the water is rapidly collected and conveyed downstream; and the approach is readily applicable to both existing and newly developing urban areas. Storm sewers represent only a minimal hazard to the public health and safety, and the hydraulic design procedures, as well as the construction techniques, are simple, well developed, and commonly used. The disadvantages of the conveyance approach are that downstream peak flows and areas of inundation may be increased, pollutants are not removed from the runoff, and there is little potential for multipurpose uses of the system.

Table 30

CHARACTERISTICS OF ALTERNATIVE STORMWATER MANAGEMENT APPROACHES

Characteristic		Conveyance	Centralized Detention	Onsite Detention	Retention	Open Natural Channels	Nonstructural
Function		● Provide for the collection of stormwater runoff and the rapid conveyance of stormwater from the area so as to minimize disruptive and possibly damaging surface ponding in streets and low-lying areas and possible inundation of residential and other sites and structures	● Provide for the temporary storage of stormwater runoff in the service area for subsequent slow release to downstream channels or storm sewers, thus minimizing disruption and damage within and downstream of the service area and reducing the required size and therefore cost of any constructed downstream conveyance facilities	● Provide for the temporary storage of stormwater runoff at small sites located close to the source of generation of the runoff to be controlled	● Provide for the storage of stormwater runoff for subsequent evaporation, infiltration to the groundwater table, and/or slow release to downstream conveyance facilities, while maintaining a minimum pool of water at almost all times	● Provide for the temporary storage and/or conveyance of stormwater runoff using natural or vegetated channels which slow the runoff rate and allow a portion of the runoff to infiltrate into the soil	● Primarily to reduce damages from excessive stormwater runoff and flooding, rather than controlling the runoff rates or flood levels themselves
Components	Principal	● Improved open drainage channels and storm sewers	● Surface or subsurface detention facilities	● Parking lot storage facilities ● Rooftop storage facilities ● Infiltration systems ● Relatively small detention facilities ● Swales, over-sized channels, and diversions	● Surface retention facilities	● Open vegetated channels and canals ● Swales ● Natural surface depressions and wetlands	● Floodproofing of structures ● Relocation of structures ● Land use regulations ● Open space and floodland preservation
	Secondary	● Inlets and catch basins ● Culverts ● Outfalls ● Manholes	● Open drainage channels ● Inlets and catch basins ● Culverts ● Outfalls ● Manholes ● Inlet and outlet works and/or pumping facilities	● Same as centralized detention	● Same as centralized detention	● An open channel system may be supplemented with storm sewers, inlets, catch basins, outfalls, manholes, and culverts	● Can be used with other stormwater management facilities
Applicability		● Suitable for installation in existing and newly developing urban areas	● Most suitable for incorporation in newly developing urban areas if suitable surface or subsurface sites are available	● Suitable for installation in existing and newly developing urban areas. May be more suitable than centralized detention in many existing urban areas due to reduced site requirements	● Most suitable for incorporation in newly developing urban areas but may be used in existing urban areas if suitable surface sites are available	● Suitable for incorporation in newly developing urban areas. Open channels may be undesirable in moderate- or high-density urban development and it may be difficult to develop an economically feasible open channel system which can accommodate the high peak flows from developed urban areas	● Suitable for implementation in existing and newly developing urban areas
Downstream Impact	Quantity	● Tends to significantly increase--relative to predevelopment conditions--downstream discharges, stages, and areas of inundation	● May be designed to cause no significant increase, relative to predevelopment conditions, in downstream discharges, stages, and areas of inundation. Decreased discharges, stages, and areas of inundation are possible	● Same as centralized detention, although onsite detention facilities are frequently designed for smaller storms and shorter detention times than are centralized detention facilities	● Same as centralized detention	● May be designed to allow storm runoff to be temporarily stored in a low gradient channel, allowing the water to evaporate and infiltrate into the soil reducing downstream discharges, volumes, and peak flows	● Minimal impact although preservation of open space lands may maintain higher levels of natural storage and infiltration than if these lands were developed
	Quality	● Transmits suspended solids and other pollutants to downstream areas without removal	● Provides for removal, by the natural settling process, of sediment and other suspended material, thus reducing the pollutant loading on receiving waters. Provides an opportunity for physical-chemical treatment such as disinfection, coagulation-flocculation, and swirl concentration	● Provides some pollutant removal, but may be less than by centralized detention if detention time is shorter. Less opportunity for physical-chemical treatment than with centralized facilities	● Same as centralized detention, although retention facilities may provide even greater water quality benefits if detention time is significantly longer for a major portion of the runoff	● Provides for removal of pollutants in storm runoff by infiltration into the soil, settling of solids, and filtration by vegetation	● Minimal impact
Multipurpose Capability		● Storm sewers serve only a stormwater collection and conveyance function ● Open drainage channels can provide a basis for development of linear park and open space areas	● Quantity control ● Quality control ● Can provide park and open space areas	● Same as centralized detention	● Quantity control ● Quality control ● Recreation benefits ● Aesthetic benefits ● Groundwater Recharge ● Wildlife Habitat	● Quantity control ● Quality control ● Park and open space areas	● Park and open space areas
Operation and Maintenance Requirements		● Periodic cleaning and repair of catch basins, inlets, channels, and storm sewers required ● Maintenance of open channel lining material required	● Pumping and/or inlet-outlet control operation and maintenance required ● Insect and odor control required ● Periodic cleaning and maintenance of facility lining required ● Dam maintenance required	● Same as centralized detention except that maintenance of onsite facilities may be less intensive but required at a larger number of sites	● Pumping and/or inlet-outlet control required ● Operation and maintenance required ● Sediment removal required ● Insect control required ● Weed and algae control and water pollution control required ● Bank maintenance required ● Dam maintenance required	● Periodic cleaning of channels and inlets required ● Maintenance of open channel vegetative cover required	● Minimal
Impact on Sanitary Sewer System		● Surcharging of storm sewers accompanied by inundation of streets may result in infiltration of stormwater from storm sewers to adjacent sanitary sewers and inflow of stormwater into sanitary sewers through manholes. Flow in excess of stormwater channel capacity may also result in surface inundation and inflow to sanitary sewers	● Runoff volumes in excess of available storage volume and runoff rates in excess of the capacity of tributary storm sewers and channels accompanied by inundation of streets may result in infiltration of stormwater from storm sewers to adjacent sanitary sewers and inflow of stormwater into sanitary sewers through manholes	● Same as centralized detention	● Same as centralized detention	● Exceedance of channel capacity accompanied by inundation of streets may result in infiltration of stormwater into adjacent sanitary sewers and inflow of stormwater in sanitary sewers through manholes	● Minimal
Hazards		● Minimal hazard associated with storm sewers ● High velocities in improved open channels may pose a safety hazard, particularly to children	● Minimal hazard associated with subsurface storage but surface storage may pose a health and safety hazard, particularly to children	● Ponded water in parking lots, small detention facilities, and swales may pose a health and safety hazard, particularly to children	● Retained water may pose a health and safety hazard, particularly to children	● Flowing channels may pose a safety hazard, particularly to children	● Minimal
Hydrologic-Hydraulic Analysis and Design Procedure		● Requires determination only of the peak rate of flow associated with a specified recurrence interval. This is normally obtained with the relatively simple and widely accepted rational method	● Requires determination of both a peak rate and a volume of inflow associated with a specified recurrence interval and an estimate of allowable outflow rate and design of pumps or control works to satisfy the discharge conditions. A hydrograph-developing technique, such as the ILLUDAS model, must be used to simulate peak flow and volume conditions	● Same as centralized detention	● Same as centralized detention	● Requires determination of peak rate of flow, flow volumes, flow velocity, and flow depths. This can be obtained by using the rational method and Manning's equation, or by using a hydrograph-developing technique such as the ILLUDAS model	● Requires delineation of areas affected by flooding and poor stormwater drainage. A technique such as the Hydrologic Engineering Center (HEC-2) model may be used to determine flood stages under various recurrence interval storm events
Ability to Meet Stormwater Management Objectives and Supporting Standards		● All objectives and supporting standards can be met	● All objectives and supporting standards can be met	● All objectives and supporting standards can be met	● All objectives and supporting standards can be met	● Some objectives and supporting standards would probably not be met because of the difficulty of this approach to accommodate the design flows efficiently and economically	● This alternative approach would not satisfy the recommended objectives and supporting standards by itself, and must be combined with other alternative approaches

Source: SEWRPC.

Since most of the developed portion of the Village of Sussex currently relies on an engineered storm sewerage system, further application of the conveyance approach would represent a continuation of the existing practices and policies. Hence, this approach would likely be understood and well accepted by local public officials and citizens alike. Technically, the existing stormwater problems experienced by the Village, as well as probable future problems, could be abated using the conveyance approach. However, there would be some concern about the downstream impacts of the conveyance system. Given the advantages of the conveyance approach, it was utilized in the development of alternative stormwater management system plans for the Sussex area.

Centralized Detention: A centralized detention approach would utilize major surface or subsurface detention facilities or basins to provide for the temporary storage of stormwater runoff for subsequent slow release to downstream channels or storm sewers. The centralized detention facilities would be located on a few strategic sites to maximize benefits, and not all areas would drain to a centralized facility. The centralized detention facilities can be supplemented by improved conveyance facilities as may be necessary.

The major advantages of a centralized detention approach are that if properly applied, the facilities can limit the effects of urban development on downstream discharges and areas of inundation; sediment and other particulate pollutants are removed; the size and resultant cost of downstream conveyance facilities can be reduced; and the facilities can provide multipurpose uses such as recreation and open space. The disadvantages of a centralized detention approach are that site requirements are frequently large, thereby reducing the availability of adequate potential sites; the facility may be expensive if these costs cannot be offset by providing smaller conveyance facilities downstream; the operation and maintenance requirements may be substantial; the ponded water may represent a public health and safety hazard; odor problems and insect nuisances could potentially be produced; and the hydraulic design techniques and analytic procedures are more involved than those for conventional storm sewerage systems. 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 Sussex planned urban service area, centralized detention facilities could be used to abate some of the existing and potential stormwater runoff problems. High initial costs, maintenance requirements, and an opposition to ponded water in urban areas by some citizens for aesthetic or health and safety reasons may make this approach unacceptable on a large scale in the service area. However, because of its potential benefits, the centralized detention approach was utilized in the development of alternative stormwater management plans for the Sussex area.

Onsite Detention: Like centralized detention, onsite detention also provides for the temporary storage of stormwater runoff, but the storage sites are located close to, or at, the source of runoff generation. Hence, these detention sites tend to be smaller than centralized detention facilities. Onsite detention measures include parking lot storage, infiltration systems, swales, and large channels with gentle slopes. To a limited extent, onsite detention is included in all alternative approaches to stormwater management in the Sussex area because the adopted land use plan recommends the preservation of the remaining floodlands, wetlands and other natural open areas, all of which effectively serve as onsite detention areas. The onsite detention systems, like centralized detention systems, can also be supplemented by improved conveyance facilities.

The advantages of the onsite detention approach are similar to the centralized detention approach with regard to water quantity and quality control downstream, and to the potential for reducing the size requirements for downstream conveyance systems. However, onsite facilities have smaller unit site requirements, thereby being more readily applicable--although not without difficulty--in existing as well as newly developing urban areas. Onsite facilities may be less suitable for multipurpose uses such as recreation and open space, but more suitable for other uses such as parking or yard space in residential areas. Disadvantages of the onsite detention approach are that maintenance requirements may be substantial, although probably less intensive than for centralized facilities; the ponded water may cause localized inconvenience and represent a health and safety hazard; odor problems and insect nuisances may be produced; hydraulic design techniques are more involved than for conveyance systems; and the costs may be high if not offset by smaller downstream conveyance systems. While readily applicable as an integral part of large-scale, urban development proposals, the concept is more difficult to effectively implement with small-scale, piecemeal development proposals and in areas of existing urban development.

The onsite detention approach could be used to abate the existing and potential stormwater runoff problems in the planning area. Although there may be some citizen opposition to ponded water in urban areas, the smaller affected sites and greater availability of potential sites may make this approach more acceptable than the centralized approach. Because of its potential benefits, the onsite detention approach was utilized in the development of alternative stormwater management plans for the Sussex area.

Retention: Retention facilities provide for the storage of stormwater runoff for subsequent evaporation, infiltration, and/or slow release to downstream waterways while maintaining a permanent pool in the facility. This approach can also be supplemented by improved conveyance facilities.

The advantages of the retention approach are similar to those of the detention approach for control of downstream water quantity and quality and for the reduced size requirements for downstream conveyance systems. An additional benefit of the retention approach is that multiple purposes, such as recreational use, aesthetic enhancement, and groundwater recharge, can be served. The disadvantages of the retention approach are that the facilities are relatively expensive, maintenance requirements are substantial, and the water quality of the permanent pool may be poor due to the generally highly polluted nature of urban runoff. Due to the large site requirements, the approach is generally suitable only in newly developing urban areas. The permanently ponded water may present a potential health and safety hazard, and the hydraulic design and construction techniques are more involved than for conveyance systems.

While retention facilities could be utilized to abate some of the existing and potential stormwater management problems in the Sussex urban service area, there has been no demonstrated need or desire for the additional multipurpose use benefits which a retention facility provides. Accordingly, given the generally higher cost and maintenance requirements of a retention facility compared to a detention facility, retention facilities were not considered further in the development of alternative stormwater management plans for the Sussex area.

Open Channels: An open channel stormwater management system consists of vegetation-lined channels 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 infiltration. The drainage system of an area may consist entirely of open channels, or it may be supplemented by other management measures including storm sewers.

The advantages of an open channel approach are that downstream peak flows may be reduced; pollutants in storm runoff may be removed by filtration through the soil and vegetation and by sedimentation; the open channels and related drainage areas can serve as part of park and open space sites; construction costs may be lower; and the aesthetic qualities of a "natural" drainage system may be attractive to some citizens. The disadvantages of an open channel approach are that it may not be economically feasible to develop an open channel system which can effectively accommodate the high peak flows generated from medium- and high-density urban areas; the channels generally are difficult to incorporate into existing urban areas served by storm sewers; the flowing channels may pose a safety hazard; such systems often are not properly cleaned and maintained by the responsible authorities; and some citizens and local public officials may not desire open channel flow in urban areas.

Limited utilization of this alternative approach was made in the design of stormwater management plans for the Sussex area. Under this limited approach, open, turf-lined channels and related system components were used but only in conjunction with other alternative approaches.

Nonstructural Measures: The nonstructural approach to stormwater management primarily involves reducing damages from excessive stormwater runoff and inundation rather than controlling the runoff rates or inundation levels themselves. Nonstructural measures include structure floodproofing, relocation of structures, land use regulations, and open space and floodland preservation. The nonstructural approach is not in itself an alternative in that in medium- and high-density urban areas the existing and potential stormwater management problems cannot be abated by nonstructural measures alone, although the impact of these problems may be reduced. Hence, nonstructural measures are usually considered only in combination with the other alternative approaches described above.

The advantages of the nonstructural approach are that the measures are suitable for use in existing as well as newly developing urban areas; the measures are highly flexible and adaptable to different situations; the cost of nonstructural measures is generally 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 and quality is generally not controlled; most stormwater problems are not abated; land condemnation may be necessary; and some measures may benefit only a relatively few individuals.

Because of its applicability under a wide array of situations, the nonstructural approach was utilized in the design of alternative stormwater management plans for the Sussex area but only in conjunction with other alternative approaches.

ALTERNATIVE STORMWATER MANAGEMENT PLANS

Utilizing the alternative stormwater management approaches, as described above, three alternative stormwater management plans were developed for the Sussex area. These three alternative stormwater management plans were: 1) a conveyance plan; 2) a centralized detention plan; and 3) an onsite detention plan. Elements of the open channel approach and the nonstructural approach were incorporated into each of these three alternative plans as applicable. Retention basins were not considered in the preparation of any of the alternative plans.

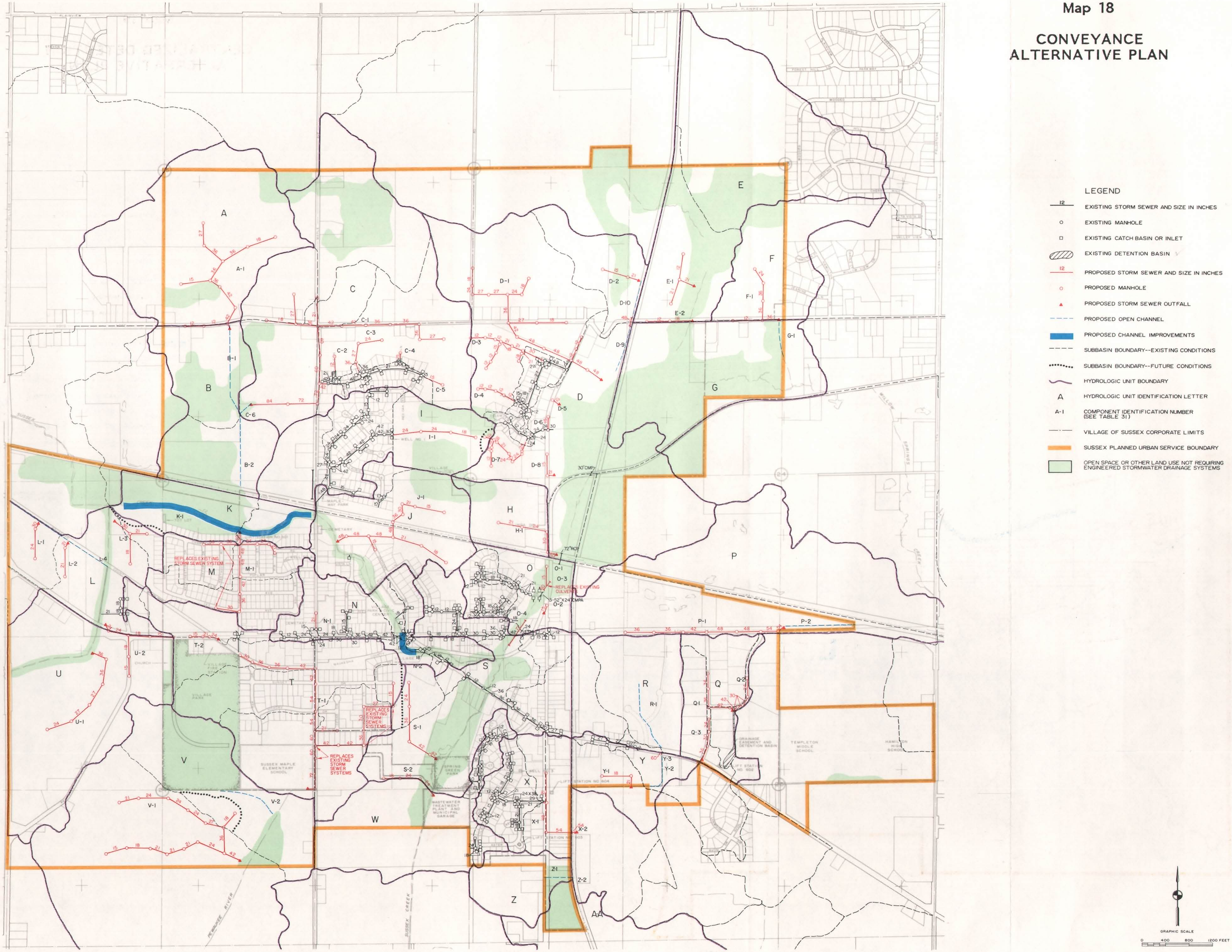
In the alternative plan development and evaluation stage of the work, only the minor system components of the total stormwater management system and certain components of the minor system including storm sewers, drainage channels and related culverts, and detention facilities were considered. In some cases, the water courses of the major system were also considered when the design of the minor system was directly influenced by the outlet control at the major system water course or where the major system water course is influenced by the location of a proposed detention facility. In areas with existing urban street patterns, or in areas with planned urban street patterns, the alternative plans included a complete system of these minor system components. In areas planned to be developed for urban use, but for which no street layout had yet been established, only the major components such as trunk storm sewers, drainage channels, and centralized and onsite detention facilities could be considered. Smaller collector storm sewers and some onsite storage systems could be only generally considered. Roadway ditches, curbs and gutters, and inlets were considered only in a generalized manner in the development and evaluation of the alternative system plans. However, these details of the minor system, together with the major system, were specifically considered in the design and evaluation of the recommended plan.

For purposes of comparing and evaluating the alternative plans, the Sussex urban service area was divided into 27 hydrologic units. Each hydrologic unit is comprised of two or more subbasins tributary to the same conveyance system component, or to a detention facility and its associated downstream conveyance system. A description of individual components and the estimated costs is presented for each hydrologic unit under each alternative plan. The hydrologic unit boundaries are shown on Maps 18, 19, and 20.

The three alternative plans were all designed to serve the Sussex planned urban service area. Stormwater management facilities for areas outside that area but within the study area were not specifically considered in the alternative plan

Map 18

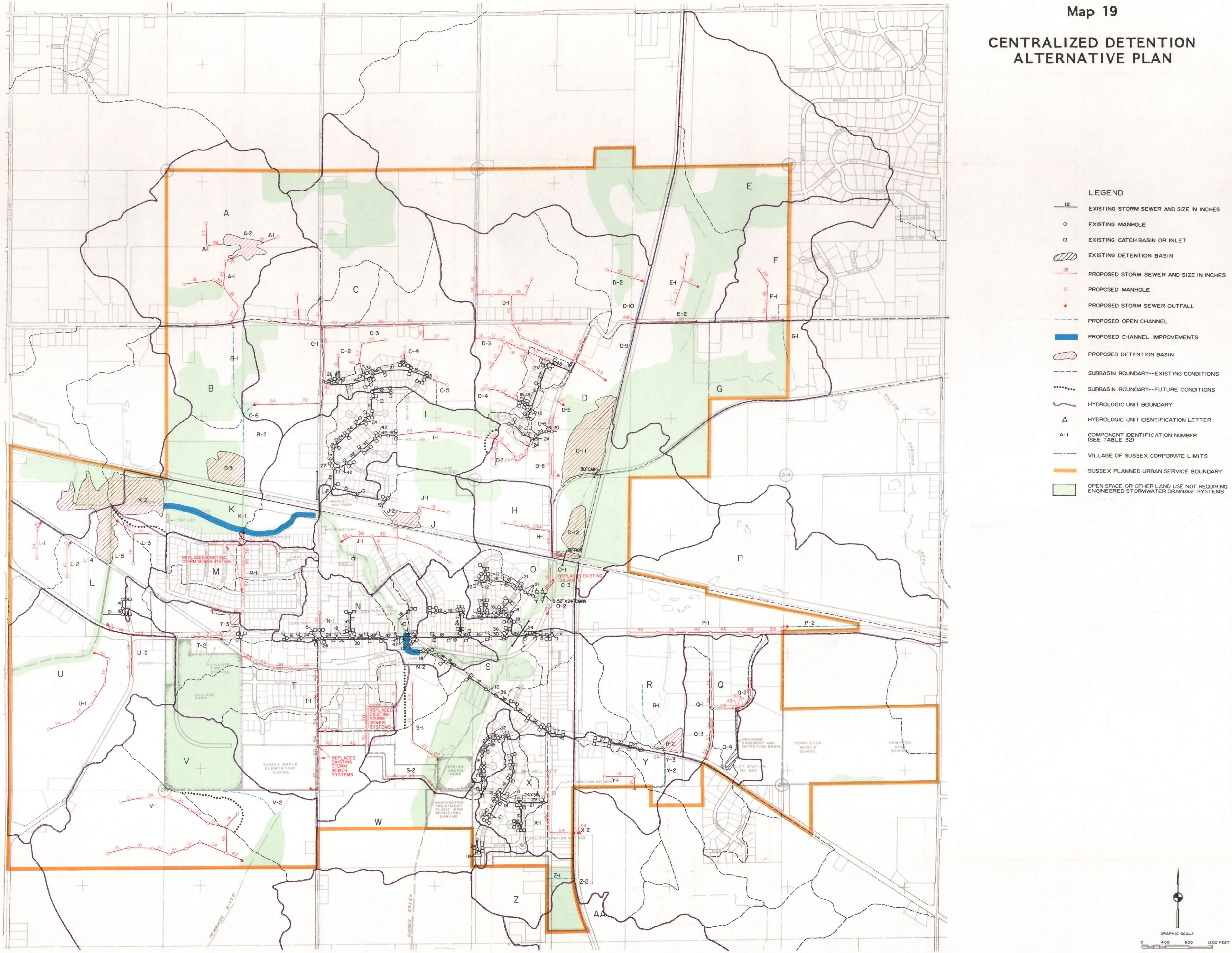
CONVEYANCE ALTERNATIVE PLAN



Source: SEWRPC.

Map 19

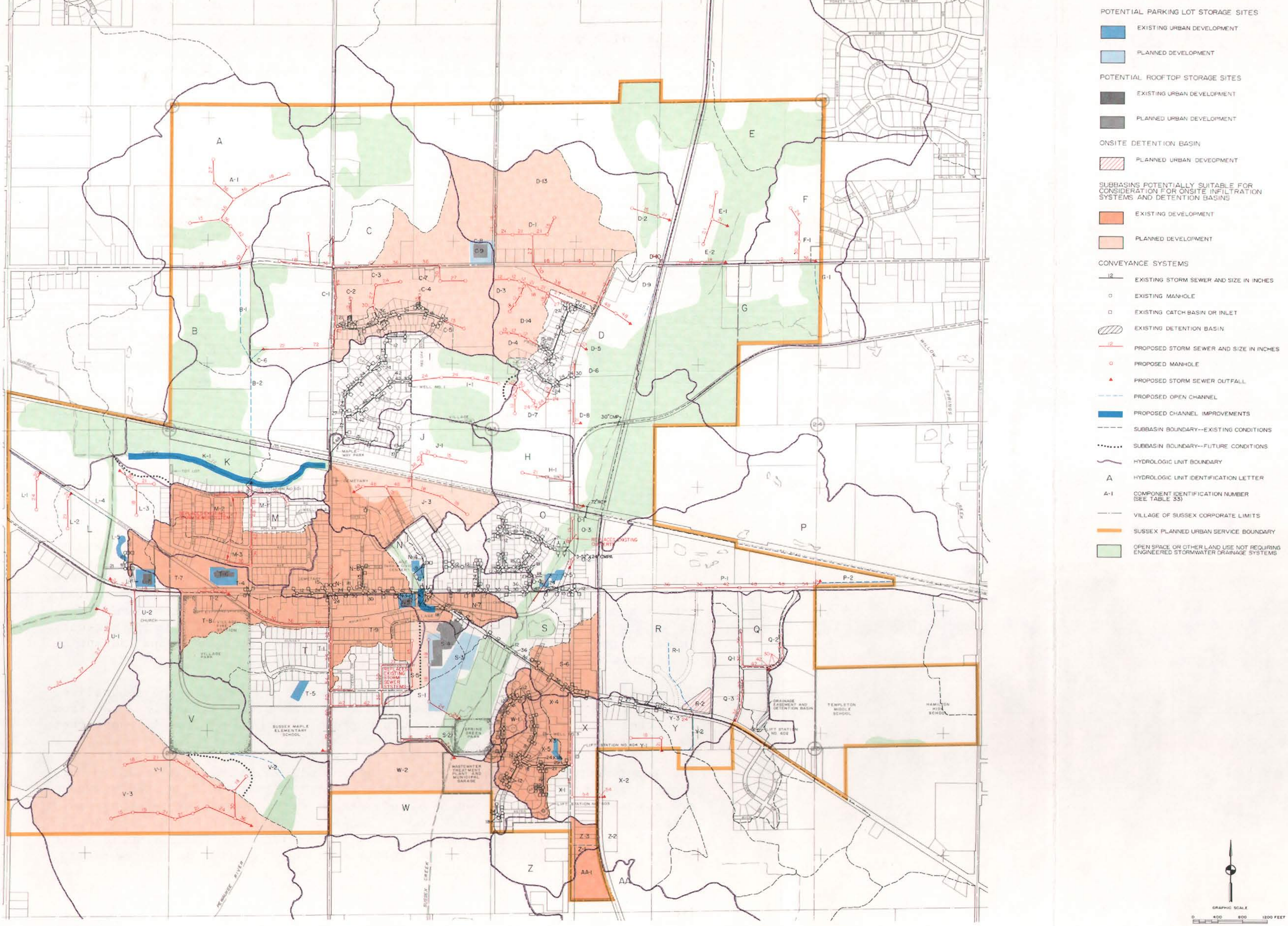
CENTRALIZED DETENTION ALTERNATIVE PLAN



Source: SEWRPC.

Map 20

ONSITE DETENTION ALTERNATIVE PLAN



Source: SEWRPC.

development and evaluation stage except that the anticipated peak flow rates generated under each alternative at the locations where stormwater flows out of the urban service area were an important consideration in the evaluation of alternative plans. An in-depth analysis of, and recommendations relating to, the impacts of the recommended stormwater management plan for the Sussex urban service area on the areas outside the urban service area but within the study area is specifically addressed as part of the recommended plan.

Conveyance Alternative Plan

The conveyance alternative plan involves the provision of new storm sewers and engineered open channels to abate existing stormwater runoff problems and to effectively serve planned new urban development within the Village of Sussex planned urban service area. Map 18 shows the location and alignment of new storm sewers and engineered open channels proposed under the conveyance alternative. Table 31 presents selected characteristics of the new storm sewers and channels comprising this alternative plan.

The conveyance alternative consists of 65,223 lineal feet of new storm sewers ranging in size from 12 to 84 inches in diameter. All new storm sewers are assumed to be constructed of reinforced concrete pipe. New sewer segments would discharge to surface streams or open channels from 32 new outfalls, while nine new sewer segments would discharge to existing storm sewers. About 206 manholes and 412 inlets would be required for the new sewers.

About 11,980 lineal feet of new engineered open channels would be provided under this alternative as shown on Map 18. All of the new engineered channels would be turf lined. The channels would have the cross-sections indicated in Table 31.

Centralized Detention Alternative Plan: The centralized detention alternative plan would provide nine detention basins strategically located within the study area. These basins would reduce downstream discharges, allowing, in some cases, the use of smaller conveyance facilities downstream. The detention basins, along with supplementary conveyance facilities, would serve to abate existing stormwater runoff problems and to effectively accommodate increased runoff from new urban development within the Village of Sussex planned urban service area. Map 19 shows the location of the proposed centralized detention facilities, as well as the major supplementary conveyance facilities. Table 32 presents selected characteristics of the new storm sewers, channels and detention facilities comprising this plan.

The centralized detention alternative consists of a total of nine centralized detention facilities. The nine detention basins would range in size from 1.5 acres to 23 acres in area and would range in volume of from 1.5 acre-feet to 83 acre-feet.

The supplementary conveyance facilities include 62,723 lineal feet of new storm sewer ranging in diameter from 12 to 72 inches. All new storm sewers are assumed to be constructed of reinforced concrete. New sewer segments would discharge into surface streams, open channels or detention basins from 36 new outfalls, while eight new sewer segments would discharge into existing storm sewers. About 200 manholes and 400 inlets would be required for the new sewers.

Table 31

SELECTED CHARACTERISTICS OF THE SUSSEX STORMWATER MANAGEMENT SYSTEM UNDER THE CONVEYANCE ALTERNATIVE PLAN: 2000

Hydrologic Unit Designation	Component Designation	Component Description	Estimated Cost: Capital	Estimated Cost: Annual Operation and Maintenance
A	1	4,340 feet of storm sewer ranging in size from 12 inches to 42 inches in diameter with 12 manholes and 24 inlets	$ 371,200	$ 800
B	1	1,650 feet of open channel 2.8 feet deep with a bottom width of 10 feet and side slopes of 1 on 3	24,800	600
	2	1,270 feet of open channel 3.7 feet deep with a bottom width of 20 feet and side slopes of 1 on 4	19,100	500
C	1	6,840 feet of storm sewer ranging in size from 18 inches to 84 inches in diameter with 15 manholes and 30 inlets	1,014,500	1,300
	2	280 feet of storm sewer 12 inches in diameter with 1 manhole and 2 inlets	10,000	100
	3	860 feet of storm sewer ranging in size from 24 inches to 36 inches in diameter with 3 manholes and 6 inlets	73,000	200
	4	50 feet of storm sewer 15 inches in diameter with 1 manhole and 2 inlets	3,600	100
	5	340 feet of storm sewer 15 inches in diameter with 1 manhole and 2 inlets	15,200	100
	6	280 feet of open channel 3.7 feet deep with a bottom width of 20 feet and side slopes of 1 on 4	4,200	100
D	1	5,300 feet of storm sewer ranging in size from 12 inches to 48 inches in diameter with 15 manholes and 30 inlets	576,700	1,000
	2	660 feet of storm sewer ranging in size from 15 inches to 21 inches in diameter with 2 manholes and 4 inlets	33,800	100
	3	2,019 feet of storm sewer ranging in size from 12 inches to 30 inches in diameter with 12 manholes and 24 inlets	121,900	400
	4	654 feet of storm sewer 12 inches in diameter with 4 manholes and 8 inlets	26,000	100
	5	110 feet of storm sewer 12 inches in diameter with 1 manhole and 2 inlets	4,900	100
	6	310 feet of storm sewer ranging in size from 15 inches to 24 inches in diameter with 2 manholes and 4 inlets	18,300	100
	7	1,590 feet of storm sewer ranging in size from 12 inches to 24 inches in diameter with 11 manholes and 22 inlets	103,300	300
	8	440 feet of storm sewer ranging in size from 15 inches to 21 inches in diameter with 2 manholes and 4 inlets	22,200	100
	9	1,640 feet of open channel 2 feet deep with a bottom width of 10 feet and side slopes of 1 on 3	24,600	600
	10	70 feet of concrete culvert 48 inches in diameter	4,800	--
E	1	1,120 feet of storm sewer ranging in size from 12 inches to 21 inches in diameter with 3 manholes and 6 inlets	58,500	200
	2	770 feet of storm sewer ranging in size from 12 inches to 18 inches in diameter with 2 manholes and 4 inlets	33,300	100
F	1	1,660 feet of storm sewer ranging in size from 12 inches to 36 inches in diameter with 5 manholes and 10 inlets	134,200	300
G	1	610 feet of open channel 2.5 feet deep with a bottom width of 10 feet and side slopes of 1 on 3	9,200	200
H	1	1,290 feet of storm sewer ranging in size from 21 inches to 30 inches in diameter with 4 manholes and 8 inlets	101,500	200
I	1	1,410 feet of storm sewer ranging in size from 18 inches to 24 inches in diameter with 3 manholes and 6 inlets	94,900	300
J	1	3,600 feet of storm sewer ranging in size from 18 inches to 27 inches in diameter with 5 manholes and 10 inlets	371,900	700
K	1	Improvement of 3,230 feet of existing open channel	60,900	--
L	1	600 feet of storm sewer ranging in size from 24 inches to 30 inches in diameter with 2 manholes and 4 inlets	47,200	100
	2	580 feet of storm sewer 21 inches in diameter with 2 manholes and 4 inlets	39,000	100
	3	1,060 feet of storm sewer ranging in size from 18 inches to 30 inches in diameter with 3 manholes and 6 inlets	71,800	200
	4	1,970 feet of open channel 3 feet deep with a bottom width of 10 feet and side slopes of 1 on 3	29,600	700

Table 31 (continued)

Hydrologic Unit Designation	Component Designation	Component Description	Estimated Cost: Capital	Estimated Cost: Annual Operation and Maintenance
M	1	3,060 feet of storm sewer ranging in size from 21 inches to 60 inches in diameter with 11 manholes and 22 inlets	384,000	600
N	1	370 feet of storm sewer 21 inches in diameter with 1 manhole and 2 inlets	23,800	100
	2	430 feet of open channel renovation	20,000	200
O	1	380 feet of storm sewer 15 inches in diameter with 1 manhole and 2 inlets	16,800	100
	2	70 feet of storm sewer 15 inches in diameter	4,400	100
	3	170 feet of concrete culvert 60 inches in diameter	17,000	100
	4	500 feet of storm sewer 72 inches in diameter	66,000	100
P	1	2,730 feet of storm sewer ranging in size from 36 inches to 64 inches in diameter with 7 manholes and 14 inlets	416,400	500
	2	1,260 feet of open channel 3.5 feet deep with a bottom width of 10 feet and side slopes of 1 on 3	18,900	500
Q	1	1,020 feet of storm sewer ranging in size from 36 inches to 42 inches in diameter with 4 manholes and 8 inlets	125,100	200
	2	640 feet of storm sewer ranging in size from 24 inches to 30 inches in diameter with 4 manholes and 8 inlets	57,600	100
	3	710 feet of storm sewer ranging in size from 24 inches to 36 inches in diameter with 3 manholes and 6 inlets	67,700	100
R	1	1,080 feet of open channel 2.5 feet deep with a bottom width of 10 feet and side slopes of 1 on 3	16,200	400
S	1	1,500 feet of storm sewer ranging in size from 24 inches to 42 inches in diameter with 4 manholes and 8 inlets	162,900	300
	2	930 feet of storm sewer ranging in size from 18 inches to 24 inches in diameter with 3 manholes and 6 inlets	64,300	200
T	1	6,100 feet of storm sewer ranging in size from 15 inches to 72 inches in diameter with 18 manholes and 36 inlets	839,900	1,200
	2	410 feet of storm sewer ranging in size from 21 inches to 27 inches in diameter with 3 manholes and 6 inlets	26,000	100
U	1	1,900 feet of storm sewer ranging in size from 24 inches to 36 inches in diameter with 5 manholes and 10 inlets	151,100	400
	2	1,840 feet of storm sewer ranging in size from 15 inches to 24 inches in diameter with 6 manholes and 12 inlets	101,400	300
V	1	5,080 feet of storm sewer ranging in size from 15 inches to 42 inches in diameter with 14 manholes and 28 inlets	374,900	1,000
	2	960 feet of open channel 2 feet deep with a bottom width of 5 feet and side slopes of 1 on 3	14,400	400
X	1	1,430 feet of storm sewer ranging in size from 21 inches to 54 inches in diameter with 3 manholes and 6 inlets	212,300	300
	2	110 feet of concrete culvert 54 inches in diameter	21,500	--
Y	1	670 feet of storm sewer ranging in size from 18 inches to 21 inches in diameter with 2 manholes and 4 inlets	38,400	100
	2	820 feet of open channel 3.5 feet deep with a bottom width of 10 feet and side slopes of 1 on 3	12,300	300
	3	70 feet of concrete culvert 60 inches in diameter	7,000	--
Z	1	440 feet of open channel 2 feet deep with a bottom width of 5 feet and side slopes of 1 on 3	6,600	200
	2	110 feet of concrete culvert 30 inches in diameter	9,900	--
Total			$6,800,900	$17,600

Source: SEWRPC.

Table 32

SELECTED CHARACTERISTICS OF THE SUSSEX STORMWATER MANAGEMENT SYSTEM UNDER THE CENTRALIZED DETENTION ALTERNATIVE PLAN: 2000

Hydrologic Unit Designation	Component Designation	Component Description	Estimated Cost: Capital	Estimated Cost: Annual Operation and Maintenance
A	1	3,590 feet of storm sewer ranging in size from 12 inches to 30 inches in diameter with 11 manholes and 22 inlets	$ 221,400	$ 700
	2	3.0-acre detention basin with a volume of 4.5 acre-feet and an outlet discharge rate of 5 cfs	22,500	2,000
B	1	1,650 feet of open channel 2.8 feet deep with a bottom width of 10 feet and side slopes of 1 on 3	18,300	600
	2	1,270 feet of open channel 3.7 feet deep with a bottom width of 20 feet and side slopes of 1 on 4	19,100	500
	3	7.1-acre detention basin with a volume of 7.1 acre-feet and an outlet discharge rate of 20 cfs	17,000	1,000
C	1	6,840 feet of storm sewer ranging in size from 18 inches to 84 inches in diameter with 15 manholes and 30 inlets	1,014,500	1,300
	2	280 feet of storm sewer 12 inches in diameter with 1 manhole and 2 inlets	10,000	100
	3	860 feet of storm sewer ranging in size from 24 inches to 36 inches in diameter with 3 manholes and 6 inlets	73,000	200
	4	50 feet of storm sewer 15 inches in diameter with 1 manhole and 2 inlets	3,600	100
	5	340 feet of storm sewer 15 inches in diameter with 1 manhole and 2 inlets	15,200	100
	6	280 feet of open channel 3.7 feet deep with a bottom width of 20 feet and side slopes of 1 on 4	4,200	100
D	1	5,300 feet of storm sewer ranging in size from 12 inches to 48 inches in diameter with 15 manholes and 30 inlets	576,700	1,000
	2	660 feet of storm sewer ranging in size from 15 inches to 21 inches in diameter with 2 manholes and 4 inlets	33,800	100
	3	2,019 feet of storm sewer ranging in size from 12 inches to 30 inches in diameter with 12 manholes and 24 inlets	121,900	400
	4	654 feet of storm sewer 12 inches in diameter with 4 manholes and 8 inlets	26,000	100
	5	110 feet of storm sewer 12 inches in diameter with 1 manhole and 2 inlets	4,900	100
	6	310 feet of storm sewer ranging in size from 15 inches to 24 inches in diameter with 2 manholes and 4 inlets	13,800	100
	7	1,590 feet of storm sewer ranging in size from 12 inches to 24 inches in diameter with 11 manholes and 22 inlets	103,300	300
	8	440 feet of storm sewer ranging in size from 15 inches to 21 inches in diameter with 2 manholes and 4 inlets	22,200	100
	9	1,640 feet of open channel 2.0 feet deep with a bottom width of 10 feet and side slopes of 1 on 3	24,600	600
	10	70 feet of concrete culvert 48 inches in diameter	4,800	--
	11	10.1-acre detention basin with a volume of 26.0 acre-feet and an outlet discharge rate of 50 cfs	40,000	1,000
	12	4.2-acre detention basin with a volume of 10.0 acre-feet and an outlet discharge rate of 50 cfs	35,000	1,000
E	1	1,120 feet of storm sewer ranging in size from 12 inches to 21 inches in diameter with 3 manholes and 6 inlets	58,500	200
	2	770 feet of storm sewer ranging in size from 12 inches to 18 inches in diameter with 2 manholes and 4 inlets	33,300	100
F	1	1,660 feet of storm sewer ranging in size from 12 inches to 36 inches in diameter with 5 manholes and 10 inlets	134,200	300
G	1	610 feet of open channel 2.5 feet deep with a bottom width of 10 feet and side slopes of 1 on 3	9,200	200
H	1	1,290 feet of storm sewer ranging in size from 21 inches to 30 inches in diameter with 4 manholes and 8 inlets	101,500	200

Table 32 (continued)

Hydrologic Unit Designation	Component Designation	Component Description	Estimated Cost: Capital	Estimated Cost: Annual Operation and Maintenance
I	1	1,410 feet of storm sewer ranging in size from 18 inches to 24 inches in diameter with 3 manholes and 6 inlets	94,900	300
J	1	3,010 feet of storm sewer ranging in size from 18 inches to 24 inches in diameter with 4 manholes and 8 inlets	212,200	600
	2	1.5-acre detention basin with a volume of 1.5 acre-feet and an outlet discharge rate of 5 cfs	18,000	2,000
K	1	Improvement of 2,550 feet of existing channel	45,900	--
L	1	600 feet of storm sewer ranging in size from 24 inches to 30 inches in diameter with 2 manholes and 4 inlets	47,200	100
	2	580 feet of storm sewer 21 inches in diameter with 2 manholes and 4 inlets	39,000	100
	3	1,060 feet of storm sewer ranging in size from 18 inches to 30 inches in diameter with 3 manholes and 6 inlets	71,800	200
	4	1,970 feet of open channel 3 feet deep with a bottom width of 10 feet and side slopes of 1 on 3	29,500	700
M	1	2,400 feet of storm sewer ranging in size from 18 inches to 36 inches in diameter with 11 manholes and 22 inlets	229,700	500
N	1	370 feet of storm sewer 21 inches in diameter with 1 manhole and 2 inlets	23,800	100
	2	430 feet of open channel renovation	20,000	200
O	1	380 feet of storm sewer 15 inches in diameter with 1 manhole and 2 inlets	16,800	100
	2	70 feet of storm sewer 15 inches in diameter with 1 manhole and 2 inlets	4,400	100
	3	170 feet of concrete culvert 48 inches in diameter	11,600	--
P	1	2,730 feet of storm sewer ranging in size from 36 inches to 64 inches in diameter with 7 manholes and 14 inlets	416,400	500
	2	1,260 feet of open channel 3.5 feet deep with a bottom width of 10 feet and side slopes of 1 on 3	18,900	500
Q	1	1,020 feet of storm sewer ranging in size from 36 inches to 42 inches in diameter with 4 manholes and 8 inlets	125,100	200
	2	640 feet of storm sewer ranging in size from 24 inches to 30 inches in diameter with 4 manholes and 8 inlets	57,600	100
	3	710 feet of storm sewer ranging in size from 24 inches to 36 inches in diameter with 3 manholes and 6 inlets	66,700	100
	4	Improvement of a 1.5-acre detention basin with a volume of 5.2 acre-feet and an outlet discharge rate of 1 cfs	23,000	2,000
R	1	1,080 feet of open channel 2.5 feet deep with a bottom width of 10 feet and side slopes of 1 on 3	16,200	400
	2	2.8-acre detention basin with a volume of 9.8 acre-feet and an outlet discharge rate of 15 cfs	12,000	2,000
S	1	1,500 feet of storm sewer ranging in size from 24 inches to 42 inches in diameter with 4 manholes and 8 inlets	162,900	300
	2	930 feet of storm sewer ranging in size from 18 inches to 24 inches in diameter with 3 manholes and 6 inlets	64,300	200
T	1	6,100 feet of storm sewer ranging in size from 15 inches to 72 inches in diameter with 18 manholes and 36 inlets	801,000	1,200
	2	410 feet of storm sewer ranging in size from 21 inches to 27 inches in diameter with 3 manholes and 6 inlets	26,000	100
	3	1.6-acre detention basin with a volume of 3.5 acre-feet and an outlet discharge rate of 10 cfs	12,000	2,000

Table 32 (continued)

Hydrologic Unit Designation	Component Designation	Component Description	Estimated Cost	
			Capital	Annual Operation and Maintenance
U	1	1,900 feet of storm sewer ranging in size from 24 inches to 36 inches in diameter with 5 manholes and 10 inlets	151,100	400
	2	1,840 feet of storm sewer ranging in size from 15 inches to 24 inches in diameter with 6 manholes and 12 inlets	101,400	300
V	1	5,080 feet of storm sewer ranging in size from 15 inches to 42 inches in diameter with 14 manholes and 28 inlets	374,900	1,000
	2	960 feet of open channel 2 feet deep with a bottom width of 5 feet and side slopes of 1 on 3	14,400	400
X	1	1,430 feet of storm sewer ranging in size from 21 inches to 54 inches in diameter with 3 manholes and 6 inlets	212,300	300
	2	110 feet of concrete culvert 54 inches in diameter	21,500	--
Y	1	670 feet of storm sewer ranging in size from 18 inches to 21 inches in diameter with 2 manholes and 4 inlets	38,400	100
	2	820 feet of open channel 3.5 feet deep with a bottom width of 10 feet and side slopes of 1 on 3	12,300	300
	3	70 feet of concrete culvert 36 inches in diameter	1,400	--
Z	1	440 feet of open channel 2 feet deep with a bottom width of 5 feet and a side slope of 1 on 3	6,600	200
	2	110 feet of concrete culvert 30 inches in diameter	9,900	--
Total	--	--	$6,373,600	$30,100

Source: SEWRPC.

About 11,980 feet of new engineered open channels would be provided under this alternative, as shown on Map 19. All of the new engineered channels would be turf lined. The channels would have the cross-sections indicated in Table 32.

Onsite Detention Alternative Plan: The onsite detention alternative plan includes the following elements:

- Stormwater runoff from all existing paved parking lots, where practical, and all new parking lots would be detained in parking lot storage facilities.

- Stormwater runoff from existing commercial and industrial flat roofs, where feasible, and all new commercial and industrial roofs greater than 20,000 square feet in area would be stored in rooftop storage facilities or similar structures. It should be noted that this alternative is being developed assuming the use of rooftop storage in order to test the value of such a method of reducing the peak flow rates in areas with larger rooftops. Structural analyses were not conducted for the existing buildings to determine if the stormwater loads could be handled. Such analyses would have to be done as part of plan implementation.

- A portion of the stormwater runoff from 761 acres would drain into small onsite detention basins and related infiltration systems.

As already noted, some onsite detention would be provided by implementation of the environmental corridor protection recommendations of the the land use plan, which serves as the basis for all of the alternative stormwater management plans. This onsite detention is provided by the preservation of floodlands, wetlands, and other open natural areas, which serve to store stormwater runoff.

In addition to the onsite detention elements described above, the onsite detention alternative plan includes a supplementary conveyance system. The onsite detention facilities, along with the supplementary conveyance system, would serve to abate existing stormwater runoff problems and to effectively accommodate increased runoff from new urban development within the Village of Sussex planned urban service area.

Map 20 shows the location of the proposed potential onsite detention facilities, as well as the supplementary conveyance facilities. Table 33 presents selected characteristics of the onsite detention facilities, storm sewers and channels comprising this alternative plan.

The 10 potential parking lot storage sites would range in size from 0.3 acre to 6.3 acres and would have a volume of from 0.2 acre-feet to 3.2 acre-feet, at a maximum depth of six inches during a 10-year recurrence interval design storm. It was assumed that, during the design storm, about one-half of the area of each parking lot could be used to store runoff. The maximum total amount of storage provided by all of the parking lot storage sites together is 6.2 acre-feet. The five potential rooftop storage sites would range in size from 0.4 acre to 4.5 acres each, and have a volume of from 0.2 acre-feet to 2.2 acre-feet, at a maximum depth of six inches during a 10-year recurrence interval design storm. The maximum amount of storage provided by all of the potential rooftop storage sites together is 3.6 acre-feet.

Selected subbasins, as shown on Map 20, are assumed to be suitable for the location of infiltration systems and onsite detention basins because less than one-half of the area of these subbasins has bedrock within five feet of the surface, has poorly drained or very poorly drained soils, has a seasonally high water table, contains wetlands or floodlands, or has steep slopes. It was further assumed that these onsite facilities could reduce peak flow rates and flow volumes from the subbasin by approximately 10 percent. The small detention basins and infiltration systems would have a combined maximum stormwater storage volume of 3.9 acre-feet. All of the onsite detention and infiltration facilities combined would have a maximum storage volume of approximately 13.7 acre-feet.

The supplementary conveyance facilities to the onsite detention alternative include 65,223 lineal feet of new storm sewer ranging in diameter from 12 to 72 inches. All new storm sewers are assumed to be constructed of reinforced concrete. New sewer segments would discharge into surface streams or open channels from 32 new outfalls, while nine of the new sewer segments would discharge into existing storm sewers. About 205 manholes and 410 inlets would be required for the new sewers.

About 11,980 feet of new engineered open channels would be provided under this alternative, as shown on Map 20. All of the new engineered channels would be turf lined. The channels would have the cross-sections indicated in Table 33.

Table 33

SELECTED CHARACTERISTICS OF THE SUSSEX STORMWATER MANAGEMENT SYSTEM UNDER THE ONSITE DETENTION ALTERNATIVE PLAN: 2000

Hydrologic Unit Designation	Component Designation	Component Description	Estimated Cost: Capital	Estimated Cost: Annual Operation and Maintenance
A	1	4,340 feet of storm sewer ranging in size from 12 inches to 42 inches in diameter with 12 manholes and 24 inlets	$ 371,200	$ 800
B	1	1,650 feet of open channel 2.8 feet deep with a bottom width of 10 feet and side slopes of 1 on 3	24,800	600
	2	1,270 feet of open channel 3.7 feet deep with a bottom width of 20 feet and side slopes of 1 on 4	19,100	500
C	1	6,840 feet of storm sewer ranging in size from 12 inches to 72 inches in diameter with 15 manholes and 30 inlets	800,700	1,300
	2	280 feet of storm sewer 12 inches in diameter with 1 manhole and 2 inlets	10,000	100
	3	860 feet of storm sewer ranging in size from 24 inches to 30 inches in diameter with 3 manholes and 6 inlets	70,900	200
	4	50 feet of storm sewer 15 inches in diameter with 1 manhole and 2 inlets	3,600	100
	5	340 feet of storm sewer 15 inches in diameter with 1 manhole and 2 inlets	15,200	100
	6	280 feet of open channel 3.7 feet deep with a bottom width of 20 feet and side slopes of 1 on 4	4,200	100
	7	Onsite infiltration and detention basins installed in the 90.5 acre subbasin to provide a 10 percent reduction in the total peak runoff flow rate and volume from the subbasin	26,100	1,400
	8	1.2-acre parking lot detention facility with a capacity of 0.6 acre-feet	15,000	2,000
	9	1.1-acre rooftop detention facility with a capacity of 0.6 acre-feet	4,800	500
D	1	5,300 feet of storm sewer ranging in size from 12 inches to 48 inches in diameter with 16 manholes and 32 inlets	437,300	1,000
	2	660 feet of storm sewer ranging in size from 15 inches to 21 inches in diameter with 2 manholes and 4 inlets	33,800	100
	3	2,019 feet of storm sewer ranging in size from 12 inches to 27 inches in diameter with 12 manholes and 24 inlets	116,000	400
	4	654 feet of storm sewer 12 inches in diameter with 4 manholes and 8 inlets	26,000	100
	5	110 feet of storm sewer 12 inches in diameter with 1 manhole and 2 inlets	4,900	100
	6	310 feet of storm sewer ranging in size from 15 inches to 24 inches in diameter with 2 manholes and 4 inlets	18,300	100
	7	1,590 feet of storm sewer ranging in size from 12 inches to 24 inches in diameter with 11 manholes and 22 inlets	103,300	300
	8	440 feet of storm sewer ranging in size from 15 inches to 21 inches in diameter with 2 manholes and 4 inlets	22,200	100
	9	1,640 feet of open channel 2 feet deep with a bottom width of 10 feet and side slopes of 1 on 3	24,600	600
	10	70 feet of concrete culvert 48 inches in diameter	4,800	--
	13	Onsite infiltration and detention basins installed in the 89.5-acre subbasin to provide a 10 percent reduction in the total peak runoff flow rate and volume from the subbasin	25,800	1,400
	14	Onsite infiltration and detention basins basins installed in the 41.3-acre subbasin to provide a 10 percent reduction in the total peak runoff flow rate and volume from the subbasin	11,900	600
E	1	1,120 feet of storm sewer ranging in size from 12 inches to 21 inches in diameter with 3 manholes and 6 inlets	58,500	200
	2	770 feet of storm sewer ranging in size from 12 inches to 18 inches in diameter with 2 manholes and 4 inlets	33,300	100

Table 33 (continued)

Hydrologic Unit Designation	Component Designation	Component Description	Estimated Cost: Capital	Estimated Cost: Annual Operation and Maintenance
F	1	1,660 feet of storm sewer ranging in size from 12 inches to 36 inches in diameter with 5 manholes and 10 inlets	134,200	300
G	1	610 feet of open channel 2.5 feet deep with a bottom width of 10 feet and side slopes of 1 on 3	9,200	200
H	1	1,290 feet of storm sewer ranging in size from 21 inches to 30 inches in diameter with 4 manholes and 8 inlets	101,500	200
I	1	1,410 feet of storm sewer ranging in size from 18 inches to 24 inches in diameter with 3 manholes and 6 inlets	94,900	300
J	1	3,600 feet of storm sewer ranging in size from 18 inches to 27 inches in diameter with 5 manholes and 10 inlets	333,300	700
	3	Onsite infiltration and detention basins installed in the 52.9-acre subbasin to provide a 10 percent reduction in the total peak runoff flow rate and volume from the subbasin	15,300	800
K	1	Improvement of 3,230 feet of existing open channel	60,900	--
L	1	600 feet of storm sewer ranging in size from 24 inches to 30 inches in diameter with 2 manholes and 4 inlets	47,200	100
	2	580 feet of storm sewer 21 inches in diameter with 2 manholes and 4 inlets	39,000	100
	3	1,060 feet of storm sewer ranging in size from 18 inches to 30 inches in diameter with 3 manholes and 6 inlets	71,800	200
	4	1,970 feet of open channel 3 feet deep with a bottom width of 10 feet and side slopes of 1 on 3	29,500	700
	5	0.4-acre parking lot detention facility with a capacity of 0.2 acre-feet	5,200	700
	6	0.7-acre parking lot detention facility with a capacity of 0.4 acre-feet	9,100	1,200
	7	0.5-acre rooftop detention facility with a capacity of 0.2 acre-feet	3,300	200
M	1	3,060 feet of storm sewer ranging in size from 21 inches to 60 inches in diameter with 11 manholes and 22 inlets	374,700	600
	2	Onsite infiltration and detention basins installed in the 20.5-acre subbasin to provide a 10 percent reduction in the total peak runoff flow rate and volume from the subbasin	5,900	300
	3	Onsite infiltration and detention basins installed in the 35.7-acre subbasin to provide a 10 percent reduction in the total peak runoff flow rate and volume from the subbasin	10,300	500
N	1	370 feet of storm sewer 21 inches in diameter with 1 manhole and 1 inlet	23,800	100
	2	430 feet of open channel renovation	20,000	--
	3	0.5-acre parking lot detention facility with a capacity of 0.2 acre-feet	6,500	900
	4	0.6-acre parking lot detention facility with a capacity of 0.3 acre-feet	7,800	1,000
	5	0.4-acre rooftop detention facility with a capacity of 0.2 acre-feet	2,600	200
	6	Onsite infiltration and detention basins installed in the 36.7-acre subbasin to provide a 10 percent reduction in the total peak runoff flow rate and volume from the subbasin	10,600	600
	7	Onsite infiltration and detention basins installed in the 19.7-acre subbasin to provide a 10 percent reduction in the total peak runoff flow rate and volume from the subbasin	5,600	300
O	1	380 feet of storm sewer 15 inches in diameter with 1 manhole and 2 inlets	16,800	100
	2	70 feet of storm sewer 15 inches in diameter with 1 manhole and 2 inlets	4,400	100
	3	170 feet of concrete culvert 60 inches in diameter	17,000	--
	4	500 feet of storm sewer 72 inches in diameter	66,000	100

Table 33 (continued)

Hydrologic Unit Designation	Component Designation	Component Description	Estimated Cost: Capital	Estimated Cost: Annual Operation and Maintenance
O (continued)	5	0.5-acre parking lot detention facility with a capacity of 0.3 acre-feet	7,200	1,000
P	1	2,730 feet of storm sewer ranging in size from 36 inches to 54 inches in diameter with 7 manholes and 14 inlets	416,400	500
	2	1,260 feet of open channel 3.5 feet deep with a bottom width of 10 feet and side slopes of 1 on 3	18,900	500
Q	1	1,020 feet of storm sewer ranging in size from 36 inches to 42 inches in diameter with 4 manholes and 8 inlets	125,100	200
	2	640 feet of storm sewer ranging in size from 24 inches to 30 inches in diameter with 4 manholes and 8 inlets	57,600	100
	3	710 feet of storm sewer ranging in size from 24 inches to 36 inches in diameter with 3 manholes and 6 inlets	67,700	100
R	1	1,080 feet of open channel 2.5 feet deep with a bottom width of 10 feet and side slopes of 1 on 3	16,200	400
	2	2.8-acre onsite detention basin with a volume of 9.8 acre-feet and an outlet discharge rate of 15 cfs	12,000	2,000
S	1	1,500 feet of storm sewer ranging in size from 18 inches to 24 inches in diameter with 4 manholes and 8 inlets	87,400	300
	2	930 feet of storm sewer ranging in size from 18 inches to 24 inches in diameter with 3 manholes and 6 inlets	64,300	200
	3	6.3-acre parking lot detention facility with a capacity of 3.2 acre-feet	82,300	11,000
	4	4.5-acre rooftop detention facility with a capacity of 2.2 acre-feet	19,600	2,000
	5	Onsite infiltration and detention basins installed in the 21.8-acre subbasin to provide a 10 percent reduction in the total peak runoff flow rate and volume from the subbasin	6,300	300
	6	Onsite infiltration and detention basins installed in the 24.5-acre subbasin to provide a 10 percent reduction in the total peak runoff flow rate and volume from the subbasin	7,100	400
T	1	6,100 feet of storm sewer ranging in size from 15 inches to 72 inches in diameter with 18 manholes and 36 inlets	852,400	1,200
	2	410 feet of storm sewer ranging in size from 18 inches to 21 inches in diameter with 3 manholes and 6 inlets	27,400	100
	4	1.0-acre parking lot detention facility with a capacity of 0.5 acre-feet	13,700	1,800
	5	0.6-acre parking lot detention facility with a capacity of 0.3 acre-feet	8,500	1,100
	6	0.8-acre rooftop detention facility with a capacity of 0.4 acre-feet	5,200	300
	7	Onsite infiltration and detention basins installed in the 25.0-acre subbasin to provide a 10 percent reduction in the total peak runoff flow rate and volume from the subbasin	7,200	400
	8	Onsite infiltration and detention basins installed in the 31.0-acre subbasin to provide a 10 percent reduction in the total peak runoff flow rate and volume from the subbasin	8,900	500
	9	Onsite infiltration and detention basins installed in the 59.3-acre subbasin to provide a 10 percent reduction in the total peak runoff flow rate and volume from the subbasin	17,100	900
U	1	1,900 feet of storm sewer ranging in size from 24 inches to 36 inches in diameter with 5 manholes and 10 inlets	151,100	400
	2	1,840 feet of storm sewer ranging in size from 15 inches to 24 inches in diameter with 6 manholes and 12 inlets	101,400	300
V	1	5,080 feet of storm sewer ranging in size from 15 inches to 36 inches in diameter with 14 manholes and 28 inlets	346,000	1,000
	2	960 feet of open channel 2 feet deep with a bottom width of 5 feet and side slopes of 1 on 3	14,400	400

Table 33 (continued)

Hydrologic Unit Designation	Component Designation	Component Description	Estimated Cost: Capital	Estimated Cost: Annual Operation and Maintenance
V (continued)	3	Onsite infiltration and detention basins installed in the 109.9-acre subbasin to provide a 10 percent reduction in the total peak runoff flow rate and volume from the subbasin	31,600	1,700
W	1	Onsite infiltration and detention basins installed in the 12.9-acre subbasin to provide a 10 percent reduction in the total peak runoff flow rate and volume from the subbasin	3,700	200
	2	Onsite infiltration and detention basins installed in the 39.5-acre subbasin to provide a 10 percent reduction in the total peak runoff flow rate and volume from the subbasin	11,400	600
X	1	1,430 feet of storm sewer ranging in size from 18 inches to 54 inches in diameter with 3 manholes and 6 inlets	207,500	300
	2	110 feet of concrete culvert 54 inches in diameter	21,500	--
	3	0.3-acre parking lot detention facility with a capacity of 0.2 acre-feet	3,900	500
	4	Onsite infiltration and detention basins installed in the 8.1-acre subbasin to provide a 10 percent reduction in the total peak runoff flow rate and volume from the subbasin	2,300	100
	5	Onsite infiltration and detention basins installed in the 27.8-acre subbasin to provide a 10 percent reduction in the total peak runoff flow rate and volume from the subbasin	8,000	400
Y	1	670 feet of storm sewer ranging in size from 18 inches to 21 inches in diameter with 2 manholes and 4 inlets	38,400	100
	2	820 feet of open channel 3.5 feet deep with a bottom width of 10 feet and side slopes of 1 on 3	12,300	300
	3	70 feet of concrete culvert 36 inches in diameter	1,400	--
Z	1	440 feet of open channel 2 feet deep with a bottom width of 5 feet and side slopes of 1 on 3	6,600	200
	2	110 feet of concrete culvert 30 inches in diameter	9,900	--
	3	Onsite infiltration and detention basins installed in the 5.5-acre subbasin to provide a 10 percent reduction in the total peak runoff flow rate and volume from the subbasin	1,600	100
AA	1	Onsite infiltration and detention basins installed in the 8.5-acre subbasin to provide a 10 percent reduction in the total peak runoff flow rate and volume from the subbasin	2,400	100
Total	--	--	$6,716,600	$55,300

Source: SEWRPC.

EVALUATION OF ALTERNATIVE STORMWATER MANAGEMENT PLANS

The preceding section described the three alternative stormwater management plans for the Village of Sussex study area. The information presented was intended to provide a basis for a comparative evaluation of the three specific alternative system plans. Each alternative is designed to fully resolve the identified existing drainage problems as well as to serve planned development within the Village of Sussex urban service area. Thus, the principal basis of the comparative evaluation becomes cost. However, each alternative has certain advantages and disadvantages associated with it, which were briefly described on a general basis in the preceding section. Accordingly, only the major advantages and disadvantages of each specific alternative plan are listed in Table 34. Table 35 compares, for each hydrologic unit within the planning area,

Table 34

SUMMARY OF PRINCIPAL COMPONENTS AND ADVANTAGES AND DISADVANTAGES OF ALTERNATIVE STORMWATER MANAGEMENT PLANS FOR THE VILLAGE OF SUSSEX PLANNED URBAN SERVICE AREA

Alternative	Principal New Components	Advantages	Disadvantages
Conveyance	• 65,223 feet of storm sewer • 11,980 feet of engineered open channel or channel improvement • 412 inlets • 206 manholes	Components are acceptable and well known to the public; minimal operation and maintenance is required	Downstream peak discharges and flow volumes are increased; pollutants in storm runoff are not removed
Centralized Detention	• 9 centralized surface detention facilities • 62,723 feet of storm sewer • 11,980 feet of engineered open channels or channel improvement • 400 inlets • 200 manholes	Reduces or eliminates the increase in peak discharges and areas of inundation; traps pollutants in runoff, reducing pollutant loads to receiving waters; reduces the required size and resultant cost of some downstream conveyance systems	Maintenance requirements are substantial; land requirements are considerably greater than under the conveyance alternative; some public officials amd cotozems may oppose ponded water in urban areas
Onsite Detention	• 10 parking lot detention facilities • 5 commercial and industrial rooftop detention facilities • 761 acres to be considered for infiltration systems and small onsite detention basins • 62,223 feet of storm sewer • 11,980 feet of engineered open channels or channel improvement • 410 inlets • 205 manholes	Reduces or eliminates the increase in peak discharge and areas of inundation; traps pollutants in runoff, reducing pollutant loads to receiving waters; reduces the required size and resultant cost of some downstream conveyance systems	Maintenance requirements are substantial; land requirements are considerably greater than under the conveyance alternative; many components are necessarily located on private property, so implementation may be difficult; some local opposition to onsite detention facilities may occur

Source: SEWRPC.

Table 35

COSTS OF ALTERNATIVE STORMWATER MANAGEMENT PLANS FOR THE VILLAGE OF SUSSEX PLANNED URBAN SERVICE AREA

Hydrologic Unit Designation	Estimated Cost--Planned Year 2000 Land Use Conditions					
	Conveyance Alternative		Centralized Detention Alternative		Onsite Detention Alternative	
	Capital	Annual Operation and Maintenance	Capital	Annual Operation and Maintenance	Capital	Annual Operation and Maintenance
A	$ 371,200	$ 800	$ 243,900	$ 2,700	$ 371,200	$ 800
B	43,900	1,100	54,400	2,100	43,900	1,100
C	1,120,500	1,900	1,120,500	1,900	950,500	5,800
D	936,500	2,800	1,007,000	4,800	828,900	4,800
E	91,800	300	91,800	300	91,800	300
F	134,200	300	134,200	300	134,200	300
G	9,200	200	9,200	200	9,200	200
H	101,500	200	101,500	200	101,500	200
I	94,900	300	94,900	300	94,900	300
J	371,900	700	230,200	2,600	348,600	1,500
K[a]	60,900	--	45,900	--	60,900	--
L	187,600	1,100	187,500	1,100	205,100	3,200
M	384,000	600	229,700	500	390,900	1,400
N	43,800	300	43,800	300	76,900	3,100
O	104,200	300	32,800	200	111,400	1,300
P	435,300	1,000	435,300	1,000	435,300	1,000
Q	250,400	400	272,400	2,400	250,400	400
R	16,200	400	28,200	2,400	28,200	2,400
S	227,200	500	227,200	500	267,000	14,200
T	865,900	1,300	839,000	3,300	940,400	6,300
U	252,500	700	252,500	700	252,500	700
V	389,300	1,400	389,300	1,400	392,000	3,100
W	--	--	--	--	15,100	800
X	233,800	300	233,800	300	243,200	1,300
Y	57,700	400	52,100	400	52,100	400
Z	16,500	200	16,500	200	18,100	300
AA	--	--	--	--	2,400	100
Total	$6,800,900	$ 17,500	$6,373,600	$ 30,100	$6,716,600	$ 55,300

[a]The cost of a major system detention basin proposed for hydrologic unit K is not included under Alternative 2. This cost along with costs for alternative channel improvements in lieu of providing the detention basin are further considered in the recommended plan chapter.

Source: SEWRPC.

the capital and annual operation and maintenance costs of each alternative. Table 36 compares the peak flow rates for each pertinent component under each of the three alternative plans. A comparison of the ability of each alternative plan to meet the recommended stormwater management objectives and supporting standards is set forth in Table 37.

Review of the alternative plan maps and cost information presented in Table 36 indicates that seven hydrologic units--E, F, G, H, I, P, and U--have essentially the same components and costs under each alternative plan. Accordingly, it was not found necessary to further consider these hydrologic units in the following discussion. Similarly, eight hydrologic units--L, N, S, V, W, X, Z, and AA--have essentially the same components and costs for the conveyance alternative and the centralized detention alternative, with significantly greater capital and operation and maintenance costs for the onsite detention alternative. The onsite detention alternatives for these hydrologic units were not found to offer any significant advantage over the conveyance and

Table 36

PEAK FLOW RATES OF INDIVIDUAL MINOR SYSTEM COMPONENTS FOR SELECTED ALTERNATIVE STORMWATER MANAGEMENT MEASURES

Hydrologic Unit	Component Number	Peak Discharge (cfs)		
		Alternative No. 1	Alternative No. 2	Alternative No. 3
		Conveyance	Centralized Detention	Onsite Detention
A	1	100	43	100
	2	--	8[a]	--
C	1	219	219	202
	2	3	3	3
	3	29	29	26
	4	5	5	5
	5	10	10	9
D	1	190	190	171
	2	27	27	27
	3	29	29	26
	4	10	10	9
	5	2	2	2
	6	51	51	46
	7	24	24	24
	8	11	11	11
E	1	19	19	19
	2	6	6	6
F	1	54	54	54
H	1	69	69	69
I	1	47	47	47
J	1	105	45	101
	2	--	5[a]	--
L	1	35	35	35
	2	16	16	16
	3	29	29	29
M	1	93	64	86
N	1	12	12	11
O	1	7	7	7
	2	5	5	5
P	1	138	138	138
Q	1	39	39	39
	2	25	25	25
	3	64	64	64
	4	1[b]	1	1[b]
R	1	85	85	85
	2	--	10[a]	10[a]
S	1	94	94	47
	2	26	26	26
T	1	232	214	217
	2	20	20	18
	3	--	10[a]	--
U	1	31	31	31
	2			
V	1	89	89	89
X	1	72	72	65
Y	1	20	20	20

[a]Represents the proposed detention basin outfall discharge capacity. This component may not be included in the conveyance and/or onsite detention basin alternatives.

[b]Represents the existing detention basin outfall discharge capacity.

Source: SEWRPC

Table 37

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

Stormwater Management Objective	Supporting Standards	Degree to Which Standard Can be Met		
		Conveyance	Centralized Detention	Onsite Detention
A. The development of a stormwater management system which reduces the exposure of humans to drainage-related inconvenience and to health and safety hazards and which reduces the exposure of real and personal property to damage through inadequate stormwater drainage and inundation	1. In order to prevent significant property damage and safety hazards, the major components of the stormwater management system should be designed to accommodate runoff from a 100-year recurrence interval storm event	Can be met	Can be met	Can be met
	2. In order to provide for an acceptable level of traffic service and access to property the minor component of the stormwater management system should be designed to accommodate runoff from a 10-year recurrence interval storm event	Can be met	Can be met	Can be met
	3. In order to provide an acceptable level of traffic service and access to property, the stormwater management system should be designed to provide two clear 10-foot lanes for moving traffic on arterial streets, and one clear 10-foot lane for moving traffic on collector and land access streets during storm events up to the 10-year recurrence interval event	Can be met	Can be met	Can be met
	4. When functioning as a part of the minor storm water drainage system, flow across arterial and collector streets should not be allowed and inlets should be located and sized accordingly. Controlled flow across land access streets is acceptable	Can be met	Can be met	Can be met

Table 37 (continued)

Stormwater Management Objective	Supporting Standards	Degree to Which Standard Can be Met		
		Conveyance	Centralized Detention	Onsite Detention
A. (continued)	5. When functioning as a part of the major stormwater drainage system, uncontrolled flow across collector and land access streets is acceptable; and controlled flow across arterial streets will be determined by the traffic-carrying importance of the arterial and the availability of convenient alternative arterial routes	Can be met	Can be met	Can be met
B. The development of a stormwater management system which will effectively serve the existing and planned land uses and promote implementation of the adopted land use plan	1. Stormwater drainage systems should be designed with the assumption that the layout of collector and land access streets for all proposed urban development and redevelopment will be care-adjusted to the topography in order to minimize grading and drainage problems, to utilize to the fullest extent practicable the natural drainage and storage capabilities of the site, and to provide the most economical installation of a gravity flow 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	Can be met	Can be met	Can be met
	2. Stormwater drainage systems should be designed with the assumption 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 assume that mid-block sags in street grades will be avoided and that street grades will generally parallel storm sewer gradients	Can be met	Can be met	Can be met

Table 37 (continued)

Stormwater Management Objective	Supporting Standards	Degree to Which Standard Can be Met: Conveyance	Centralized Detention	Onsite Detention
B. (continued)	3. Engineered stormwater management systems utilizing urban street cross-sections and storm sewers should be provided only in areas recommended for urban development in the adopted land use plan for the Village of Sussex	Can be met	Can be met	Can be met
	4. Stormwater drainage systems for planned new urban development should minimize the creation of new drainage or flooding problems or the intensification of existing problems, both at the development site and at downstream locations.	Partially met; downstream flows will be considerably higher than existing flows and may be somewhat less than estimated future flows during a 100-year recurrence interval storm event	Can be met	Partially met; downstream flows will be considerably higher than existing flows and may be somewhat less than estimated future flows during a 100-year recurrence interval storm event
C. The development of a stormwater management system which will minimize soil erosion, sedimentation, and attendant water pollution	1. Flow velocities which increase stream bank erosion and channel sediment scouring should be avoided	Partially met; flow velocities may increase slightly due to higher streamflows	Can be met	Partially met; flow velocities may increase slightly due to higher streamflows
	2. Storm sewer outfalls should be located and designed so as to prevent stream bank erosion and channel sediment scouring	Can be met	Can be met	Can be met
	3. Both urban and rural nonpoint source pollution abatement measures, as in the adopted regional water quality management plan, should be incorporated wherever appropriate, into the stormwater management system	Can be met only if nonpoint source pollution abatement measures are implemented	Can be met; the detention facilities will reduce nonpoint source loadings by up to 90 percent in some cases	Can be met; the detention facilities will reduce nonpoint source loadings by up to 90 percent in some cases

Table 37 (continued)

Stormwater Management Objective	Supporting Standards	Degree to Which Standard Can be Met		
		Conveyance	Centralized Detention	Onsite Detention
D. The development of a stormwater management system which will be flexible and readily adaptable to changing needs.	1. Larger, less frequent storm events should be used to used to design and size those site-specific elements of the stormwater drainage system for which it would not be economically feasible to provide flow relief during a major storm event	Can be met	Can be met	Can be met
	2. Larger, less frequent storm events should be used to design and size special structures such as roadway underpasses requiring pumping stations	Can be met	Can be met	Can be met
	3. Stormwater management facilities should be designed for staged or incremental construction, where feasible and economical, so as to limit the total investment in such facilities at any one time and to permit maximum flexibility to accommodate changes in urban development, economic activity growth, changes in the objectives or standards, or changes in the technology of stormwater management	Can be met	Can be met	Can be met
E. The development of a stormwater management system which will efficiently and effectively meet all of the other stated objectives at the lowest practicable cost	1. The sum of storm sewerage system capital investment and the operation and maintenance costs should be minimized	Partially met; this alternative has the lowest capital cost, or is equal to the lowest cost for 19 of the 27 hydrologic units within the urban service area. The total operation and maintenance cost is the lowest for the planning area as a whole	Partially met; this alternative has the lowest capital cost, or is equal to the lowest cost for 21 of the 27 hydrologic units within the urban service area. The total operation and maintenance cost is nearly twice as high as for the conveyance alternative	Partially met; this alternative has the lowest capital cost, or is equal to the lowest cost for 11 of the 27 hydrologic units within the urban service area. The total operation and maintenance cost is the highest--over three times the cost of the conveyance alternative

Table 37 (continued)

Stormwater Management Objective	Supporting Standards	Degree to Which Standard Can be Met		
		Conveyance	Centralized Detention	Onsite Detention
E. (continued)	2. Maximum feasible use should be made of all existing stormwater 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 management needs generated by implementation of the adopted land use plan	Can be met	Can be met	Can be met
	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	Can be met	Can be met	Partially met; most of the onsite detention facilities would be located on private property
	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 immediately downstream of these potential storage sites	Not met; by design, stormwater storage facilities were not included in the conveyance alternative	Met	Met

Source: SEWRPC.

centralized detention alternatives with regard to peak flow reduction. Accordingly, it was not found necessary to further consider these hydrologic units in the following discussion. The remaining 12 hydrologic units are considered in the discussion of each alternative plan.

Conveyance Alternative Plan

Under the conveyance alternative plan the Village of Sussex would continue to rely on storm sewers to convey stormwater runoff as quickly and directly as practicable to receiving surface watercourses. The alternative would entail a capital cost of about $6.8 million with an average annual operation and maintenance cost of about $17,600.

For the planning area as a whole, the conveyance alternative has a similar capital cost and is considerably lower in operation and maintenance costs than the other two alternatives. Significantly, the annual operation and maintenance cost is 43 percent less than the cost of the centralized detention alternative and 68 percent less than the cost of the onsite detention alternative. However, there are certain subareas of the Village of Sussex urban service area where components of the conveyance alternative would be more costly than components of the detention alternatives needed to serve the same hydrologic units. Specifically, in hydrologic units A,C,J,M,O,T, and Y, the capital cost of the conveyance alternative plan would be higher than the cost of one or both of the detention alternatives. Offsetting operation and maintenance costs for the onsite detention alternative for Hydrologic Unit C, however, makes the detention alternative less desirable than the conveyance alternative.

When compared to the other two alternative system plans, advantages of the conveyance alternative plan, in addition to cost, are that the proposed system would be readily implementable and likely to be acceptable to local officials and citizens; minimal operation and maintenance costs would be entailed; and few health and safety hazards would be created.

The most significant disadvantage of the conveyance alternative plan is that downstream peak discharges may be higher than existing discharges and discharges under the centralized and onsite detention alternatives. For example, the peak rate of discharge of a 10-year recurrence interval storm event from hydrologic unit J under the conveyance alternative would be 105 cfs. This compares with a discharge of 45 cfs under the centralized detention alternative and 101 cfs under the onsite detention alternative. Other disadvantages are that pollutants in the stormwater runoff will be more directly conveyed to receiving streams, and the alternative provides no multipurpose use benefits.

As shown in Table 36, most stormwater management objectives could be met by the conveyance alternative plan. However, the water quality objective would be met only if pollutants are removed from the runoff by other nonpoint source controls and, by design, stormwater storage was not considered in the alternative. Importantly, for seven of the 12 hydrologic units being considered in the discussion, the conveyance alternative plan does not have the lowest capital cost.

Centralized Detention Alternative Plan

The centralized detention alternative plan would provide nine centralized surface detention basins to temporarily store a portion of the stormwater runoff generated from the urban service area for subsequent slow release to the drainage system. The alternative would entail a capital cost of about $6.37 million; and an annual operation and maintenance cost of about $31,100.

For the planning area as a whole, the capital cost of the centralized detention alternative is about the same as that of the conveyance alternative and the onsite detention alternative. However, for certain hydrologic units--specifically units A, J, M, O, and T, as shown on Map 21--the centralized detention alternative would have a lower capital cost than either the conveyance alternative or the onsite detention alternative. The annual operation and maintenance costs of the conveyance alternative and onsite detention alternative are respectively 44 percent less than and 78 percent greater than the centralized detention alternative.

In addition to the cost advantages in certain areas, the centralized detention alternative also reduces the peak rate of stormwater flow downstream of proposed detention facilities. For example, the peak rate of discharge of a 10-year recurrence interval storm event from hydrologic unit A under the centralized detention alternative would be 43 cfs. This compares with a discharge of 100 cfs under the conveyance alternative. Another advantage is that pollutant concentrations and loadings would be reduced downstream of the detention facilities. The estimated maximum pollutant removal effectiveness of centralized detention facilities is set forth in Table 37. The disadvantages of the centralized detention alternative are that additional lands must be reserved for the location of proposed detention facilities and in some cases the centralized detention alternative is more costly than the conveyance alternative.

As shown in Table 36, most stormwater management objectives could be met by the centralized detention alternative plan. However, for four of the 12 hydrologic units being considered in this discussion, the centralized detention alternative plan would have a higher capital cost than either the conveyance or the onsite detention alternatives.

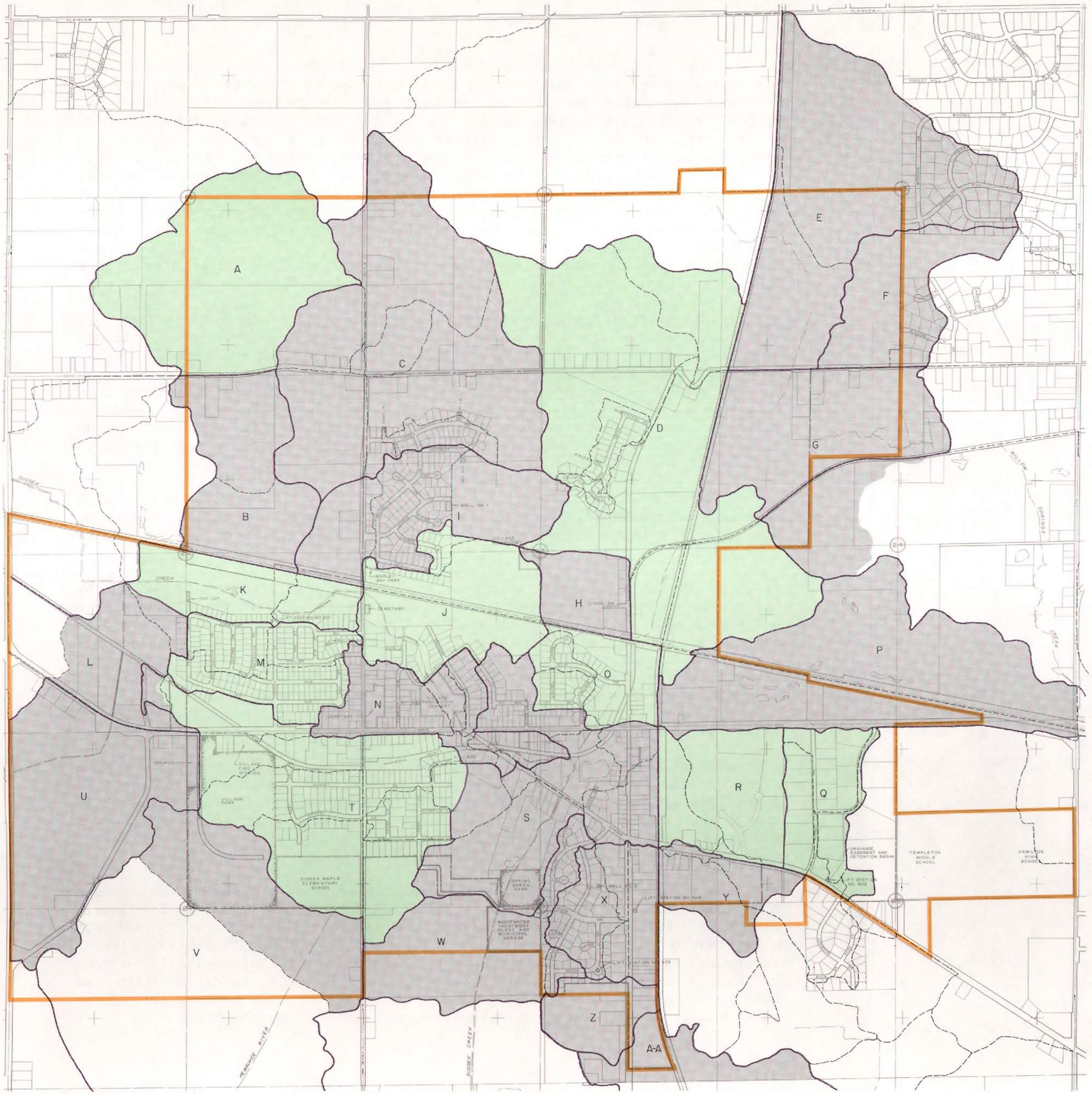
Based on the cost analysis and other considerations, detention facility components A-2, J-2, Q-4, R-2, and T-3 should be considered further in the recommended plan. Facilities D-10 and D-11, which result in major system cost savings within Hydrologic Unit O, and K-2, which will result in major system cost savings downstream of Hydrologic Unit K, should also be considered further in a discussion of the major system in Chapter VIII.

Onsite Detention Alternative Plan

The onsite detention alternative plan would provide several onsite stormwater detention and infiltration facilities to temporarily store a portion of the stormwater runoff generated from the urban service area for subsequent slow release to the drainage system. Compared to the centralized detention alternative, the onsite detention alternative contains a greater number and variety of detention facilities, although the hydraulic capacity of each facility would be smaller.

Map 21

SELECTED COMBINATION OF ALTERNATIVE PLANS FOR THE VILLAGE OF SUSSEX URBAN SERVICE AREA



Source: SEWRPC.

The onsite alternative would entail a capital cost of about $6.72 million, and an annual operation and maintenance cost of about $55,300. The cost of the onsite detention alternative is essentially the same as the cost of the conveyance alternative and the centralized detention alternative. The annual operation and maintenance costs of the conveyance alternative and the centralized detention alternative are respectively 68 percent and 44 percent less than the cost of the onsite detention alternative. As indicated in Table 35, only in Hydrologic Unit C does the onsite detention alternative have the lowest capital cost. However, even for that hydrologic unit, onsite detention does not have the lowest total cost, since the annual operation and maintenance cost of the onsite detention alternative is substantially higher than that of either the conveyance or centralized detention alternatives.

The most significant advantage of the onsite detention alternative is that peak rates of discharge would be somewhat less than under the conveyance alternative. For example, the peak rate of discharge of a 10-year recurrence interval storm event for Hydrologic Unit C under the onsite detention alternative would be 202 cfs. This compares with a discharge of 219 cfs under the conveyance alternative. Another advantage is that pollutant concentrations and loadings would be reduced downstream of the onsite facilities. The estimated maximum pollutant removal effectiveness of detention facilities and infiltration systems is set forth in Table 38.

The primary disadvantages of the onsite detention alternative include high maintenance costs and the required location of the detention facilities on what is now private property, which could make implementation and funding of this alternative difficult.

As shown in Table 36, most stormwater management objectives could be met by the onsite detention alternative plan. However, for all of the 12 hydrologic units being considered in the discussion, the onsite detention alternative plan capital cost and operation and maintenance costs combined are considerably higher than either the conveyance or centralized detention alternative costs. Based upon the cost analyses and other considerations, the onsite detention alternative will not be considered further in the recommended plan.

SUMMARY

The comparative evaluation of three alternative stormwater management system plans for the Village of Sussex study area indicated that the capital cost of such plans may be expected to range from $6.3 million to $6.8 million, while the annual operation and maintenance costs may be expected to range from $17,500 to $55,300. A summary of the components, and of the principal advantages and disadvantages of each alternative plan, is given in Table 34.

The comparative evaluation of the three alternative stormwater management plans considered indicates that the onsite detention alternative as previously discussed is not a suitable alternative in any hydrologic unit and that a combination of the conveyance and centralized detention alternative plans--incorporating the most cost-effective elements of each plan--should be considered. Such a combined plan would provide beneficial water quantity and quality control at the least cost, be implementable, and satisfy the stormwater management objectives and standards formulated under the study.

Table 38

ESTIMATED MAXIMUM POLLUTANT REMOVAL EFFECTIVENESS OF STORMWATER STORAGE AND INFILTRATION FACILITIES

Facility	Maximum Percent Removal of Pollutant Load Input				
	Total Solids	Volatile Solids	Lead	Phosphorus	Chemical Oxygen Demand
Retention Facilities[a]....	95	60	85	75	60
Infiltration Systems[b]....	100	100	100	100	100

[a] The above pollutant removal rates are estimated for retention basins and are based on Nationwide Urban Runoff Program data. Conventional detention basins can be expected to achieve much lower levels of pollutant removal, although detention basins can be modified with restricted outlet structures in order to achieve the relatively high removal levels shown above. The actual level of pollutant removal achieved by any individual detention facility depends upon the type of facility and outlet structure, the detention time, and the characteristics of the inflowing pollutant loads.

[b] It was assumed that essentially all of the pollutants infiltrating into the soil would be retained by the soil and would not contaminate the groundwater.

Source: SEWRPC.

The Sussex urban service area has been divided into 27 hydrologic units for purposes of evaluating the components of each alternative stormwater management plan considered. Based upon the evaluation of the components of each of the three alternative plans considered, it was concluded that certain components of each alternative should be combined to form the recommended plan. The alternative plans considered to be the best for each hydrologic unit are shown on Map 21. For 18 of these 27 units, the conveyance alternative components are judged to be the best. This includes the 15 hydrologic units that did not receive specific centralized detention or onsite detention recommendations. For nine hydrologic units, the centralized detention alternative components are judged to be the best. None of the onsite detention alternative components were selected for use in the recommended plan.

The recommended plan presented in Chapter VIII represents, for the planning area as a whole, a judicious combination of the conveyance and the centralized detention alternatives. Chapter VIII more fully describes the recommended plan, and provides additional details of the plan by including the components of the major stormwater management system and by providing additional consideration of those components serving areas within the study area but beyond the urban service area limits.

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Chapter VIII

RECOMMENDED STORMWATER MANAGEMENT PLAN

INTRODUCTION

In order to design a recommended stormwater management plan, it is necessary to select for each hydrologic unit one of the three alternative plans considered for the Village of Sussex urban service area. These three alternative plans, as presented in Chapter VII of this report, were a conveyance alternative, a centralized detention alternative, and an onsite detention alternative. The comparative evaluation of these plans as described in Chapter VII was based primarily on the cost of the minor stormwater management system components of the plans. The hydraulic capacities of the minor system components were all designed to accommodate flows from storm events up to and including the 10-year recurrence interval event. The impacts of the alternative plans on the peak rates of flow in the receiving watercourses and the effects of stormwater detention on surface water quality were also considered in the comparative evaluation. The evaluation of the three alternatives indicated that different alternatives should be selected for various hydrologic units and combined to form a composite system plan for the urban service area. Of the 27 hydrologic units delineated in the urban service area, the pure conveyance alternative was found to be best for 19 of the units, and the centralized detention alternative was found to be best for eight of the units. The onsite detention alternative was not found to be suitable for use in the Sussex urban service area. This determination was based on the high costs of this alternative, the disruption of urban activities that would occur in areas of existing development, and the uncertainty of public acceptance of the alternative. The onsite detention methods were accordingly eliminated from further consideration.

This chapter presents the resulting recommended stormwater management system plan. The minor system components are described in some detail, including the approximate number of storm sewer inlets; the approximate locations, lengths, sizes, and slopes of storm sewers; the approximate number, location, invert elevation, and rim elevations of storm sewer manholes; and the approximate location, tributary area, size, storage capacity, water depth, detention time, and outlet capacities of centralized detention facilities. The ability of the partial roadway cross-sections to effectively serve the required stormwater collection system during minor storms while providing for adequate traffic movement was also determined. The capacities of the minor system components were sized to accommodate flows from storm events up to and including the 10-year recurrence interval event.

This chapter also describes and evaluates the performance of the major stormwater management system components--the full street cross-sections, major open channel drainageways, and receiving natural watercourses. Street pavement crown elevations are recommended for all intersections and for all locations of recommended changes in street grade. The capacity of the major system components is evaluated on the basis of the flows resulting from a 100-year recurrence interval storm event. In addition, the components of the major drainage system located downstream of the urban service area are described and evaluated to the extent that these systems affect, or are affected by, stormwater flows from the urban service area.

The design of the recommended plan is thus based upon careful consideration of many factors, with primary emphasis upon the degree to which the recommended stormwater management objectives and supporting standards are satisfied. Most important among the considerations of those objectives and standards were those relating to cost and to the ability of the system components to accommodate flows resulting from the design storm events.

PLAN RECOMMENDATIONS

Based upon the comparative evaluation of the various alternative plans considered, as set forth in Chapter VII, the following minor and major stormwater management system components are recommended for inclusion in the stormwater management system plan for the Village of Sussex urban service area. Minor and major components of the recommended plan are described below, with a detailed discussion for each hydrologic unit. The recommended plan is shown in graphic form on Map 22, located in the pocket attached to the inside back cover of this report. In addition, 1" = 200' scale maps depicting the recommended system are on file in the office of the Village of Sussex Engineer.

Minor Stormwater Management System

The minor stormwater management system includes conveyance and centralized detention components which have been designed to contain flows from a 10-year recurrence interval storm. Onsite detention components have been eliminated from further consideration. The conveyance components include storm sewers and related inlets, manholes, and outfalls. The centralized detention components include surface detention basins with associated basin inlets and outlets. The ability of yard swales and roadway cross-sections to collect and convey drainage to the minor conveyance system was considered in the design of the system. A description of individual minor system components and costs of the recommended plan are presented in Table 39.

Conveyance Components: The planned conveyance components of the recommended plan include 61,633 lineal feet of new storm sewer, ranging in size from 12 inches to 72 inches in diameter, and 2,480 feet of new open channel. Approximately 199 new manholes and 398 inlets would be required. All new storm sewers are assumed to be constructed of precast, reinforced concrete pipe. New sewer segments would discharge to open channels or natural watercourses from 36 new outfalls, while nine new sewer segments would be connected to an existing storm sewer. The existing storm sewer system discharges through 22 existing outfalls. Sewer slopes would range from 0.002 through 0.047, and the sewers would be installed in storm drainage easements or in public rights-of-way at depths to inverts ranging from 4 to 15 feet below the existing or proposed ground surfaces or street grades. All recommended open channels would be grass lined. Map 22 shows the location and configuration of the recommended conveyance system. Design computations for the recommended storm sewer components are presented in Appendix A.

Centralized Detention Components: The centralized detention components of the recommended plan include eight surface detention basins. Of the eight basins, five are to be incorporated as components of the minor drainage system and accordingly are designed utilizing a 10-year recurrence interval storm. The remaining three basins are to be incorporated as components of the major drainage system and accordingly are designed utilizing a 100-year recurrence interval storm. Major system detention components will be discussed in the following section. Centralized detention basins of the minor system are

Table 39

SELECTED CHARACTERISTICS AND COSTS OF THE MINOR SYSTEM COMPONENTS OF THE RECOMMENDED SUSSEX STORMWATER MANAGEMENT PLAN: 2000

Hydrologic Unit Designation	Component Designation	Component Description	Estimated Cost	
			Capital	Annual Operation and Maintenance
A	1	3,590 feet of storm sewer ranging in size from 12 inches to 30 inches in diameter with 11 manholes and 22 inlets	$ 221,400	$ 700
	2	3.0-acre detention basin with a volume of 4.5 acre-feet and an outlet discharge rate of 5 cfs	22,500	2,000
C	1	5,750 feet of storm sewer ranging in size from 18 inches to 72 inches in diameter with 15 manholes and 30 inlets	$ 732,600	$ 1,100
	2	280 feet of storm sewer 12 inches in diameter with 1 manhole and 2 inlets	10,000	100
	3	860 feet of storm sewer ranging in size from 24 inches to 36 inches in diameter with 3 manholes and 6 inlets	73,000	200
	4	50 feet of storm sewer 15 inches in diameter with 1 manhole and 2 inlets	3,600	100
	5	340 feet of storm sewer 15 inches in diameter with 1 manhole and 2 inlets	15,200	100
D	1	5,300 feet of storm sewer ranging in size from 12 inches to 48 inches in diameter with 15 manholes and 30 inlets	$ 576,700	$ 1,000
	2	660 feet of storm sewer ranging in size from 15 inches to 21 inches in diameter with 2 manholes and 4 inlets	33,800	100
	3	2,019 feet of storm sewer ranging in size from 12 inches to 30 inches in diameter with 12 manholes and 24 inlets	121,900	400
	4	654 feet of storm sewer 12 inches in diameter with 4 manholes and 8 inlets	26,000	100
	5	110 feet of storm sewer 12 inches in diameter with 1 manhole and 2 inlets	4,900	100
	6	310 feet of storm sewer ranging in size from 15 inches to 24 inches in diameter with 2 manholes and 4 inlets	13,800	100
	7	1,590 feet of storm sewer ranging in size from 12 inches to 24 inches in diameter with 11 manholes and 22 inlets	103,300	300
	8	440 feet of storm sewer ranging in size from 15 inches to 21 inches in diameter with 2 manholes and 4 inlets	22,200	100
E	1	1,120 feet of storm sewer ranging in size from 12 inches to 21 inches in diameter with 3 manholes and 6 inlets	$ 58,500	$ 200
	2	770 feet of storm sewer ranging in size from 12 inches to 18 inches in diameter with 2 manholes and 4 inlets	33,300	100
F	1	1,660 feet of storm sewer ranging in size from 12 inches to 36 inches in diameter with 5 manholes and 10 inlets	$ 134,200	$ 300
H	1	1,290 feet of storm sewer ranging in size from 21 inches to 30 inches in diameter with 4 manholes and 8 inlets	$ 101,500	$ 200
I	1	1,410 feet of storm sewer ranging in size from 18 inches to 24 inches in diameter with 3 manholes and 6 inlets	$ 94,900	$ 300
J	1	3,010 feet of storm sewer ranging in size from 18 inches to 24 inches in diameter with 4 manholes and 8 inlets	$ 212,200	$ 600
	2	1.5-acre detention basin with a volume of 1.5 acre-feet and an outlet discharge rate of 5 cfs	18,000	2,000
L	1	600 feet of storm sewer ranging in size from 24 inches to 30 inches in diameter with 2 manholes and 4 inlets	$ 47,200	$ 100
	2	580 feet of storm sewer 21 inches in diameter with 2 manholes and 4 inlets	39,000	100
	3	1,060 feet of storm sewer ranging in size from 18 inches to 30 inches in diameter with 3 manholes and 6 inlets	71,800	200
M	1	2,400 feet of storm sewer ranging in size from 18 inches to 36 inches in diameter with 11 manholes and 22 inlets	$ 229,700	$ 500
N	1	370 feet of storm sewer 21 inches in diameter with 1 manhole and 2 inlets	$ 23,800	$ 100

Table 39 (continued)

Hydrologic Unit Designation	Component Designation	Component Description	Estimated Cost	
			Capital	Annual Operation and Maintenance
O	1	380 feet of storm sewer 15 inches in diameter with 1 manhole and 2 inlets	$ 16,800	$ 100
	2	70 feet of storm sewer 15 inches in diameter with 1 manhole and 2 inlets	4,400	100
P	1	2,730 feet of storm sewer ranging in size from 36 inches to 64 inches in diameter with 7 manholes and 14 inlets	$ 416,400	$ 500
Q	1	1,020 feet of storm sewer ranging in size from 36 inches to 42 inches in diameter with 4 manholes and 8 inlets	$ 125,100	$ 200
	2	640 feet of storm sewer ranging in size from 24 inches to 30 inches in diameter with 4 manholes and 8 inlets	57,600	100
	3	710 feet of storm sewer ranging in size from 24 inches to 36 inches in diameter with 3 manholes and 6 inlets	66,700	100
	4	Improvement of a 1.5-acre detention basin with a volume of 5.2 acre-feet and an outlet discharge rate of 1 cfs	23,000	2,000
R	1	1,080 feet of open channel 2.5 feet deep with a bottom width of 10 feet and side slopes of 1 on 3	$ 16,200	$ 400
	2	2.8-acre detention basin with a volume of 9.8 acre-feet and an outlet discharge rate of 15 cfs	12,000	2,000
S	1	1,500 feet of storm sewer ranging in size from 24 inches to 42 inches in diameter with 4 manholes and 8 inlets	$ 162,900	$ 300
	2	930 feet of storm sewer ranging in size from 18 inches to 24 inches in diameter with 3 manholes and 6 inlets	64,300	200
T	1	6,100 feet of storm sewer ranging in size from 15 inches to 72 inches in diameter with 18 manholes and 36 inlets	$ 801,000	$ 1,200
	2	410 feet of storm sewer ranging in size from 21 inches to 27 inches in diameter with 3 manholes and 6 inlets	26,000	100
	3	1.6-acre detention basin with a volume of 3.5 acre-feet and an outlet discharge rate of 10 cfs	12,000	2,000
U	1	1,900 feet of storm sewer ranging in size from 24 inches to 36 inches in diameter with 5 manholes and 10 inlets	$ 151,100	$ 400
	2	1,840 feet of storm sewer ranging in size from 15 inches to 30 inches in diameter with 6 manholes and 12 inlets	101,400	300
V	1	5,080 feet of storm sewer ranging in size from 15 inches to 42 inches in diameter with 15 manholes and 30 inlets	$ 374,900	$ 1,000
	2	960 feet of open channel 2 feet deep with a bottom width of 5 feet and side slopes of 1 on 3	14,400	400
X	1	1,430 feet of storm sewer ranging in size from 21 inches to 54 inches in diameter with 3 manholes and 6 inlets	$ 212,300	$ 300
Y	1	670 feet of storm sewer ranging in size from 18 inches to 24 inches in diameter with 2 manholes and 4 inlets	$ 38,400	$ 100
Z	1	440 feet of open channel 2 feet deep with a bottom width of 5 feet and side slopes of 1 on 3	$ 6,600	$ 200
Total			$5,748,500	$23,200

Source: SEWRPC.

recommended to be located in Hydrologic Units A, J, Q, R, and T. The five basins range in surface area from 1.5 acres to 3.0 acres and in storage capacities from 1.5 acre-feet to 9.8 acre-feet. The basins would store runoff from about 263 acres, or about 9 percent of the urban service area. The basins are recommended to be turf-lined, and during dry periods could be used for park or open space purposes. Flow rates out of the basins range from 2 through 10 cubic feet per second (cfs). The basins have maximum stormwater detention times during a design storm of 3 through 12 hours in length. All basins would discharge to storm sewers or to engineered open channels. Map 22 shows the location of the recommended centralized detention basins. Table 40 presents pertinent design information for the recommended centralized detention facilities. A schematic drawing showing a typical detention facility is shown in Figure 39 in Chapter VI.

Major Stormwater Management System

The major stormwater management system includes conveyance components and centralized detention components which have been designed to contain flows from a 100-year recurrence interval storm. Conveyance components include street cross-sections, major open channel drainageways, and receiving watercourses. Centralized detention components include surface detention basins and associated basin inlets and outlets. The major stormwater management system consists of those minor stormwater management system components necessary to meet drainage requirements, together with certain components recommended to offset adverse impacts of the recommended minor system facilities on downstream flood flows. The major drainage system plan does not include facilities for comprehensive flood control. A description of the individual major system components and the costs of the recommended plan are presented in Table 41.

Street Cross-Section Components: The recommended stormwater management plan envisions that the full street cross-section will be utilized to convey flows generated in excess of those generated by a 10-year recurrence interval storm event and up to the flows generated by a 100-year recurrence interval storm event. In areas with existing urban street patterns, or in areas where planned urban street patterns were known, the capacity of the streets to convey the stormwater was evaluated. In other planned urban areas it was assumed that street patterns will be developed which will be consistent with stormwater drainage needs. Recommended typical street cross-sections for arterial, collector, and minor land access streets are provided in Chapter VI of this report. The hydraulic pathways for stormwater under major storm event conditions are shown on Map 22, which includes the location of those areas where the capacity of the street cross-section will likely be exceeded, and where adjacent land may be expected to be inundated by a major storm event. In such areas it has been determined that inundation of land outside the street cross-section will

Table 40

PERTINENT CHARACTERISTICS OF PROPOSED CENTRALIZED DETENTION FACILITIES OF THE MINOR AND MAJOR STORMWATER MANAGEMENT SYSTEM

Hydrologic Unit Designation	Component Designation	Recurrence Interval Design (years)	Tributary Area (acres)	Storage Volume Required (acre-feet)	Storage Volume Provided (acre-feet)	Basin Size (acres)	Maximum Water Depth (feet)	Maximum Detention Time (hours)	Maximum Outlet Capacity (cfs)
A	A-2	10	84	3.0	4.5	3.0	3.0	8	5
D	D-9	100	250	25.0	26.0	10.1	3.0	11	30
D	D-10	100	370	9.0	10.0	4.2	4.0	8	45
J	J-2	10	42	1.0	1.5	1.5	2.0	3	5
K	K-2	10	3,500	35.0	40.0	20.0	4.0	8	260
Q	Q-4	10	38	4.0	5.2	1.5	3.8	12	2
R	R-1	10	57	7.0	9.8	2.8	3.5	9	10
T	T-2	10	42	2.5	3.5	1.6	2.5	4	10

Source: SEWRPC.

Table 41

SELECTED CHARACTERISTICS AND COSTS OF THE MAJOR SYSTEM COMPONENTS OF THE RECOMMENDED SUSSEX STORMWATER MANAGEMENT PLAN: 2000

Hydrologic Unit Designation	Component Designation	Component Description	Estimated Cost: Capital	Estimated Cost: Annual Operation and Maintenance
B	1	1,650 feet of open channel 2.8 feet deep with a bottom width of 10 feet and side slopes of 1 on 3	$ 24,800	$ 600
	2	1,270 feet of open channel 3.7 feet deep with a bottom width of 20 feet and side slopes of 1 on 4	19,100	500
C	6	1,370 feet of open channel 3.7 feet deep with a bottom width of 20 feet and side slopes of 1 on 4	$ 20,600	$ 500
D	9	1,640 feet of open channel 2.0 feet deep with a bottom width of 10 feet and side slopes of 1 on 3	$ 24,600	$ 600
	10	70 feet of concrete culvert 48 inches in diameter	4,800	--
	11	10.1-acre detention basin with a volume of 26.0 acre-feet and an outlet discharge rate of 50 cfs	40,000	1,000
	12	4.2-acre detention basin with a volume of 10.0 acre-feet and an outlet discharge rate of 50 cfs	35,000	1,000
G	1	610 feet of open channel 2.5 feet deep with a bottom width of 10 feet and side slopes of 1 on 3	$ 9,200	$ 200
K	1	Improvement of 2,550 feet of existing channel	$ 55,000	$ --
	2	20.0-acre detention basin with a volume of 40 acre-feet and an outlet discharge rate of 210 cfs	65,000	1,000
L	4	1,970 feet of open channel 3 feet deep with a bottom width of 10 feet and side slopes of 1 on 3	$ 29,600	$ 700
N	2	430 feet of open channel renovation	$ 20,000	$ 200
O	3	170 feet of concrete culvert 48 inches in diameter	$ 11,600	$ --
P	2	1,260 feet of open channel 3.5 feet deep with a bottom width of 10 feet and side slopes of 1 on 3	$ 18,900	$ 500
X	2	110 feet of concrete culvert 54 inches in diameter	$ 21,500	$ --
Y	2	820 feet of open channel 3.5 feet deep with a bottom width of 10 feet and side slopes of 1 on 3	$ 12,300	$ 300
	3	70 feet of concrete culvert 60 inches in diameter	7,000	--
Z	2	110 feet of concrete culvert 30 inches in diameter	$ 9,900	$ --
Total			$ 428,900	$ 7,100

Source: SEWRPC.

not cause major property damage or endanger human health or safety. Accordingly, no major drainage system improvements were recommended for these areas. Approximate street pavement crown elevations are recommended for all intersections and for all locations of recommended changes in street grade. These are intended to assure the proper functioning of the major stormwater drainage system, as well as to facilitate the design of the minor system; and are intended to be used as guides in the legal establishment of street grades throughout the urban service area as required by law.

Storm Sewer Components: In areas where it was determined that the hydraulic capacity of the full street cross-section would be exceeded by the stormwater flows generated by a 100-year recurrence interval storm event, and where the resulting ponding would have a significant adverse impact on residences or other facilities, increasing the capacity of the minor system components was considered. This would result in a reduction of flows to be conveyed by the major system components, since the minor system components would function, in effect, as part of the major system. Certain street cross-sections were identified as having insufficient capacity to convey stormwater from the 100-year recurrence interval storm event; however, it was determined that no significant adverse impacts would result from the minor flooding that would occur. Accordingly, no changes were recommended to be made to the design of the minor drainage system components.

Open Channel Components: To provide adequate conveyance to major stream channels, it is recommended that 10,590 lineal feet of engineered open channels be provided at the eight locations shown on Map 22. It is recommended that all new open channels be turf-lined and have cross-sections as shown on Map 22. The recommended plan also includes 360 lineal feet of new culvert to be installed at four locations with headwalls and endwalls. Profiles of open channel components of the major drainage system are provided in Appendix B.

Stream Channel Modifications and Associated Detention Basin Components: As already noted, the recommended major stormwater management system includes certain components recommended to offset adverse impacts of the recommended minor stormwater management facilities on downstream flows. Table 42 presents estimated 10- and 100-year recurrence interval flood flows at pertinent locations throughout the study area under existing land use and drainage system conditions, and future land use and existing drainage system conditions. In addition, Table 42 presents estimated 10- and 100-year recurrence interval flood flows under future land use and recommended minor and major drainage system conditions.

Channel modifications along two stream segments and three detention basins are recommended as components of the major drainage system. The first channel modification and detention basin combination is recommended to accommodate the discharge of minor system flows from Hydrologic Unit M located along the main stem of Sussex Creek. The peak stage of the 10-year flood flows in Hydrologic Unit K is such that the outfall of Hydrologic Unit M will surcharge, restricting stormwater flow from that unit and prohibiting achievement of the objectives of the minor drainage system. In order to meet the objectives of the minor drainage system in Hydrologic Unit M, it is necessary to reduce the in-channel floodwater surface profile of a 10-year recurrence interval storm by approximately three feet. The proposed channel modifications include channel profile adjustments along the main stem of Sussex Creek from Grogan Drive extended--about 100 feet downstream of the confluence with the South Branch of Sussex Creek--to approximately 300 feet upstream of Maple Avenue. The existing channel bottom slope varies from approximately 2.1 feet per mile to approximately 26.9 feet per mile. The proposed improved channel would have a uniform bottom slope of about 4.6 feet per mile. The channel bottom would be lowered approximately two feet at the outfall from Hydrologic Unit M. In addition, channel cross-section adjustments would be required for a portion of the stream length proposed to be lowered, and for the stream segment extending from Maple Avenue approximately 300 feet upstream. The stream segment immediately above Maple Avenue has a very narrow cross-section, producing

Table 42

COMPARISON OF 10-YEAR AND 100-YEAR RECURRENCE INTERVAL FLOOD FLOWS FOR SUSSEX CREEK, WILLOW SPRINGS CREEK, AND PEWAUKEE RIVER UNDER EXISTING AND FUTURE CONDITIONS

Location	Existing Land Use and Drainage System Conditions (cfs)		Future Land Use and Existing Drainage System Conditions (cfs)		Future Land Use and Recommended Drainage System Conditions (cfs)	
	10 Year	100 Year	10 Year	100 Year	10 Year	100 Year
Sussex Creek						
Main Stem at Confluence with East Branch of Sussex Creek....	203	318	424	627	390	590
East Branch of Sussex Creek.....	27	37	159	193	80	100
Downstream of Sussex Stormwater Management Study Area (CTH K)............	215	363	517	754	490	720
Willow Springs Creek						
Downstream of Sussex Stormwater Management Study Area....................	69	89	87	109	87	109
Pewaukee River						
Downstream of Sussex Urban Service Area............	63	110	93	158	93	158
Downstream of Sussex Stormwater Management Study Area (CTH K)............	91	202	117	255	117	255

Source: SEWRPC.

a high water surface profile. The channel slope adjustments and channel cross-section modifications would require that two private bridges located 250 feet and 700 feet upstream of Maple Avenue be removed. These channel improvement and bridge removal measures together may be expected to provide approximately 1.8 feet of the required three-foot reduction in backwater elevation near the outfall of Hydrologic Unit M. In order to reduce the water surface profile further, the proposed channel improvements are to be supplemented by the construction of a detention basin upstream of Grogan Drive extended. The detention basin would function as a component of the major drainage system. It would, however, provide only a 10-year recurrence interval level of protection with an available storage capacity of approximately 35 acre-feet. The proposed detention basin would reduce the 10-year flood stage in the stream reach adjacent to Hydrologic Unit M by approximately 1.2 feet of the three-foot water surface profile reduction. The implementation of these two plan recommendations may be expected to permit the effective operation of the minor stormwater drainage system in Hydrologic Unit M.

Further modification of the profile of the main stem of Sussex Creek is recommended in Hydrologic Unit N. The stream segment has been previously documented as a problem area because of a history of local flooding. Review of hydraulic conditions in this area indicates that channel maintenance and modification is necessary in order to provide maximum efficiency of the existing channel cross-section. The proposed channel profile for this segment of Hydrologic Unit N is shown in Appendix B. This recommendation is considered primarily as a maintenance procedure and is not expected to have a significant impact on the areal extent of the established 100-year recurrence interval floodplain in this area.

Channel modification and detention basins are recommended to reduce the impact of recommended major and minor stormwater management system components on downstream flows from the East Branch of Sussex Creek. The proposed improvements are to be located in Hydrologic Units D and O. The 100-year recurrence interval flood flow of the East Branch of Sussex Creek under existing conditions is estimated to be 37 cfs. Upon full development of lands within the upstream urban service area and upon implementation of the recommended minor and major system improvements, the 100-year flood flow of the East Branch of Sussex Creek would increase to 193 cfs. By increasing the amount of impervious surfaces and replacing the natural drainageways with more efficient paved drainageways down the steep slopes of the contributing drainage area, flood flows will be significantly increased. This increase may be expected to have significant adverse impacts on downstream flood flows and flooding. The following major drainage system improvements are, therefore, recommended. The detention area upstream of the abandoned Chicago, Milwaukee, St. Paul & Pacific Railroad is recommended to be retained and improved to provide approximately 25 acre-feet of storage, a 20-acre-foot increase.

The detention area upstream of the Chicago & North Western Railway tracks is also recommended to be retained and improved to provide approximately nine acre-feet of storage, a seven-acre-foot increase. Additional storage capacity for both detention basins is to be provided by earthern berms and control structures to be constructed adjacent to and downstream of the existing storage areas. The earthern berms should be designed to approximately increase the storage capacity of each basin. The combined effect of these improved detention facilities may be expected to reduce the 100-year recurrence interval flood flow of the East Branch of Sussex Creek to approximately 100 cfs. Even with this reduction in the flood flows, it will be necessary to improve the capacity of the existing major drainage system under Waukesha Avenue and the adjacent abandoned Chicago, Milwaukee, St. Paul & Pacific Railroad right-of-way. It is recommended that the existing culverts under Waukesha Avenue and the abandoned railway right-of-way be replaced by a single 170-foot length of 48-inch-diameter reinforced concrete culvert pipe, or by multiple pipes of equivalent capacity, and that the alignment of the proposed culvert coincide with that of the existing triple culvert section under Elm Avenue. The 48-inch-diameter concrete culvert pipe upstream of Main Street was previously identified as having insufficient capacity to accommodate the 100-year recurrence interval flood flows. With full implementation of the recommended major drainage system improvements, the 48-inch-diameter concrete culvert upstream of Main Street will not require replacement for capacity reasons.

By implementation of the recommended detention facilities and culvert improvements under Waukesha Avenue and the Chicago, Milwaukee, St. Paul & Pacific Railroad, the minor and major stormwater drainage system objectives will be met in Hydrologic Units D and O.

One Hundred-Year Recurrence Interval Flood Flows and Floodplain: Major drainage system flood flows and stages, and attendant flood hazard areas, were evaluated for Sussex Creek and its major tributaries and for Willow Springs Creek in SEWRPC Community Assistance Planning Report No. 11, Floodland Information Report for Sussex Creek and Willow Springs Creek, Village of Sussex, Waukesha County, Wisconsin, March 1977. Major drainage system flood flows and stages and attendant flood hazard areas were also evaluated for the Pewaukee River in SEWRPC Community Assistance Planning Report No. 9, Floodland Information Report for the Pewaukee River, Village of Pewaukee, Waukesha County, Wisconsin, October 1976. A hydrologic-hydraulic simulation model was used to develop the data presented in these reports. The model was used to simulate selected 10- through 500-year recurrence interval flood discharges under existing (1975) and planned (2000) land use conditions and existing channel conditions. The resulting flood discharges were then applied to a hydraulic backwater model used to determine flood stages and the corresponding flood hazard areas. The results of these simulation model analyses were used as a basis for the comparative evaluation of the effects of the recommended major drainage system improvements. The impacts of the recommended major drainage system improvements on the 100-year recurrence interval flood flows and stages along stream reaches within the urban service area were considered in detail. Such impacts on stream reaches downstream of the urban service area were considered more generally based upon changes in the peak flood discharge at the downstream limits of the urban service and study areas.

The recommended stormwater management plan includes major drainage system components providing both improved conveyance and increased stormwater detention capacity. Recommended conveyance improvements consist of channel modifications and channel profile adjustments that will increase the hydraulic capacity of the open channels concerned by either increasing the cross-sectional area of the channels or increasing the velocity of the waters being transported. Both of these types of adjustment tend to increase peak downstream flows. Recommended storage improvements consist of both increased storage capacity and an improved distribution of storage in the major drainage system. These recommendations are designed to offset the effects of the improved channel conveyance capacity and attendant reduction in floodplain storage. The detention facilities reduce the overall volume of stormwater runoff by allowing some of the detained stormwater to percolate into the groundwater system, and increase the time required to transport surface waters out of the watershed. The impacts of these stormwater management plan recommendations are considered below by subwatershed.

Sussex Creek--Estimated 10-year and 100-year recurrence interval flood flows for various locations and land use conditions along Sussex Creek are set forth in Table 42. The 100-year recurrence interval flood flow at CTH K located downstream of the urban service area is estimated to be 363 cfs under existing land use and channel conditions. Under planned land use and existing channel conditions, the 100-year recurrence interval flood flow at the same location is estimated to be 754 cfs, or about double the flow under existing conditions. Under planned land use and recommended stormwater drainage system conditions within the Sussex urban service area, the 100-year recurrence interval flood flow at CTH K is estimated to be essentially the same as the flood flows identified for the planned land use and existing channel conditions. Review of hydraulic simulation data indicates that the rate of runoff from existing and proposed development under the recommended plan conditions may be expected to be generally increased. However, the timing of the delivery of this increased rate of runoff is such as to not produce a significant increase in the downstream peak flood flow. The increased rate of runoff from the East Branch of Sussex Creek may be expected to be significantly reduced by the recommended detention facilities prior to entry into the main stem of Sussex Creek. Thus, the net result of the plan recommendations is no significant change in the downstream peak flood flows. The plan recommends the construction of approximately 8,720 feet of new open channel, 3,280 feet of improved open channel, and three detention basins with a total storage capacity of approximately 69 acre-feet.

The headwaters of an unnamed tributary to Sussex Creek lie in the southeastern corner of the Sussex urban service area designated as Hydrologic Unit R. Due to the headwaters location of this area, the 10-year and 100-year recurrence interval floodplain for this unnamed tributary have not been identified in previously published floodland information reports. This area has been selected as a site for a major industry to be constructed in 1983. The impact of proposed industrial development in this hydrologic unit has been addressed in a letter from the Regional Planning Commission to the Village of Sussex dated September 22, 1982. An evaluation of the planned development indicates that there would be an effective reduction in the peak rate of discharge from the development area with full implementation of the planned stormwater management measures. Such measures include construction of a nine-acre-foot detention basin north of Silver Spring Road to receive stormwater runoff from the total industrial development area. Accordingly, the proposed industrial development will not adversely affect downstream flows. The natural drainage channel downstream of Silver Spring Road has been identified as a problem area and requires improvement and maintenance even with an effective reduction in the peak rate of discharge from the subject area.

The areal extent of the 100-year recurrence interval floodplain along Sussex Creek in Hydrologic Unit K is expected to be reduced by approximately 7.2 acres because of the channel profile and cross-section modifications previously discussed. The areal extent of the 100-year recurrence interval floodplain along the East Branch of Sussex Creek is expected to be reduced by approximately 8.2 acres owing to the increased detention storage provided in two detention basins located upstream in Hydrologic Unit D. No significant change in the extent of the established 100-year recurrence interval floodplain is expected as a result of the channel maintenance recommended for Hydrologic Unit N. Also, no significant change in the extent of the 100-year recurrence interval floodplain is expected downstream of the confluence of the East Branch of Sussex Creek with the main stem of Sussex Creek. The areal extent of the 100-year recurrence interval floodplain and the reduced floodplain attendant to the proposed major drainage system improvements are shown in Appendix C.

Willow Springs Creek--The 100-year recurrence interval flood flows on Willow Springs Creek downstream of the urban service area are set forth in Table 42. Under existing land use and channel conditions, that discharge is estimated at 89 cfs. Under proposed land use and existing channel conditions this discharge may be expected to increase to about 109 cfs. Implementation of the recommended stormwater management plan is not expected to significantly increase the 100-year recurrence interval flood flows. This condition is based upon an investigation of the potential impact of the recommended stormwater management plan on downstream flows. The investigation indicated that the drainage area tributary to the proposed improvements totals approximately 120 acres, or only 5 percent of the 2,385 acres of the Willow Springs Creek subwatershed within the study area. Because of the small area affected and the limited extent of the conveyance improvements recommended in the plan in the Willow Springs Creek subwatershed, no significant increase in the 100-year recurrence interval flood flows or in the extent of the attendant flood hazard area downstream of the urban service area is expected.

Pewaukee River--The 100-year recurrence interval flood hazard area along the Pewaukee River was established in the floodland information report prepared by the Commission for the Pewaukee River.[1] That report was designed primarily to produce flood flow information for locations downstream of the headwaters of the Pewaukee River in the Town and Village of Pewaukee. Flood flows were, however, established for the upstream reaches immediately downstream of the Village of Sussex at CTH K. A more detailed analysis of the flood flows within and immediately downstream of the Sussex urban service area was conducted under the stormwater management study for the Village of Sussex. That study indicated that the peak flood flows may be expected to be considerably greater than those determined under the floodland information study. A comparison of the results of the flow studies is shown in Table 43. The comparison shows a significant difference in the peak flows immediately downstream of the Sussex urban service area; however, the difference is progressively diminished at points downstream of the urban service area and is essentially eliminated at a location upstream of the Pewaukee Lake outlet. This difference in flood flows immediately downstream of the urban service area may be attributed to a difference in the level of detail applied in each analysis. The floodland information study described portions of the Sussex urban area within the headwaters of the Pewaukee River subwatershed generally as a part of a large subbasin of predominantly rural character. The stormwater management plan incorporated a more detailed breakdown of the subwatershed, allowing a more precise characterization of the land use and its hydrologic and hydraulic features. While the generalized characterization of the subwatershed in the floodland information report provided acceptable results for the estimation of flood flows along downstream reaches of the Pewaukee River through and below the Village of Pewaukee, the calculation of flood flows near the headwaters of a subwatershed is more likely to be affected by such generalizations. Accordingly, the flood flows established under the village stormwater management study based upon more detailed analyses may be considered a refinement of the flows determined under the floodland information study. The newly developed 100-year recurrence interval flood flows on the Pewaukee River immediately downstream of the urban service area and at CTH K that have been incorporated into the stormwater management plan are set forth in Table 42. The flow at CTH K under existing land use and channel conditions is estimated to be 202 cfs. Under future land use and existing channel conditions, the flow may be expected to increase to 255 cfs. Based upon the 100-year flood flows established for future land use and existing channel conditions--which are essentially the same flows that have been determined for the recommended stormwater management plan--the 100-year recurrence interval floodplain has been established for the Pewaukee River within the Sussex urban service area. This delineation represents a decrease of approximately 1.3 acres from the delineated 100-year floodplain which was previously established by approximate methods. The areal extent of the 100-year recurrence interval floodplain and the reduced floodplain attendant to the newly established flood flows within the Sussex urban service area are shown in Appendix C.

Auxiliary Plan Recommendations

The foregoing recommendations primarily address stormwater drainage system improvements. To provide a comprehensive stormwater management plan, however,

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[1]See SEWRPC Community Assistance Planning Report No. 9, Floodland Information Report for the Pewaukee River, Village of Pewaukee, Waukesha County, Wisconsin, October 1976.

Table 43

COMPARISON OF PEAK FLOWS ESTABLISHED UNDER THE PEWAUKEE RIVER FLOODLAND INFORMATION REPORT AND THE SUSSEX STORMWATER MANAGEMENT PLAN

Location	Pewaukee River Floodland Information Report		Sussex Stormwater Management Study	
	Future Land Use and Existing Drainage System Conditions		Future Land Use and Existing Drainage System Conditions	
	Recurrence Interval		Recurrence Interval	
	10 Year (cfs)	100 Year (cfs)	10 Year (cfs)	100 Year (cfs)
Downstream of Sussex Urban Service Area.............	--	--	93	158
Downstream of Sussex Stormwater Management Study Area (CTH K).............	54	132	117	255
Upstream of Pewaukee Village Limits..................	54	132	83	191
Upstream of Confluence with Pewaukee Lake Outlet...........	205	347	210	372

Source: SEWRPC.

these drainage system recommendations must be supplemented by plan elements relating to natural resource and open space protection, soil erosion control, and the continual proper maintenance of the stormwater drainage system.

Natural Resource and Open Space Preservation: The recommended land use plan for the Village of Sussex provides a pattern of urban land use development which can be readily served by public sanitary sewerage and water supply facilities and other essential urban facilities and services. The land use plan also recommends that primary environmental corridors, including associated floodlands and wetlands, be maintained in essentially natural, open uses; and that the most productive farmlands be maintained in agricultural use. The protection of floodlands, wetlands, and agricultural lands has important implications for stormwater management since these lands can provide needed capacity for the storage, infiltration, and transport of stormwater runoff.

As presented in Table 20 of Chapter IV, the land use plan for the urban service area of the Village recommends the preservation of about 121 acres of agricultural and other open lands, or about 3 percent of the total area; and of about 440 acres of wetlands and woodlands, or about 13 percent of the total area. As shown on Map 15 of Chapter IV, essentially all of these woodlands and wetlands are located in primary and secondary environmental corridors. Primary environmental corridor lands are located at the western edge of the urban service area. Secondary environmental corridors are located along Sussex Creek, and are recommended to be preserved in natural open uses to the extent practicable, and particularly as may be required for stormwater management purposes. Some isolated natural areas are also recommended to be preserved in natural, open uses.

To provide needed water quantity and quality control, it is recommended that the natural and open space areas designated on the land use plan map be carefully protected, with the primary environmental corridors being preserved in essentially natural, open uses. The secondary environmental corridors should be preserved as required for recreational areas, urban greenways, and stormwater conveyance and detention areas. The effectiveness of the more specific drainage-related recommendations will be seriously reduced if the land use plan recommendations are greatly compromised in this respect.

Soil Erosion Control: Although the stormwater management recommendations presented above will provide a degree of water quality protection, largely through the detention of some stormwater, additional soil erosion control measures are recommended to more fully achieve the recommended water use objectives and supporting water quality standards. These erosion control recommendations, as set forth in SEWRPC Planning Report No. 30, A Regional Water Quality Management Plan for Southeastern Wisconsin: 2000, include measures to control erosion from both rural and urban land use, and to control erosion during the construction of urban development. Rural erosion control measures will become less important as land in the urban service area is converted to urban use. Recommended erosion--or nonpoint source--control measures for developed urban land include improved public works operations, such as street sweeping, leaf collection, and catch basin cleaning; pet waste and litter control; stream bank and roadside erosion control; control of industrial land runoff; and public education. Erosion control is particularly critical during construction activities, when large amounts of sediment may be discharged to surface waters. Recommended construction erosion control techniques include sedimentation basins, surface-covering measures such as mulching and seeding, maintenance of vegetative cover, diversions, check dams, and slope and bank protection measures.

Maintenance of Stormwater Management Facilities: The effectiveness of the stormwater conveyance and detention facilities, once developed, can be maintained only if proper operation, repair, and maintenance procedures are carefully followed. Important maintenance activities include the periodic inspection and repair of storm sewers, clearing of sewer obstructions, maintenance of open channel vegetative lining, clearing of debris and sediment from open channels, maintenance of detention facility inlets and outlets, maintenance of detention basin vegetative cover, periodic removal of sediment accumulated in detention basins, and sweeping of parking lots used as detention facilities. These maintenance activities are recommended to be carried out on a continuing basis. Such maintenance will not only maximize the effectiveness of the stormwater management facilities and measures but also protect the capital investment in the facilities. Estimates of the costs of the recommended maintenance activities are included in the total plan costs.

Discussion of the Recommended Stormwater Management System by Hydrologic Unit

A brief summary of the stormwater drainage needs and the recommended plan components for each of the 27 hydrologic units in the planned urban service area is provided below.

Hydrologic Unit A contains no significant existing urban development, and in 1980 had no identified drainage problems. Anticipated stormwater management problems include the need to accommodate the increased stormwater runoff from proposed new urban development over approximately 75 percent of the hydrologic unit. To accommodate this anticipated increase in runoff, approximately 3,590 feet of new storm sewer ranging in size from 12 inches to 30 inches in diameter and a 3.0-acre centralized detention basin with a volume of 4.5 acre-feet are proposed to be constructed as a part of the minor drainage system for the unit. In addition, it is estimated that 2,300 feet of 12-inch-diameter storm sewer will be required to drain future land access and collector streets, the layout of which has not as yet been determined. By application of accepted urban design techniques, the street system required to support future urban development would provide the necessary major drainage system conveyance capacity.

Hydrologic Unit B contains no significant existing urban development, and in 1980 had no identified drainage problems. Anticipated stormwater management problems include the need to accommodate the increased stormwater runoff from upstream urbanizing areas, and the increased runoff from proposed new urban development over approximately 25 percent of the hydrologic unit. In addition, it is estimated that 500 feet of 12-inch-diameter storm sewer will be required to drain future land access and collector streets, the layout of which has not as yet been determined. Approximately 2,920 feet of new turf-lined, open channel is recommended as a new component of the major drainage system. In addition, there is a naturally low area upstream of a 30-inch-diameter cast iron culvert at the outfall of Hydrologic Unit B that serves as a natural detention area for excess stormwater. It is recommended that this culvert be maintained as the outlet structure from Hydrologic Unit B, and that the storage area upstream of that structure be maintained in its existing natural condition. By application of accepted urban design techniques, the street system required to support future urban development would provide the remainder of the necessary major drainage system conveyance capacity.

Approximately 10 percent of Hydrologic Unit C was urbanized in 1980. Three problems related to the minor sytem were identified. Two culverts under Good Hope Road and a storm sewer segment in Michele Lane had insufficient capacity to accommodate the flow from a 10-year recurrence interval storm event. The locations of these problem areas are shown on Map 17 in Chapter VII. Anticipated stormwater management problems include the need to accommodate the increased stormwater runoff from proposed new urban development over an additional 80 percent of the hydrologic unit. To accommodate this anticipated increase in runoff, approximately 7,290 feet of new storm sewer ranging in size from 12 inches to 72 inches in diameter is proposed to be constructed as a part of the minor drainage system for the unit. In addition, it is estimated that 4,900 feet of 12-inch-diameter storm sewer will be required to drain future land access and collector streets, the layout of which has not as yet been determined. Approximately 1,370 feet of turf-lined open channel is recommended as a new component of the major drainage system. By application of accepted urban design techniques, the street system required to support future urban development would provide the remainder of the necessary major drainage system conveyance capacity. Special consideration may be necessary north of the intersections of Prides Road and Michele Lane and Prides Road and Lynne Ann Lane, where the natural drainage pattern is to be interrupted by the proposed street pattern.

Approximately 20 percent of Hydrologic Unit D was urbanized in 1980. No significant problems related to the minor system were identified. Anticipated stormwater management problems include the need to accommodate the increased stormwater runoff from proposed new urban development of an additional 40 percent of the hydrologic unit. To accommodate this anticipated increase in runoff, approximately 11,083 feet of new storm sewer ranging in size from 12 inches to 48 inches in diameter is proposed to be constructed as a part of the minor drainage system of the unit. In addition, it is estimated that 1,500 feet of 12-inch-diameter storm sewer will be required to drain future land access and collector streets, the layout of which has not as yet been determined. Approximately 1,640 feet of open channel, 70 feet of 48-inch-diameter concrete culvert, and two centralized detention basins are proposed to be developed as necessary components of the major drainage system. The detention basins are recommended in order to reduce the design requirements of major system components downstream. By application of accepted urban design techniques, the street system required to support future urban development would provide the remainder of the necessary major drainage system conveyance capacity.

Hydrologic Unit E contains no significant existing urban development, and in 1980 had no identified drainage problems. Anticipated stormwater management problems include the need to accommodate the increased stormwater runoff from proposed new urban development of approximately 10 percent of the hydrologic unit. To accommodate this anticipated increase in runoff, approximately 1,890 feet of new storm sewer ranging in size from 12 inches to 21 inches in diameter is proposed to be constructed as a part of the minor drainage system for the unit. In addition, it is estimated that 500 feet of 12-inch-diameter storm sewer will be required to drain future land access and collector streets, the layout of which has not as yet been determined. By application of accepted urban design techniques, the street system required to support future urban development would provide the necessary major drainage system conveyance capacity.

Approximately 30 percent of Hydrologic Unit F was urbanized in 1980. No problems related to the minor system were identified. Anticipated stormwater management problems include the need to accommodate the increased stormwater runoff from new urban development over an additional 40 percent of the hydrologic unit. To accommodate this anticipated increase in runoff, approximately 1,660 feet of new storm sewer ranging in size from 12 inches to 36 inches in diameter is proposed to be constructed as a part of the minor drainage system of the unit. In addition, it is estimated that 600 feet of 12-inch-diameter storm sewer will be required to drain future land access and collector streets, the layout of which has not as yet been determined. By application of accepted urban design techniques, the street system required to support future urban development would provide the necessary major drainage system conveyance capacity.

Hydrologic Unit G contains no significant existing urban development, and in 1980 had no identified drainage problems. Anticipated stormwater management problems include the need to accommodate the increased stormwater runoff from proposed new urban development over approximately 40 percent of the hydrologic unit and a small amount of new urban development within Hydrologic Unit G. To accommodate this anticipated increase in runoff, it is estimated that 500 feet of 12-inch-diameter storm sewer will be required to drain future land access and collector streets, the layout of which has not as yet been determined. Approximately 610 feet of new turf-lined, open channel is recommended as a new component of the major drainage system. By application of accepted urban design techniques, the street system required to support future urban development would provide the remainder of the necessary major drainage system conveyance capacity.

Hydrologic Unit H contains a small amount of existing urban development located adjacent to and west of Waukesha Avenue, and in 1980 had no drainage problems. Anticipated stormwater management problems include the need to accommodate the increased stormwater runoff from proposed new urban development over approximately 90 percent of the hydrologic unit. To accommodate this anticipated increase in runoff, approximately 1,290 feet of new storm sewer ranging in size from 21 inches to 30 inches in diameter is proposed to be constructed as part of the minor drainage system for the unit. In addition, approximately 600 feet of 12-inch-diameter storm sewer may have to be constructed to drain future land access and collector streets, the layout of which has not as yet been determined. By application of accepted urban design techniques, the street system required to support future urban development would provide the necessary major drainage system conveyance capacity.

Approximately 40 percent of Hydrologic Unit I was urbanized in 1980. Anticipated stormwater management problems include the need to accommodate the increased stormwater runoff from proposed new urban development over approximately 50 percent of the hydrologic unit. To accommodate this anticipated increase in runoff, approximately 1,410 feet of new storm sewer ranging in size from 18 inches to 24 inches in diameter is proposed to be constructed as a part of the minor drainage system for the unit. In addition, approximately 2,000 feet of 12-inch-diameter storm sewer will be required to drain future land access and collector streets, the layout of which has not as yet been determined. By application of accepted urban design techniques, the street system required to support future urban development would provide the necessary major drainage system conveyance capacity.

Approximately 30 percent of Hydrologic Unit J was urbanized in 1980. No problems related to the minor system were identified. Anticipated stormwater management problems include the need to accommodate the increased stormwater runoff from proposed new urban development over an additional 60 percent of the hydrologic unit. To accommodate this anticipated increase in runoff, approximately 3,010 feet of new storm sewer ranging in size from 15 inches to 42 inches in diameter and a 1.5-acre centralized detention basin with a volume of 1.5 acre-feet are proposed to be constructed as part of the minor drainage system for the unit. In addition, approximately 1,800 feet of 12-inch-diameter storm sewer may have to be constructed to drain future land access and collector streets, the layout of which has not as yet been determined. By application of accepted urban design techniques, the street system required to support future urban development would provide the necessary major drainage system conveyance capacity.

Less than 10 percent of Hydrologic Unit K was urbanized in 1980. No problems related to the minor system were identified in the unit. It has been determined that the main stem of Sussex Creek through this hydrologic unit does not have adequate capacity to maintain effective operation of the minor stormwater drainage system in adjacent hydrologic units. In addition, the limited channel capacity and downstream backwater conditions cause minor flooding of adjacent urban areas under 100-year recurrence interval storm conditions. Anticipated stormwater management problems include the need to accommodate the increased stormwater runoff from developing urban areas upstream of Hydrologic Unit K and proposed new urban development over an additional 10 percent of the hydrologic unit. To abate the problems associated with the main stem of Sussex Creek, it is recommended that channel improvements be implemented along approximately 2,800 feet of the main stem of Sussex Creek within Hydrologic Unit K. In addition, it is recommended that a 20.0-acre detention basin with a volume of 35.0 acre-feet be constructed on the main stem of Sussex Creek immediately upstream of Grogan Drive extended. This detention facility is designed to reduce the 10-year recurrence interval flood flow by approximately 30 percent. The combined effect of the channel modifications and detention storage will reduce the 10-year recurrence interval flood stage at the outfall of Hydrologic Unit M by approximately three feet and allow effective operation of the minor stormwater drainage system at that location. The proposed detention basin is considered a major system plan recommendation; however, it is recommended to provide relief for the minor drainage system of adjacent hydrologic units and has accordingly been designed for a 10-year level of protection. The proposed detention facility is not expected to have an impact on the 100-year recurrence interval flood flows. Detailed information on the nature of channel improvements and their effects on the downstream conveyance facilities is set forth in the preceding section on the major drainage system.

Approximately 30 percent of Hydrologic Unit L was urbanized in 1980. No problems related to the minor system were identified. Anticipated stormwater management problems include the need to accommodate the increased stormwater runoff from new urban development over an additional 60 percent of the hydrologic unit. To accommodate this anticipated increase in runoff, approximately 2,240 feet of new storm sewer ranging in size from 18 inches to 30 inches in diameter is proposed to be constructed as a part of the minor drainage system. In addition, approximately 1,600 feet of 12-inch-diameter storm sewer may have to be constructed to drain future land access and collector streets, the layout of which has not as yet been determined. Approximately 1,970 feet of new turf-lined, open channel is recommended as a new component of the major drainage system. By application of accepted urban design techniques, the street system required to support future urban development would provide the necessary additional major drainage system capacity.

Approximately 95 percent of Hydrologic Unit M was urbanized in 1980. Two problems related to the minor system were identified in the unit: inadequate storm sewer capacity along Locust Street from Ivy Avenue to Champeny Road and at the intersection of Westhaven Road and Champeny Road. Anticipated stormwater management problems include slightly increased stormwater runoff from proposed new urban development of an additional 5 percent of the hydrologic unit. To accommodate the existing minor system problem areas and anticipated increases in runoff, 2,400 feet of new storm sewer ranging in size from 18 inches to 36 inches in diameter is proposed to be constructed as a part of the minor drainage system. Approximately 1,050 feet of proposed minor system conveyance components are recommended primarily as a replacement for the existing stormwater drainage system. A portion of the existing storm sewer system is recommended not to be replaced, allowing stormwaters to flow in the surface drainage pattern to the Pewaukee River watershed. The proposed minor system improvements require that major drainage system improvements be made along the main stem of Sussex Creek in Hydrologic Unit K. Because limited roadway slopes are incorporated in the existing development design, it is not possible to provide sufficient major system flow capacity within the street right-of-way. Accordingly, a portion of the property adjacent to roads in this area would temporarily be flooded following a 100-year recurrence interval storm event. This condition is not considered to be hazardous to property in this area, and, thus, no additional major system components have been recommended to relieve the temporary inundation.

Approximately 90 percent of Hydrologic Unit N was developed in 1980. There were no problem areas identified in the minor stormwater drainage system. Approximately 370 feet of storm sewer, 21 inches in diameter, is proposed to be constructed as part of the minor drainage system. One major drainage system problem area was identified regarding the conveyance capacity of the main stem of Sussex Creek. This problem area is identified on Map 17. The problem may be attributed in part to sedimentation and debris that has accumulated in that area, resulting in a variable channel bottom profile and reduced channel capacity. Accordingly, it is recommended that channel improvements be made to maximize the overall channel capacity of the main stem of Sussex Creek in this area. It is estimated that the proposed channel improvements will not eliminate the backwater condition in this area. They are, however, considered low-cost improvements that can be readily applied to improve the existing channel conditions. In order to fully resolve the documented flooding problems in this area, it is recommended that a comprehensive flood control study be completed in this area, the details of which are described in the preceding section on the major drainage system.

Approximately 20 percent of Hydrologic Unit O was urbanized in 1980. No major drainage system problem areas were identified in this hydrologic unit. Major system problem areas consist of inadequate capacity in the culvert under the abandoned Chicago, Milwaukee, St. Paul & Pacific Railroad adjacent to Waukesha Avenue and under Waukesha Avenue, and inadequate capacity in the enclosed segment of the East Branch of Sussex Creek under Main Street. Anticipated stormwater management problems include the need to accommodate the increased stormwater runoff from proposed new urban development over an additional 20 percent of the hydrologic unit and increases in runoff from new development upstream. To accommodate these anticipated increases in runoff, 450 feet of new storm sewer 15 inches in diameter is proposed to be constructed as part of the minor drainage system. Approximately 900 feet of 12-inch-diameter storm sewer is required to drain future land access and collector streets, the layout of which has not as yet been determined. In addition, the replacement of culverts under the abandoned Chicago, Milwaukee, St. Paul & Pacific Railroad line and Waukesha Avenue at Elm Avenue is recommended as a new element of the major drainage system. These two existing roadway culverts are proposed to be replaced by a single culvert to be installed in line with the existing culverts under Elm Avenue. The culvert is proposed to be 170 feet long with a capacity equivalent to a 48-inch-diameter pipe. The major drainage system peak flow through this hydrologic unit would be controlled by the discharge from two detention basins recommended to be located upstream in Hydrologic Unit D. These detention areas have been designed to reduce the required downstream major drainage system conveyance capacity, thereby eliminating the need to replace the currently undersized, 48-inch-diameter, reinforced concrete pipe that runs through an established commercial area upstream of Main Street. By application of accepted urban design techniques, the street system required to support future urban development would provide the remainder of the necessary major drainage system conveyance capacity.

Approximately 30 percent of Hydrologic Unit P was urbanized in 1980. No problems related to the minor system were identified in the unit. Anticipated stormwater management problems include the need to accommodate the increased stormwater runoff from proposed new urban development over an additional 30 percent of the hydrologic unit. The remaining 40 percent of the hydrologic unit is to remain in extractive development. To accommodate this anticipated increase in runoff, approximately 2,730 feet of new storm sewer ranging in size from 36 inches to 54 inches in diameter is proposed to be constructed as part of the minor drainage system. In addition, approximately 2,600 feet of 12-inch-diameter storm sewer may have to be constructed to drain future land access and collector streets, the layout of which has not as yet been determined. Approximately 1,260 feet of turf-lined, open channel is recommended as a part of the major drainage system. By application of accepted urban design techniques, the street system required to support future urban development would provide the remainder of the necessary major drainage system conveyance capacity.

Approximately 20 percent of Hydrologic Unit Q was urbanized in 1980. One problem related to the minor system was identified in the unit. This problem consists of inadequate roadway ditch capacity adjacent to Sussex Road north of Silver Spring Drive in the Sussex Industrial Park. Anticipated stormwater management problems include the need to accommodate the increased stormwater runoff from new urban development over an additional 80 percent of the hydrologic unit. To accommodate this anticipated increase in runoff, approximately 2,370 feet of new storm sewer ranging in size from 24 inches to 42 inches in diameter is proposed to be constructed as part of the minor drainage system for the unit. Because limited roadway slopes are incorporated in the existing development design, it is not possible to provide sufficient major system flow capacity within the street right-of-way. Accordingly, a portion of the property adjacent to roads in this area would be temporarily flooded following a 100-year recurrence interval storm event. This condition is not considered to be hazardous to property in this area if recommended building grades are maintained, and, thus, no additional major system components have been recommended to relieve the temporary inundation.

Less than 10 percent of Hydrologic Unit R was urbanized in 1980. One problem related to the minor system was identified in the unit. This problem consists of a damaged culvert under Silver Spring Road that drains the hydrologic unit. The culvert is partially collapsed, reducing its hydraulic capacity. In addition to the reduced hydraulic capacity of the culvert, the upstream culvert invert elevation is too high to drain the lower portions of the hydrologic unit effectively. In addition to the identified problem within Hydrologic Unit R, marginal drainage problems exist downstream of Hydrologic Unit R which lie outside the Sussex urban service area. These problems are due primarily to the relatively flat topography and ill-defined character of the drainageway in some areas downstream of the Sussex urban service area. Anticipated stormwater management problems include the need to accommodate the increased stormwater runoff from proposed industrial development over the remaining 90 percent of the hydrologic unit. To accommodate this anticipated increase in runoff, approximately 1,080 feet of turf-lined, open channel and a 2.8-acre centralized detention basin with a volume of 9.8 acre-feet are proposed to be constucted. The culvert under Silver Spring Road is recommended to be replaced as a new component of the major drainage system. It is further recommended that consideration be given to improving the channel downstream of the Sussex urban service area on agricultural lands under the jurisdiction of the Town of Lisbon.

Approximately 50 percent of Hydrologic Unit S was urbanized in 1980. No problems related to the minor system were identified in the unit. Anticipated stormwater management problems include the need to accommodate the increased stormwater runoff from proposed new urban development over approximately 25 percent of the hydrologic unit. To accommodate this anticipated increase in runoff, approximately 1,500 feet of new storm sewer ranging in size from 18 inches to 42 inches in diameter is proposed to be constructed as part of the minor discharge system for the unit. In addition, approximately 2,300 feet of 12-inch-diameter storm sewer may have to be constructed to drain future land access and collector streets, the layout of which has not as yet been determined. The recommended minor drainage system improvements allow for the diversion of approximately 6.9 acres from the Pewaukee River subwatershed to the Sussex Creek subwatershed. This diversion includes lands designated for the proposed Sussex commercial center to be located south of Silver Spring Drive in this unit. Special consideration for appropriate diversion of the major drainage system flows from this area is required. By application of accepted urban design techniques, the street system required to support future urban development would provide the remainder of the necessary major drainage system conveyance capacity.

Approximately 90 percent of Hydrologic Unit T was urbanized in 1980. Four problems related to the minor system were identified in this unit. These consist of inadequate channel capacity along the abandoned Chicago, Milwaukee, St. Paul & Pacific Railroad, inadequate roadway ditch capacity along Maple Avenue, inadequate storm sewer capacity in Hickory Lane and Park Court, and inadequate channel capacity in the ditch that runs between Park Court and Maple Avenue. Anticipated stormwater management problems include the need to accommodate the increased stormwater runoff by improving the existing minor drainage system and by anticipating increases in impervious surfaces due to more complete development of existing urban areas. To improve the existing conditions in the problem areas and to accommodate anticipated runoff conditions, 6,510 feet of storm sewer ranging in size from 15 inches to 72 inches in diameter and a 1.6-acre centralized detention basin with a volume of 3.4 acre-feet are recommended as new components of the minor drainage system. In addition, approximately 1,000 feet of 12-inch-diameter storm sewer may have to be constructed to drain future land access and collector streets, the layout of which has not as yet been determined. Because of the limited slope of the roadway surface of Maple Avenue near the southern limits, it may not be possible to provide sufficient major system flow capacity within the street right-of-way. Accordingly, a portion of the property adjacent to roads in this area would be temporarily flooded following a 100-year recurrence interval storm event. This condition is not considered to be hazardous to property in this area, and, thus, no additional major system components have been recommended to relieve the temporary inundation.

Approximately 10 percent of Hydrologic Unit U was urbanized in 1980. No problems related to the minor system were identified in the unit. Anticipated stormwater management problems include the need to accommodate the increased stormwater runoff from proposed new development over an additional 80 percent of the hydrologic unit. To accommodate this anticipated increase in runoff, approximately 3,740 feet of new storm sewer ranging in size from 24 inches to 36 inches in diameter is proposed to be constructed as a part of the minor drainage system for the unit. In addition, approximately 2,900 feet of 12-inch-diameter storm sewer may have to be constructed to drain future land access and collector streets, the layout of which has not as yet been determined. By application of accepted urban design techniques, the street system required to support future urban development would provide the necessary major drainage system conveyance capacity.

Approximately 10 percent of Hydrologic Unit V was urbanized in 1980. No problems related to the minor system were identified in the unit. Anticipated stormwater management problems include the need to accommodate the increased stormwater runoff from proposed new development over an additional 80 percent of the hydrologic unit. To accommodate this anticipated increase in runoff, approximately 5,080 feet of new storm sewer ranging in size from 15 inches to 42 inches in diameter is proposed to be constructed as part of the minor drainage system. In addition, approximately 6,200 feet of 12-inch-diameter storm sewer may have to be constructed to drain future land access and collector streets, the layout of which has not as yet been determined. Approximately 960 feet of turf-lined, open channel are also recommended as a new component of the minor drainage system. By application of accepted urban design techniques, the street system required to support future urban development would provide the necessary major drainage system conveyance capacity.

Approximately 15 percent of Hydrologic Unit W was urbanized in 1980. No problems related to the minor system were identified in the unit. Anticipated stormwater conditions include increased stormwater runoff from proposed new development over an additional 35 percent of the hydrologic unit. Approximately 1,000 feet of 12-inch-diameter storm sewer may be required to provide drainage for future land access and collector streets, the layout of which has not as yet been determined. No other minor system or major system components are recommended for Hydrologic Unit W. By application of accepted urban design techniques, the street system required to support future urban development would provide the necessary major drainage system conveyance capacity.

Approximately 70 percent of Hydrologic Unit X was urbanized in 1980. One stormwater problem was identified in the unit. The problem consists of an inadequate open channel segment that conveys stormwater from Waukesha Avenue southeast through commercial land to a culvert under the Soo Line Railroad tracks. Anticipated stormwater management problems include the need to accommodate the increased stormwater runoff from proposed new urban development over an additional 30 percent of the hydrologic unit. To accommodate the existing excess runoff and anticipated increase in runoff, approximately 1,430 feet of new storm sewer ranging in size from 21 inches to 54 inches in diameter is proposed to be constructed as part of the minor drainage system, and 110 feet of 54-inch reinforced concrete culvert as part of the major drainage system. In addition, approximately 500 feet of 12-inch-diameter storm sewer may have to be constructed to drain future land access and collector streets, the layout of which has not as yet been determined. Because of the limited slope of Waukesha Avenue near the intersection of Clover Drive, it may not be possible to provide sufficient major system flow capacity within the street right-of-way. Accordingly, a portion of the property adjacent to Waukesha Avenue would be temporarily flooded following a 100-year recurrence interval storm. This condition is not considered to be hazardous to existing development, and with appropriate consideration in the design of future commercial and multi-family residential development, would not be hazardous to future development in this area. Thus, no additional major system components have been recommended to relieve the temporary inundation.

Approximately 10 percent of Hydrologic Unit Y was urbanized in 1980. No problems related to the minor system were identified in the unit. Anticipated stormwater management problems include the need to accommodate increased stormwater runoff from proposed new development over an additional 50 percent of the hydrologic unit and increased runoff from developing industrial lands upstream. To accommodate these anticipated increases in runoff, approximately 670 feet of new storm sewer ranging in size from 18 inches to 21 inches in diameter is proposed to be constructed as part of the minor drainage system. In addition, approximately 500 feet of 12-inch-diameter storm sewer is proposed to be constructed to drain future land access and collector streets, the layout of which has not as yet been determined. A 60-inch-diameter culvert and approximately 620 feet of turf-lined, open channel are recommended as a new component of the major drainage system. By application of accepted urban design techniques, the street system required to support future urban development, along with the new open channel, would provide the necessary major drainage system conveyance capacity.

Approximately 10 percent of Hydrologic Unit Z was urbanized in 1980. No problems related to the minor system were identified in the unit. Anticipated stormwater management problems include the need to accommodate increased stormwater runoff from proposed new development over an additional 15 percent of the hydrologic unit. To accommodate this anticipated increase in runoff, approximately 440 feet of turf-lined, open channel is proposed to be constructed as part of the minor drainage system, and 110 feet of 30-inch-diameter culvert is recommended as part of the major drainage system. By application of accepted urban design techniques, the street system required to support future urban development, along with the new open channel, would provide the majority of the necessary major drainage system conveyance capacity.

Approximately 5 percent of Hydrologic Unit AA was urbanized in 1980. No problems related to the minor system were identified in the unit. Anticipated stormwater management problems include the need to accommodate increased stormwater runoff from proposed new development over an additional 10 percent of the hydrologic unit. Approximately 500 feet of 12-inch-diameter storm sewer may be required to provide drainage for future land access streets, the layout of which has not as yet been determined. No other minor system or major system components are recommended for Hydrologic Unit AA. By application of accepted urban design techniques, the street system associated with proposed future development would provide the necessary major drainage system conveyance capacity.

Stormwater Management System Costs

The capital and operation and maintenance costs of the recommended stormwater management plan are presented by hydrologic unit and component in Tables 39 and 41. Table 39 presents those costs required for implementation of the minor drainage system and Table 41 presents those costs required for implementation of the major drainage system.

The capital cost of the recommended stormwater management plan is estimated to be $6.1 million, of which $5.7 million, or 93 percent, is attributed to the minor system costs, and $0.4 million, or 7 percent, is attributed to the major system costs. The annual operation and maintenance cost of the recommended stormwater management plan is estimated to be $30,300, of which $23,200, or 77 percent, is attributed to the minor system, and $7,100, or 23 percent, is attributed to the major system. These costs are based upon full development of the urban service area and do not include the cost of minimum diameter collector sewers that will be required to drain collector and land access roadways, the alignment of which has not as yet been determined, or the cost of the roadway sections that have been designated to function as a component of the major drainage system.

IMPACTS OF RECOMMENDED STORMWATER MANAGEMENT PLAN

Hydraulic Impacts

The primary impact of the recommended stormwater management plan is that storm flows from a 10-year recurrence interval storm event, or smaller, will be safely and efficiently conveyed by the minor drainage system to major drainage channels with only minimal inconvenience to residents. Also, storm flows from a 10-year to a 100-year recurrence interval storm event will not be significantly increased along the main stems of and major tributaries to Sussex Creek and Willow Springs Creek, and in some instances will be effectively reduced as a result of the stormwater management plan recommendations. Storm flows for the Pewaukee River will be somewhat increased immediately downstream of the urban service area; however, that increase will be substantially reduced at the downstream limits of the study area.

Water Quality Improvement

The recommended plan will provide water quality benefits in that it will result in the detention of some storm runoff, with subsequent settling of particulate pollutants within the detention facilities. The attendant reductions in such pollutants as biochemical-oxygen-demanding organic materials, nutrients, and toxic metals such as lead are consistent with, and serve to advance, the regional water quality management plan prepared and adopted by the Regional Planning Commission, and will help in achieving the recommended water quality standards in the stream system.[2]

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[2]See SEWRPC Planning Report No. 30, A Regional Water Quality Management Plan for Southeastern Wisconsin: 2000, Volume One, Inventory Findings; Volume Two, Alternative Plans; and Volume Three, Recommended Plan, 1979.

SUMMARY

Based on the best alternative for each of 27 hydrologic units in the Sussex urban service area, a recommended plan was developed which includes minor system components and major system components. The minor system components are designed for a 10-year recurrence interval peak flow, and the major system components are designed for a 100-year recurrence interval peak flow.

The recommended minor system components consist of 61,633 feet of new storm sewers with associated appurtenances, and five centralized detention facilities. The major system components include three detention basins, 2,980 feet of stream channel modifications, and 10,590 feet of new engineered open channels. The total capital cost of the recommended plan is $6.5 million, and the average annual operation and maintenance cost is about $30,000. The recommended plan will provide protection against substantial inconvenience to residents during minor storm events, and against major property damage or a hazard to human health and safety during major storm events. The stormwater management plan has not fully addressed the flooding problems along the main stem of Sussex Creek. This condition is recommended to be addressed in a comprehensive flood control study that considers the full spectrum of alternative flood control measures.

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Chapter IX

PLAN IMPLEMENTATION

INTRODUCTION

The recommended stormwater management plan described in Chapter VIII is designed to attain, to the maximum extent practicable, the stormwater management objectives and standards set forth in Chapter V of this report. In a practical sense, however, the plan is not complete until the steps to implement it--that is, to convert the plan into action policies and programs--have been specified. Following formal adoption of this plan by the Village of Sussex, 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 village officials and staff, land developers, and concerned citizens in undertaking the substantial investments and series of actions needed to provide the existing, as well as future, urban development in the Sussex area with an efficient and effective stormwater drainage system. The plan should be used as a guide for the development of the stormwater drainage system and related stormwater management measures in the Village and environs.

The first section of this chapter describes the importance of implementation of the adopted village land use plan to the effectiveness of the planned stormwater management measures. The second section discusses the importance of more detailed engineering to implementation of the plan. The third section sets forth the actions required to implement the plan. These include formal plan adoption; the establishment of a plan implementation program by the Village, including a capital improvement schedule for the required stormwater management facilities and agreement on the means of financing that schedule; and provision for the periodic reevaluation and updating of the plan itself.

IMPORTANCE OF LAND USE PLAN IMPLEMENTATION

Fundamental to implementation of the stormwater management plan is an understanding of the importance to sound stormwater management of the underlying village-adopted land use plan upon which the stormwater management plan is based. The adopted village land use plan is described in summary form in Chapter IV of this report, and is set forth in greater detail in SEWRPC Community Assistance Planning Report No. 51, A Land Use Plan for the Village of Sussex: 2000, Waukesha County, Wisconsin, 1982. To a large degree, the effectiveness of the recommended stormwater management measures will depend upon the degree to which the land use plan is implemented, since the land use and stormwater management plans supplement and complement each other.

Implementation of the stormwater management plan will assure that those areas designated for new urban development in the land use plan will be served by a stormwater drainage system that is economical and effective; which has the capacity to accommodate stormwater runoff from not only existing development but planned future development; and which will not exacerbate existing or create new downstream flooding problems. The plan also provides an estimate of the capital investment required to meet the stormwater management needs of new urban developments, allowing the public officials and developers concerned to fairly allocate immediate and future capital cost requirements, as well as to determine the operation and maintenance costs to be imposed upon the Village.

Implementation of the land use plan will, in turn, permit the development of a more economical stormwater management system because new urban development is proposed only in those areas which are most suitable for development with a minimum investment in engineered stormwater drainage systems, and because the new development will be at a density which economically justifies the provision of such systems. Implementation of the land use plan will also allow major conveyance and detention facilities to be constructed in a timely manner prior to complete development. Most importantly, implementation of the land use plan will permit the sizing of required stormwater drainage facilities with confidence that those facilities will be able to accommodate future as well as existing flows.

Importantly, the land use plan identifies those areas of the urban service area which should be preserved in open, natural uses, or in agricultural use. Such preservation will provide major economies in stormwater management--maximizing the use of natural stormwater conveyance and storage, and permitting such conveyance and storage to be incorporated into the stormwater management plan and system. If the preservation of these open areas is greatly compromised, stormwater management problems, such as localized flooding, poor drainage, and water pollution, may be expected to result.

RELATION OF DETAILED ENGINEERING DESIGN TO SYSTEM PLANNING

The systems-level stormwater management plan presented in this report is intended to serve as a guide to the future design and construction of stormwater management facilities. The detailed engineering phase begins where the systems planning phase ends. The detailed engineering design should concentrate on examining variations of the recommended solutions to problems identified in the system plan by examining in greater depth and detail the technical, economic, and environmental features of those variations in order to determine the best means of carrying out the system plan. The resulting facility development plans should thus not only be based upon, but should be fully consistent with, the stormwater collection, conveyance, and detention facility recommendations presented in Chapter VIII of this report. In this respect, more detailed land use development planning will also be essential to identifying, in a site-specific manner, the layout and extent of the storm sewer system needed to drain future land access and collector streets, the locations of which have not as yet been established through the preparation and adoption of platting layouts.

Chapter V of this report detailed certain engineering design criteria and analytical procedures used in the preparation and evaluation of the alternative stormwater management system plans. These criteria and procedures, firmly based in current engineering practice, provided the means for quantitatively sizing and analyzing the performance of both the minor and major stormwater drainage system components. These criteria and procedures should also serve as a basis for the more detailed design of stormwater management system components in the implementation of the recommended plan. It is important that such criteria and procedures be applied uniformly and consistently in all phases of implementation of the plan if the resulting system is to perform as envisioned in the plan. Accordingly, Table 44 sets forth the design criteria and analytical

Table 44

DESIGN CRITERIA AND PROCEDURES RECOMMENDED TO BE FOLLOWED IN THE DETAILED ENGINEERING DESIGN OF THE RECOMMENDED STORMWATER MANAGEMENT SYSTEM COMPONENTS

Design Function	Recommended Criteria and Procedure
Storm Runoff Flows	Minor system components should be designed to accommodate flows expected from a 10-year recurrence interval storm event. Major system components should be designed to accommodate flows expected from a 100-year recurrence interval storm event. To determine peak rates of flow for the design of pure conveyance facilities, the Rational Method should be used as described in SEWRPC Technical Record, Vol. 2, No. 4, April-May 1965, "Determination of Runoff for Urban Stormwater Drainage System Design." The rainfall intensity, duration, and frequency curves suitable for use with the Rational Method are provided in Figure 1 of Chapter III. When storage is to be included in the facilities and estimates of runoff volumes as well as peak rates of discharge are required, the modified Rational Method or a suitable hydrologic-hydraulic simulation model should be used.
Conveyance Facilities	Manning's Formula should be used to determine hydraulic capacities of conveyance facilities. Storm sewers should be designed to flow full during the design storm event. A chart relating storm sewer pipe size, slope, and capacity is provided in Figure 10 of Chapter V. Flow velocities should not be less than two nor more than 10 feet per second in storm sewers. The chart set forth in Figure 11 of Chapter V should be used to determine the hydraulic elements of storm sewers. A chart relating open channel cross-section slopes and capacity is provided in Figure 12 of Chapter V. Flow velocities should not exceed 5 feet per second in turf-lined channels.
Street Cross-Sections, Related Site Grading, and Curb-and-Gutter Sections	Except in special cases, streets should be designed with urban cross-sections providing curb and gutter. Typical street cross-sections are shown in Figure 27 of Chapter VI of this report. Slopes away from all buildings, as well as the slopes of interior drainage swales, should be at least one-quarter inch per foot to provide positive drainage.
Storm Sewer Inlets	Storm sewer inlet location and capacity should be dictated by the allowable stormwater spread and depth of flow in streets. Combination inlets should be used in most instances. Uncontrolled flow across streets should not be allowed when the streets are functioning as a part of the minor stormwater drainage system. Charts to assist in the determination of inlet capacities are provided in Figure 9 of Chapter V.
Culverts	The length and size of recommended culverts are set forth in Tables 38 and 40 of Chapter VIII. Culvert capacities should be determined by using the charts set forth in Figures 16 through 26 in Chapter V.
Detention Facilities	The recurrence interval design, size, capacity, and discharge rate of recommended centralized detention facilities are set forth in Table 39 of Chapter VIII. Storage volumes should be calculated using a modification of the Rational Method, or using a hydrologic-hydraulic simulation model. When practical, the length of the facility, as measured from the inlet to the outlet, should be at least twice the width. Basins should be wedge-shaped, with the inlet at the apex, or narrow end.

NOTE: For a more detailed discussion of these design criteria see Chapter V of this report.

Source: SEWRPC.

procedures recommended to be followed in the detailed engineering design of the recommended plan components. Criteria and procedures are presented in the table for estimating stormwater flows, calculating hydraulic capacities of conveyance facilities, designing street cross-sections and related site grading, locating and designing storm sewer inlets, designing storm sewers, designing open channels and culverts, and designing detention facilities. In this respect, it is recognized that over time new design techniques may be developed and become available for use in the design of stormwater management system components. Such techniques, however, should be carefully reviewed for consistency with the criteria and procedures set forth in the plan.

PLAN IMPLEMENTATION

Plan Adoption

An important first step in plan implementation is the formal adoption of the recommended stormwater management plan, as documented herein, by the Village of Sussex Plan Commission and by the Village Board. Upon such adoption, the stormwater management plan becomes the official guide to the making of stormwater management decisions by village officials. Such formal adoption serves to signify agreement with, and official support for, the recommendations contained in the plan, and enables the village staff to begin integrating the plan recommendations into the ongoing public works development planning and programming, and subdivision plat review processes of the Village.

Implementation Procedures

Following formal plan adoption, the Village can draw upon a number of legal and administrative tools to assist in plan implementation. These tools include subdivision plat review; a capital improvements program; and conformance with the zoning, official mapping, and neighborhood planning recommendations set forth in the adopted land use plan.

The review of subdivision plats by the Village Plan Commission should include an evaluation of conformance with both the land use plan and the stormwater management plan. Any proposed departures from the land use plan, which was used as a basis for the stormwater management system planning, should be carefully considered in light of the stormwater management needs of the proposed development and impacts on upstream and downstream areas. Except in isolated special instances, urban land subdivisions should be required to provide a full complement of stormwater collection, conveyance, and detention services and improvements which are fully consistent with the plan recommendations.

Capital improvements programming can also be an important tool for implementing the recommended stormwater management plan. Typically, a capital improvements program is a five-year program for the timing and financing of priority capital improvement projects. Such a program is based upon the projected financial capability of the community and is formulated from a detailed analysis of municipal revenues, debt service obligations, financing procedures, and external funding potentials. Once formulated, the program should be reevaluated, refined, and extended on an annual basis. It is recommended that the Village prepare a capital improvements program and that the stormwater management plan components be incorporated into the program in a manner consistent with the construction schedule set forth below.

Implementation of the zoning, official mapping, and neighborhood planning recommendations set forth in the adopted land use plan will ensure that the identified stormwater management needs and problems, and the layout and capacity of the recommended stormwater management system components, are in balance. In addition, unlike subdivision control which operates on a plat-by-plat basis, these administrative tools can operate over a wide area well in advance of development proposals, serving to increase public acceptance of the plan recommendations and improving the coordination between upstream development and downstram stormwater management. The preparation of detailed neighborhood development plans particularly will enable the more precise location and configuration of certain stormwater management facilities.

A common stormwater management problem facing municipalities is a lack of a sound and responsive operation and maintenance program for stormwater facilities, including periodic inspection and routine preventive maintenance. This problem is caused by the absence of an assured, continuous source of funding, and incomplete records to justify budgeting for this funding. Stormwater facility maintenance can be easily ignored for a limited period of time, and many officials and citizens alike incorrectly perceive that certain components, such as open channels or sewers, are self maintaining, or that no hazards will result if such facilities become defective. However--and particularly for a stormwater management system which includes various types of components such as storm sewers, open channels, and onsite and centralized detention facilities that are interrelated and interconnected--a sound, continuing, preventive maintenance program must receive a high priority. It is therefore recommended that the public works program of the Village provide for the continuing maintenance, as well as construction, of the stormwater management facilities--including periodic inspection of conveyance and detention facilities; timely repair of facilities; cleaning of storm sewers, open channels, and detention facility inlets and outlets; maintenance of open channel and detention facility lining materials; and periodic removal of accumulated sediment from conveyance and detention facilities.

PLAN SCHEDULE OF IMPLEMENTATION AND FINANCING

Upon adoption of the recommended stormwater management plan by the Village Board, full implementation of the plan will require that the equitable allocation of system development costs between the public sector and the private sector be determined, that the means of financing the plan components be identified, and that a schedule of capital and operation and maintenance costs be prepared. Public sector costs would primarily be borne by the Village of Sussex, although state or county funds could be used to construct and maintain certain stormwater drainage systems associated with state or county trunk highways. Private sector costs would, in most cases, be borne by land developers, and these costs would generally be passed onto individual land parcel purchasers.

Total plan implementation costs would include land acquisition, construction, operation and maintenance, facility replacement, and administration costs. The plan costs presented above, as well as the schedule of costs presented below, include only the construction, or capital, costs, and operation and maintenance costs. The schedule of capital and operation and maintenance costs would result in total plan implementation over the 20-year plan implementation period of 1983 to 2003. Land acquisition, facility replacement, and administrative costs are not included in the plan costs. Most of the recommended stormwater management facilities can be placed in public street rights-of-way. Nevertheless, land acquisition costs may be significant for some types of facilities, particularly in existing, developed areas. However, the acquisition of land by dedication during land development and the joint use of some facilities, such as the joint use of detention facilities for recreational activities, can minimize such acquisition costs. New facilities recommended in the plan are not expected to require replacement prior to the year 2000, and administration costs, such as the cost of reviewing the stormwater management elements of a subdivision plat by the village staff, are considered part of the normal village government expenditure.

Schedule of Public Sector and Private Sector Costs

The development of a plan implementation schedule requires that a construction completion date be designated for each recommended stormwater management component, and that it be determined whether each component will be funded by the public sector or the private sector. It is recommended that the highest priority for the construction of system components be given to those components which resolve existing stormwater problems, and secondarily to those remaining components which would serve existing urban development. Construction dates for the components designed to serve future urban development were established by considering when the urban development which would drain to the component would probably occur, and when affected upstream or downstream components should accordingly be constructed. In general, capital costs were assumed to be borne by the public sector if the components were designed to serve public property, or if the general public--not just the owners of the new development--would benefit from the component. Capital costs were assumed to be borne by the private sector if the primary benefit of the component would accrue to the new development. The following criteria were applied to allocate capital costs to the public sector and to the private sector:

1. Upgraded, existing, drainage system components intended to resolve existing stormwater problems, and components designed to serve public property, are assumed to be funded by the public sector.

2. Components, or portions of components, designed to serve specific, new private urban development are assumed to be funded by the private sector.

3. Components intended to serve specific, new, private urban development which must be oversized to provide capacity for additional upstream urban development in the future are assumed to be funded by both the public sector and the private sector. The portion of the total capital cost allocated to each sector is based upon the percentage of the total component service area covered by the specific new urban development. The private sector is assumed to finance the costs of serving the specific new urban development; the public sector is assumed to finance the costs of the oversizing required to serve the future additional urban development upstream.

All operation and maintenance costs for conveyance facilities--storm sewers and open channels--were assumed to be financed by the public sector, regardless of whether public sector or private sector funds were used to construct the facilities. It was assumed that all conveyance facilities constructed with private sector funds would be dedicated to the Village following construction. Public sector and private sector expenditures are listed in Table 45 for minor system components and Table 46 for major system components.

The recommended stormwater management program provides for the distribution of the necessary capital and operation and maintenance costs over the 20-year plan implementation period. This expenditure schedule is described graphically on Map 23 and is set forth in Table 47. Capital expenditures are described as public sector or private sector costs. The ultimate adoption of schedules of capital and operation and maintenance costs for implementation of the recommended plan will require a determination by village officials of not only those individual plan elements to be implemented and the timing of such implementation, but of the best means available of financing.

Public Sector Financing

Local governmental agencies have available several means of financing stormwater management components that are not available to the private sector. However, although these means offer flexibility, certain constraints and limitations are imposed on these financing methods by state law and, especially, by the approvals required of the electorate. Therefore, successful public financing of the recommended plan will require a thorough study of costs and revenues available, careful financial planning, public information programs, and a timely approach for securing public support and approvals.

In addition to using current tax revenue sources, such as property taxes, the Village of Sussex may make use of such revenue sources as user fees or special assessments, reserve funds, borrowing, tax incremental financing district funds, and gifts.

As of 1982, three tax incremental financing districts had been created in the Village of Sussex. When such a tax incremental district is created, a "tax incremental base" is established; this base is the aggregate value of all taxable property in the district as of the date of creation as equalized by the Wisconsin Department of Revenue. Any subsequent growth in the tax incremental district base is then "captured" so that as property value increases, levies on this growth represent positive dollar increments used for financing redevelopment. The effect of the tax incremental law, then, is to delay the availability to general government of the increase in values due to improvements in the tax incremental district until the public costs entailed in generating the development are paid for. Tax incremental financing could be an attractive means of financing some of the recommended stormwater management system components.

Borrowing, with the use of general obligation bonds, combined with property tax revenues may also be an effective and acceptable means of financing plan components. User fees, special assessment districts, and utility assessments, while being an equitable and dependable means of financing stormwater management, have not been widely used in southeastern Wisconsin, and, accordingly, may not be politically acceptable in the Village of Sussex.

State and federal grants are generally not available to finance stormwater management measures. It is recommended that the Village, in consideration of the costs and revenues involved, legal issues, equity concerns, and political

Table 45

ASSIGNMENT OF COSTS TO PUBLIC SECTOR AND PRIVATE SECTOR SOURCES FOR MINOR SYSTEM COMPONENTS OF THE RECOMMENDED STORMWATER MANAGEMENT PLAN

Hydrologic Unit Designation	Component Designation	Public Sector		Private Sector		Total	
		Capital	Annual Operation and Maintenance	Capital	Annual Operation and Maintenance	Capital	Annual Operation and Maintenance
A	1	$ --	$ 700	$ 221,400	--	$ 221,400	$ 700
A	2	--	2,000	22,500	--	22,500	2,000
C	1	462,200	1,100	270,400	--	732,600	1,100
C	2	--	100	10,000	--	10,000	100
C	3	--	200	73,000	--	73,000	200
C	4	--	100	3,600	--	3,600	100
C	5	--	100	15,200	--	15,200	100
D	1	288,800	1,000	287,900	--	576,700	1,000
D	2	--	100	33,800	--	33,800	100
D	3	--	400	121,900	--	121,900	400
D	4	--	100	26,000	--	26,000	100
D	5	4,900	100	--	--	4,900	100
D	6	13,800	100	--	--	13,800	100
D	7	--	300	103,300	--	103,300	300
D	8	22,200	100	--	--	22,200	100
E	1	--	200	58,500	--	58,500	200
E	2	--	100	33,300	--	33,300	100
F	1	--	300	134,200	--	134,200	300
H	1	--	200	101,500	--	101,500	200
I	1	--	300	94,900	--	94,900	300
J	1	92,600	600	119,600	--	212,200	600
J	2	--	2,000	18,000	--	18,000	2,000
L	1	--	100	47,200	--	47,200	100
L	2	--	100	39,000	--	39,000	100
L	3	--	200	71,800	--	71,800	200
M	1	78,900	500	150,800	--	229,700	500
N	1	--	100	23,800	--	23,800	100
O	1	16,800	100	--	--	16,800	100
O	2	4,400	100	--	--	4,400	100
P	1	323,300	500	93,100	--	416,400	500
Q	1	--	200	125,100	--	125,100	200
Q	2	--	100	57,600	--	57,600	100
Q	3	--	100	66,700	--	66,700	100
Q	4	23,000	2,000	--	--	23,000	2,000
R	1	--	400	16,200	--	16,200	400
R	2	--	2,000	12,000	--	12,000	2,000
S	1	--	300	162,900	--	162,900	300
S	2	31,600	200	32,700	--	64,300	200
T	1	505,550	1,200	295,450	--	801,000	1,200
T	2	26,000	100	--	--	26,000	100
T	3	12,000	2,000	--	--	12,000	2,000
U	1	--	400	151,100	--	151,100	400
U	2	--	300	101,400	--	101,400	300
V	1	--	1,000	374,900	--	374,900	1,000
V	2	--	400	14,400	--	14,400	400
X	1	164,600	300	47,700	--	212,300	300
Y	1	--	100	38,400	--	38,400	100
Z	1	3,300	200	3,300	--	6,600	200
Total	--	$2,073,950	$23,200	$3,674,550	--	$5,748,500	$23,200

Source: SEWRPC

and public acceptance, evaluate potential financing programs and develop a program which assures a sufficient, reliable funding source. Furthermore, as described above, incorporating expenditures for stormwater management facilities into a sound overall capital improvements program is an important means of prioritizing and scheduling the financing of the plan.

Private Sector Financing

For new urban developments which contain recommended stormwater management components to be financed by the private sector, provision of the recommended facilities would ordinarily be a condition of plat approval by the Village.

Table 46

ASSIGNMENT OF COSTS TO PUBLIC SECTOR AND PRIVATE SECTOR SOURCES FOR MAJOR SYSTEM COMPONENTS OF THE RECOMMENDED STORMWATER MANAGEMENT PLAN

Hydrologic Unit Designation	Component Designation	Public Sector		Private Sector		Total	
		Capital	Annual Operation and Maintenance	Capital	Annual Operation and Maintenance	Capital	Annual Operation and Maintenance
B	1	$ 24,800	$ 600	$ --	--	$ 24,800	$ 600
B	2	19,100	500	--	--	19,100	500
C	6	20,600	500	--	--	20,600	500
D	9	24,600	600	--	--	24,600	600
D	10	4,800	--	--	--	4,800	--
D	11	40,000	1,000	--	--	40,000	1,000
D	12	35,000	1,000	--	--	35,000	1,000
G	1	9,200	200	--	--	9,200	200
K	1	55,000	--	--	--	55,000	--
K	2	65,000	1,000	--	--	65,000	1,000
L	4	--	700	29,600	--	29,600	700
N	2	20,000	200	--	--	20,000	200
O	3	11,600	--	--	--	11,600	--
P	2	18,900	500	--	--	18,900	500
X	2	21,500	--	--	--	21,500	--
Y	2	--	300	12,300	--	12,300	300
Y	3	3,500	--	3,500	--	7,000	--
Z	2	9,900	--	--	--	9,900	--
Total	--	$383,500	$7,100	$45,400	--	$428,900	$7,100

Source: SEWRPC.

Thus, the costs would be ultimately borne by the land parcel purchasers. Contributions of materials and services to the Village may also be made by land developers.

PLAN REEVALUATION AND UPDATING

The recommended stormwater management components, as well as the underlying forecasts and assumptions used as a basis for plan development, should be reevaluated at 10-year intervals, in light of changes in actual village development. The plan components, including the need for certain facilities, as well as the location, size, and capacity of facilities, should be revised as necessary to reflect changing development patterns and stormwater management needs. In addition, in the initial plan development it was necessary, in most new urban areas, to limit the analysis and recommendations to major conveyance and detention facilities, since the layout of collector and land access streets had not been determined. A major effort in plan updating should be directed toward developing recommendations for these smaller diameter sewers as development plans are prepared, and incorporating this information into the master stormwater management plan.

SUMMARY

This chapter has presented the recommended means for implementing the stormwater management plan for the Village of Sussex planned urban service area through the year 2000. This plan should be used as a guide for stormwater drainage system development and other stormwater management measures within this urban service area. The chapter discusses the importance of implementa-
this urban service area. The chapter discusses the importance of implementa-
tion of the adopted village land use plan and the essential role of detailed engineering design activities in implementing the plan.

Table 47

SCHEDULE OF CAPITAL AND OPERATION AND MAINTENANCE EXPENDITURES FROM PUBLIC AND PRIVATE SOURCES OF THE RECOMMENDED STORMWATER MANAGEMENT PLAN: 1983-2003

Time Interval	Public Sector		Private Sector		Total	
	Capital	Annual Operation and Maintenance	Capital	Annual Operation and Maintenance	Capital	Annual Operation and Maintenance
1983-1987	$ 540,750	$10,700	$ 834,000	--	$1,374,750	$10,700
1988-1992	720,400	8,000	1,058,150	--	1,778,550	8,000
1993-1997	1,146,900	5,100	615,500	--	1,762,400	5,100
1998-2003	49,400	6,500	1,212,300	--	1,261,700	6,500
Total	$2,457,450	$30,300	$3,719,950	--	$6,177,400	$30,300

Source: SEWRPC.

The initial step in plan implementation is formal adoption of the plan by the Village Plan Commission and by the Village Board. The recommended plan should be integrated into the Village's public works program to initiate and administer construction of the recommended facilities, as well as to ensure reliable and stable operation and maintenance of the existing, and new, facilities. Implementation procedures recommended to be used by the Village to carry out the plan include review of subdivision plats to determine conformance with both the adopted land use plan and the recommended stormwater management plan; the incorporation of public expenditures for stormwater management into a sound overall capital improvements program for the Village; and the application of zoning, mapping, and neighborhood planning programs to encourage implementation of the land use plan.

The plan is recommended to be implemented over the 20-year period of 1983 to 2003. About $2.46 million, or about 40 percent of the total plan capital cost of about $6.18 million, is recommended to be borne by the public sector, primarily financed by the Village. The remaining $3.72 million, or about 60 percent of the capital cost, would be financed by the private sector, primarily by land developers and land parcel purchasers. Approximately $30,300, or about 100 percent of the total annual operation and maintenance cost, would be financed by the public sector. The total average annual cost of the recommended plan is about $339,000, or about $43.50 per person, based on the estimated 1993 population of 7,800 persons in the Sussex urban service area. The means of financing the public sector costs are recommended to be determined by village officials, but likely sources of funding include property tax revenues, general obligation bonds, and tax incremental financing district funds.

This stormwater management plan provides the Village of Sussex and its planned urban service area with important guidelines for coordinating land use development and stormwater drainage and control. Together with the adopted land use plan, the stormwater management plan will assist village officials in guiding the physical development of the Village and surrounding area. In this respect, implementation of the plan will contribute toward enhancing the overall quality of the environment within the village planned urban service area, and thereby contribute toward making the Village of Sussex a safer and more attractive and healthful, as well as more efficient and economical, area in which to live and work.

Map 23

ESTIMATED CONSTRUCTION COMPLETION DATES FOR THE RECOMMENDED STORMWATER MANAGEMENT PLAN

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APPENDICES

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Appendix A

DESIGN COMPUTATIONS FOR RECOMMENDED STORM SEWER COMPONENTS

Hydrologic Unit, Component, and Location	From Manhole Number	To Manhole Number	Length (feet)	Incremental Area (acres)	Cumulative Area (acres)	Time of Concentration (minutes)	Time in Sewer (minutes)	Intensity (inches per hour)	Runoff Coefficient	Weighted Runoff Coefficient	Design Flow (cfs)	Size (inches)	Slope (feet per foot)	Flow Capacity (cfs)	Velocity (feet per second)	Invert Elevation Upper	Invert Elevation Lower	Rim Elevation Upper	Rim Elevation Lower
Hydrologic Unit A Component A-1																			
	a-1	a-2	240	40.4	40.4	30.00	0.42	3.07	0.29	0.29	35.3	27	0.0130	35.3	9.5	975.3	972.2	978.2	974.0
To Detention Basin	a-2	Outfall	300	5.0	45.4	30.42	0.83	2.98	0.29	0.29	39.3	36	0.0040	43.0	6.0	972.2	971.0	974.0	- -
To Detention Basin	a-3	Outfall	270	7.0	7.0	10.00	- -	5.23	0.29	- -	10.6	18	0.0100	10.6	5.8	973.7	971.0	977.8	- -
From Detention Basin	Detention Basin	a-4	270	- -	- -	- -	0.73	- -	- -	- -	7.5[a]	15	0.0130	7.5	6.1	969.5	966.0	969.5	972.0
	a-4	a-7	350	- -	- -	10.00	0.60	5.32	- -	- -	7.5	15	0.0350	11.8	9.8	966.0	953.7	972.0	958.0
	a-7	a-8	450	5.0	5.0	10.60	1.04	6.12	0.29	0.29	14.9	21	0.0130	17.5	7.2	953.7	947.9	958.0	953.0
	a-8	a-9	310	9.4	14.4	11.64	0.66	4.93	0.29	0.29	28.1	27	0.0100	31.1	7.8	947.9	944.8	953.0	948.5
Good Hope Road	a-9	Outfall	30	10.9	25.3	12.30	- -	4.82	0.29	0.29	42.9	30	0.0160	50.0	10.2	944.8	944.3	948.5	- -
	a-5	a-6	500	6.5	6.5	10.00	0.52	5.23	0.29	- -	9.9	18	0.0140	12.0	7.0	962.5	955.5	967.0	960.0
	a-6	a-7	190	9.5	16.0	10.52	0.41	5.13	0.29	0.29	23.8	27	0.0105	31.0	7.8	955.5	953.5	960.0	958.5
Good Hope Road	a-10	a-11	320	2.3	2.3	10.00	0.63	5.23	0.29	0.29	3.5	12	0.0350	6.9	8.4	962.2	951.0	966.2	958.0
Good Hope Road	a-11	a-9	400	1.7	4.0	10.63	0.91	5.11	0.29	0.29	5.9	15	0.0200	8.8	7.3	951.0	943.0	958.0	948.5
Hydrologic Unit C Component C-1																			
	c-1	c-2	500	12.6	12.6	10.00	1.39	5.23	0.36	- -	23.7	27	0.0058	23.9	6.0	964.7	961.8	970.0	968.0
	c-2	c-3	240	7.5	20.1	11.39	0.59	4.98	0.27	0.33	33.0	30	0.0063	33.4	6.8	961.8	960.3	968.0	968.0
Good Hope Road	c-3	c-4	420	3.8	23.9	11.98	1.01	4.88	0.39	0.34	39.7	36	0.0055	48.8	6.9	960.3	958.0	968.0	964.0
Good Hope Road	c-4	c-5	420	14.7	38.6	12.99	0.77	4.71	0.27	0.31	56.4	36	0.0085	64.0	9.1	958.0	954.5	964.0	960.5
Good Hope Road	c-5	c-6	420	6.1	44.7	13.76	1.06	4.59	0.27	0.31	63.5	42	0.0038	63.5	6.6	954.5	952.9	960.5	964.5
Good Hope Road	c-6	c-7	420	4.1	48.9	14.82	0.55	4.44	0.27	0.30	65.0	42	0.0152	120.0	12.8	952.9	946.5	964.5	952.0
Maple Avenue	c-7	c-8	500	50.9	99.8	15.37	0.83	4.37	0.32	0.31	130.7	54	0.0050	140.0	10.1	946.5	944.0	952.0	949.5
Maple Avenue	c-8	c-9	460	3.4	103.2	16.20	1.13	4.26	0.29	0.31	132.1	60	0.0025	133.5	6.8	944.0	942.8	949.5	948.0
Maple Avenue	c-9	c-10	360	59.1	162.4	17.33	0.87	4.12	0.29	0.30	193.3	72	0.0020	200.0	6.9	942.8	942.1	948.0	950.0
	c-10	Outfall	90	4.8	167.2	4.22	0.20	4.02	0.29	0.30	201.5	72	0.0025	200.0	7.6	942.1	941.9	950.0	944.0
	c-12	c-13	500	14.6	14.6	10.00	1.48	5.23	0.29	0.29	22.2	27	0.0055	23.0	5.6	950.0	947.3	955.0	949.5
Good Hope Road	c-13	c-7	370	6.2	20.8	11.48	1.43	4.96	0.29	0.29	29.9	36	0.0020	30.0	4.3	947.3	946.5	949.5	952.0
Good Hope Road	c-14	c-13	500	3.1	3.1	5.00	2.53	6.42	0.29	0.29	5.8	18	0.0032	6.0	3.3	948.9	947.3	949.0	949.5
Maple Avenue	c-15	c-7	460	8.5	8.5	7.80	1.24	5.69	0.29	0.29	14.0	21	0.0087	14.8	6.2	50.5	46.5	956.0	957.0

Source: SEWRPC.

Appendix A (continued)

Hydrologic Unit, Component, and Location	From Manhole Number	To Manhole Number	Length (feet)	Incremental Area (acres)	Cumulative Area (acres)	Time of Concentration (minutes)	Time in Sewer (minutes)	Intensity (inches per hour)	Runoff Coefficient	Weighted Runoff Coefficient	Design Flow (cfs)	Size (inches)	Slope (feet per foot)	Flow Capacity (cfs)	Velocity (feet per second)	Invert Elevation		Rim Elevation	
																Upper	Lower	Upper	Lower
Component C-2																			
Lynne Anne Lane	c-16	Existing	280	1.6	1.6	5.00	1.01	6.42	0.29	- -	3.0	12	0.0107	3.6	4.6	950.3	947.3	955.0	952.0
Component C-3																			
	c-17	c-18	410	7.6	7.6	7.00	1.29	5.88	0.29	- -	12.9	24	0.0060	13.0	5.3	954.5	952.0	958.0	957.0
Michele Lane Extended	c-18	c-19	330	6.2	13.8	8.29	0.86	5.58	0.29	0.29	26.1	27	0.0065	26.1	6.4	952.0	949.9	957.0	954.0
Michele Lane Extended	c-19	Existing	130	3.0	16.8	9.15	0.42	5.40	0.29	0.29	26.3	36	0.0031	38.0	5.2	949.9	949.5	954.0	954.0
Component C-4																			
Meadow Lane Extended	c-20	Existing	50	2.8	2.8	8.30	0.14	5.58	0.29	0.29	4.5	15	0.0110	6.9	5.7	963.0	962.7	966.0	966.5
Prides Road Extended	c-21	Existing	340	5.5	5.5	8.10	0.54	5.62	0.29	- -	9.0	15	0.0410	12.9	10.5	992.3	978.4	998.0	984.0
Hydrologic Unit D[b]																			
Component D-1																			
	d-1	d-2	300	9.0	9.0	10.00	0.49	5.23	0.29	- -	13.6	18	0.0330	18.0	10.2	1,001.5	991.5	1,006.0	996.0
	d-2	d-3	140	15.7	24.7	10.49	0.19	5.14	0.29	0.29	36.8	24	0.0280	37.0	12.0	991.5	987.5	996.0	995.0
	d-3	d-3a	280	- -	24.7	10.68	0.34	5.10	- -	0.29	36.5	27	0.0304	53.0	13.8	987.5	979.0	995.0	984.6
	d-3a	d-4	380	1.0	25.7	11.02	0.57	5.04	0.29	0.29	37.6	27	0.0138	37.6	9.4	979.0	974.6	984.6	982.0
	d-4	d-5	480	34.5	60.2	11.59	0.56	4.94	0.29	0.29	86.2	36	0.0221	101.0	14.2	974.6	964.0	982.0	970.0
	d-5	d-6	280	28.8	89.0	12.15	0.27	4.85	0.29	0.29	125.0	42	0.0268	168.0	17.2	964.0	956.5	970.0	962.0
	d-6	d-7	500	2.6	91.6	12.42	0.76	4.80	0.29	0.29	127.5	48	0.0092	138.0	11.0	956.5	951.9	962.0	956.0
	d-7	d-8	520	3.6	95.2	13.18	0.63	4.68	0.29	0.29	129.2	48	0.0133	170.0	13.8	951.9	945.0	956.0	952.5
	d-8	d-9	300	48.8	144.0	13.81	0.20	4.59	0.29	0.29	191.7	48	0.0483	310.0	25.0	945.0	930.5	952.5	935.0
	d-9	Outfall	240	- -	144.0	14.01	0.25	4.56	- -	0.29	190.4	48	0.0208	195.0	16.0	930.5	925.5	935.0	- -
	d-11	d-12	300	16.8	16.8	12.00	0.36	4.87	0.29	0.29	23.7	18	0.0517	24.5	14.0	999.5	984.0	1,004.0	988.0
	d-12	d-4	240	11.9	28.7	12.36	0.25	4.81	0.29	0.29	40.0	27	0.0392	61.0	16.0	984.0	974.6	988.0	981.0
Good Hope Road	d-13	d-14	500	8.0	8.0	10.00	1.16	5.23	0.29	0.29	12.1	18	0.0150	12.5	7.2	974.7	967.2	979.2	972.0
Good Hope Road	d-14	d-5	500	6.0	14.0	11.16	1.34	5.02	0.29	0.29	20.4	27	0.0064	24.0	6.2	967.2	964.0	972.0	970.0
Waukesha Avenue	d-49	d-50	200	0.8	0.8	5.00	0.33	6.42	0.29	- -	1.5	12	0.0485	8.0	10.0	963.5	954.0	967.5	958.0
Waukesha Avenue	d-50	d-8	200	1.3	2.1	5.33	0.35	6.32	0.29	0.29	3.8	12	0.0459	7.8	9.5	954.0	945.0	958.0	952.5
Component D-2																			
	d-15	d-15a	300	17.3	17.3	25.00	0.26	3.37	0.29	0.29	17.0	15	0.1267	23.8	19.2	1,000.0	962.0	1,004.0	966.0
	d-15a	d-16	160	7.2	24.5	25.26	0.16	3.35	0.29	0.29	23.8	18	0.0819	28.0	16.8	962.0	948.9	966.0	953.2
	d-16	Outfall	200	3.5	28.0	25.42	0.34	3.33	0.29	0.29	27.0	21	0.0295	30.0	9.8	948.9	943.0	953.2	- -
Component D-4																			
	d-29	d-30	97	0.7	0.7	5.00	0.24	6.42	0.24	- -	1.1	12	0.0206	5.2	6.6	1,002.0	1,001.0	1,008.0	1,006.0
	d-30	d-31	166	1.0	1.7	5.24	0.26	6.35	0.24	0.32	2.6	12	0.0540	8.2	10.5	1,001.0	991.5	1,006.0	997.0
	d-31	d-32	166	1.0	2.7	5.50	0.29	6.27	0.24	0.32	4.1	12	0.0420	7.4	9.4	991.5	983.0	997.0	990.0
	d-32	Existing	225	2.4	5.1	5.79	0.36	6.19	0.24	0.32	7.6	12	0.0524	8.1	10.3	983.0	972.1	990.0	979.8
Component D-5																			
	d-33	Outfall	110	0.9	0.9	5.00	0.10	6.42	0.29	0.32	- -	12	0.1450	13.7	17.5	946.0	930.0	950.0	- -

Appendix A (continued)

Hydrologic Unit, Component, and Location	From Manhole Number	To Manhole Number	Length (feet)	Incremental Area (acres)	Cumulative Area (acres)	Time of Concentration (minutes)	Time in Sewer (minutes)	Intensity (inches per hour)	Runoff Coefficient	Weighted Runoff Coefficient	Design Flow (cfs)	Size (inches)	Slope (feet per foot)	Flow Capacity (cfs)	Velocity (feet per second)	Invert Elevation		Rim Elevation	
																Upper	Lower	Upper	Lower
Component D-6																			
Waukesha Avenue	d-34	d-35	220	3.0	3.0	5.00	0.59	6.42	0.29	0.32	5.6	15	0.0150	7.6	6.2	937.7	934.9	942.0	939.0
	d-35	Outfall	90	22.3	25.3	5.59	0.08	6.25	0.29	0.32	50.6	24	0.0710	60.0	19.1	934.9	928.0	939.0	- -
Component D-8																			
Waukesha Avenue	d-47	d-48	370	2.1	2.1	5.00	1.31	6.42	0.29	0.29	3.9	15	0.0081	6.0	4.7	929.0	926.0	934.0	931.0
	d-48	Outfall	70	3.9	6.0	6.31	0.10	5.06	0.29	0.29	10.5	15	0.0500	14.8	12.0	926.0	922.5	931.0	- -
Hydrologic Unit E																			
Component E-1																			
	e-1	e-2	450	0.6	0.6	10.00	2.34	5.23	0.32	- -	1.0	12	0.0051	2.8	3.2	925.5	923.2	931.0	928.5
	e-3	e-2	430	5.8	5.8	15.00	1.63	4.42	0.32	- -	8.2	21	0.0042	10.7	4.4	925.0	923.2	930.2	928.5
	e-2	Outfall	240	8.0	13.8	16.63	0.54	4.20	0.32	0.32	18.5	21	0.0121	18.5	7.4	923.2	920.3	928.5	- -
Component E-2																			
Good Hope Road	e-4	e-5	260	1.2	1.2	5.00	0.59	6.42	0.32	0.32	2.5	12	0.0269	5.8	7.4	929.0	922.0	934.0	926.0
Good Hope Road	e-5	e-5a	470	2.1	3.3	5.59	1.42	6.25	0.32	0.32	6.6	18	0.0081	9.5	5.5	922.0	918.2	926.0	920.6
	e-5a	Outfall	30	- -	3.3	7.01	0.09	5.88	0.32	0.32	6.2	18	0.0081	9.5	5.5	918.2	918.0	920.6	- -
Hydrologic Unit F																			
Component F-1																			
	f-1	f-2	280	39.1	39.1	30.00	0.42	3.01	0.28	0.28	33.0	24	0.0232	36.0	11.2	925.0	918.5	931.0	924.5
	f-2	f-3	300	8.2	47.3	30.42	0.61	2.98	0.28	0.28	39.4	36	0.0074	58.0	8.2	918.5	916.2	924.5	919.3
	f-3	f-4	330	7.0	54.3	31.03	0.67	2.95	0.28	0.28	44.8	36	0.0074	58.0	8.2	916.2	913.8	919.3	917.5
Good Hope Road	f-4	Outfall	250	12.3	66.6	31.70	0.51	2.90	0.28	0.28	54.1	36	0.0074	58.0	8.2	913.8	912.0	917.5	- -
Good Hope Road	f-5	f-4	500	1.2	1.2	5.00	2.25	6.42	0.28	- -	2.2	12	0.0064	3.0	3.7	917.0	918.8	921.0	917.5
Hydrologic Unit H																			
Component H-1																			
	h-1	h-2	480	6.2	6.2	7.00	1.19	5.88	0.33	0.33	16.0	21	0.0100	10.6	6.7	943.0	938.0	949.0	944.0
	h-2	h-3	120	10.7	16.9	8.19	0.09	5.61	0.38	0.36	34.1	21	0.1200	52.0	22.0	938.0	923.6	944.0	939.6
	h-3	h-4	210	1.2	18.1	8.28	0.26	5.59	0.38	0.36	36.4	24	0.0362	43.5	13.5	923.6	916.0	939.6	922.0
Waukesha Avenue	h-4	h-5	340	6.0	24.1	8.54	0.50	5.53	0.38	0.37	49.3	30	0.0176	55.0	11.3	916.0	910.0	922.0	916.0
To Detention Basin	h-5	Outfall	120	11.1	35.2	9.04	0.11	5.42	0.33	0.36	68.7	30	0.0500	90.0	19.0	910.0	904.0	916.0	- -
Hydrologic Unit I																			
Component I-1																			
Donna Drive Extended	i-1	i-2	430	1.0	1.0	5.00	1.05	6.42	0.33	0.33	2.1	12	0.0228	5.4	6.8	973.0	963.2	979.0	969.2
Donna Drive Extended	i-2	i-3	500	10.6	11.6	6.05	1.24	6.13	0.36	0.36	25.3	27	0.0075	20.4	6.7	963.2	959.5	969.2	965.5
Donna Drive Extended	i-3	Existing	480	10.9	22.5	7.29	0.59	5.81	0.36	0.36	47.0	27	0.0313	55.0	13.5	959.5	944.5	965.5	951.2

Appendix A (continued)

Hydrologic Unit, Component, and Location	From Manhole Number	To Manhole Number	Length (feet)	Incremental Area (acres)	Cumulative Area (acres)	Time of Concentration (minutes)	Time in Sewer (minutes)	Intensity (inches per hour)	Runoff Coefficient	Weighted Runoff Coefficient	Design Flow (cfs)	Size (inches)	Slope (feet per foot)	Flow Capacity (cfs)	Velocity (feet per second)	Invert Elevation		Rim Elevation	
																Upper	Lower	Upper	Lower
Hydrologic Unit J																			
Component J-1	j-1	j-2	500	5.3	5.3	10.00	1.04	5.23	0.31	--	8.6	18	0.0200	14.0	8.0	950.0	940.0	955.0	942.0
To Detention Basin	j-2	Outfall	100	12.8	18.1	11.04	0.17	5.04	0.31	0.31	28.3	24	0.0200	31.0	9.9	940.0	938.0	942.0	938.0
From Detention Basin	Detention Basin	j-5	180	--	--	10.00	0.46	--	--	--	5.0[c]	15	0.0170	8.0	6.5	937.0	934.0	937.0	937.6
Orchard Drive Extended	j-8	j-6	250	1.8	1.8	5.00	1.10	6.42	0.31	--	3.6	15	0.0056	4.7	3.8	932.0	930.5	935.0	931.0
	j-3	j-4	500	4.8	4.8	10.00	1.81	5.23	0.31	0.31	7.8	18	0.0060	8.2	4.6	942.0	939.0	946.0	945.0
	j-4	j-5	500	4.7	9.5	11.81	1.11	4.90	0.31	0.31	14.4	21	0.0130	18.0	7.5	939.0	932.5	945.0	937.5
	j-5	j-6	440	9.3	18.8	12.92	1.16	4.72	0.31	0.31	32.5[c]	36	0.0045	27.5	6.3	932.5	930.5	937.5	931.0
	j-6	j-7	400	7.4	26.2	14.08	1.06	4.55	0.31	0.31	42.0[c]	36	0.0045	45.0	6.3	930.5	928.7	931.0	933.0
	j-7	Outfall	160	3.1	29.3	15.14	0.42	4.40	0.31	0.31	45.0[c]	36	0.0045	45.0	6.3	928.7	928.0	933.0	931.0
Hydrologic Unit L																			
Component L-1	l-1	l-2	500	5.3	5.3	15.00	1.85	4.42	0.60	0.60	14.0	24	0.0037	14.1	4.5	941.0	939.2	942.0	939.0
	l-2	Outfall	100	8.8	14.1	16.85	0.23	4.18	0.60	0.60	35.4	30	0.0077	35.8	7.3	939.2	938.4	939.0	--
Component L-2	l-3	l-4	480	3.0	3.0	15.00	2.35	4.42	0.60	0.60	8.0	21	0.0026	8.2	3.4	940.2	939.0	944.0	941.5
	l-4	Outfall	100	3.6	6.6	17.35	0.24	4.12	0.60	0.60	16.3	21	0.0100	16.6	6.9	939.0	938.0	941.5	--
Component L-3	l-5	l-6	500	3.0	3.0	5.00	1.98	6.42	0.40	0.40	7.7	18	0.0050	7.7	4.2	941.0	938.5	943.0	940.5
	l-6	Outfall	280	9.4	12.4	6.98	0.85	5.89	0.40	0.40	29.2	30	0.0050	29.5	5.5	938.5	937.1	940.5	--
	l-7	l-6	280	3.7	3.7	5.00	1.20	6.42	0.40	0.40	9.5	21	0.0035	9.5	3.9	939.5	938.5	940.5	940.5
Hydrologic Unit M																			
Component M-1																			
Locust Street	m-1	m-2	300	11.1	11.1	10.00	1.16	5.23	0.29	--	16.8	30	0.0018	17.0	4.3	933.5	932.6	938.5	940.5
Locust Street	m-2	m-3	350	1.7	12.8	11.16	2.24	5.02	0.29	0.29	18.6	36	0.0008	19.0	2.6	932.6	932.1	940.5	937.5
Locust Street	m-3	m-4	200	1.4	14.6	13.40	1.19	4.65	0.29	0.29	19.1	36	0.0009	20.0	2.8	932.1	931.8	937.5	936.7
Locust Street	m-4	Outfall	200	33.9	48.1	14.59	0.37	4.47	0.29	0.29	62.4	42	0.0045	64.0	7.0	931.8	930.0	936.7	--
Champeny Road	m-5	m-6	300	11.4	11.4	6.35	1.35	6.05	0.29	--	20.0	36	0.0017	22.0	3.7	932.8	932.3	936.5	935.5
Champeny Road	m-6	m-4	300	5.7	17.1	7.70	1.19	5.72	0.29	0.29	28.4	36	0.0020	29.0	4.2	932.3	931.7	935.5	936.7
Champeny Road	m-7	m-8	150	6.9	6.9	5.00	0.45	6.42	0.29	--	12.8	21	0.0073	13.0	5.5	935.5	934.4	940.5	940.0
Champeny Road	m-8	m-9	200	--	6.9	5.45	0.83	6.29	--	0.29	12.6	24	0.0032	12.6	4.0	934.4	933.8	940.0	938.0
Champeny Road	m-9	m-4	300	4.0	10.9	6.28	0.82	6.06	0.29	0.29	19.1	24	0.0070	19.1	6.1	933.8	931.7	938.0	936.7
Ivy Avenue	m-10	Outfall	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Ivy Avenue	m-11	Outfall	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Hydrologic Unit N																			
Component N-1																			
Maple Avenue	n-1	Existing Sewer	370	5.6	5.6	5.00	--	6.42	0.32	0.32	11.5	18	0.0160	13.0	7.6	927.0	921.1	933.0	927.0
Hydrologic Unit O																			
Component O-1																			
Waukesha Avenue	o-1	Culvert	380	4.5	4.5	20.00	1.11	3.82	0.39	0.39	6.7	15	0.0125	7.0	5.7	902.8	898.0	907.0	901.0
Component O-2																			
Waukesha Avenue	0-2	Outfall	70	2.8	2.8	20.00	--	3.82	0.43	--	4.6	15	0.0060	5.0	4.1	--	898.0	899.5	--

Appendix A (continued)

Hydrologic Unit, Component, and Location	From Manhole Number	To Manhole Number	Length (feet)	Incremental Area (acres)	Cumulative Area (acres)	Time of Concentration (minutes)	Time in Sewer (minutes)	Intensity (inches per hour)	Runoff Coefficient	Weighted Runoff Coefficient	Design Flow (cfs)	Size (inches)	Slope (feet per foot)	Flow Capacity (cfs)	Velocity (feet per second)	Invert Elevation		Rim Elevation	
																Upper	Lower	Upper	Lower
Hydrologic Unit P																			
Component P-1																			
Main Street	p-1	p-2	500	19.1	19.1	20.00	0.97	3.82	0.60	- -	43.8	36	0.0100	51.0	8.6	902.4	897.7	908.2	903.0
Main Street	p-2	p-3	500	10.0	29.1	20.97	0.90	3.72	0.60	0.60	65.0	36	0.0100	65.0	9.3	897.7	892.7	903.0	900.0
Main Street	p-3	p-4	400	7.4	36.5	21.87	0.79	3.64	0.60	0.60	79.7	42	0.0065	80.0	8.4	892.7	890.1	900.0	897.0
Main Street	p-4	p-5	500	11.7	48.2	22.66	0.95	3.57	0.60	0.60	103.1	48	0.0062	110.0	8.8	890.1	887.0	897.0	893.5
Main Street	p-5	p-6	400	8.6	56.8	23.61	0.69	3.48	0.60	0.60	118.7	48	0.0070	120.0	9.6	887.0	884.2	893.5	891.5
Main Street	p-6	p-7	330	7.2	64.0	24.30	0.65	3.42	0.60	0.60	131.5	54	0.0050	132.0	8.4	884.2	882.6	891.5	887.7
Main Street	p-7	Outfall	100	4.3	68.3	24.95	0.18	3.37	0.60	0.60	138.0	54	0.0060	138.0	9.2	882.6	882.0	887.7	- -
Hydrologic Unit Q																			
Component Q-1																			
Sussex Road	q-1	q-2	280	6.2	6.2	6.00	0.77	6.14	0.50	0.50	19.0	24	0.0070	20.0	6.1	884.0	882.0	887.5	885.5
Sussex Road	q-2	q-3	300	2.2	8.4	6.77	0.94	5.94	0.50	0.50	24.9	30	0.0033	39.0	5.3	882.0	881.1	885.5	884.5
Village Drive	q-3	q-4	340	4.7	13.1	7.84	1.07	5.71	0.50	0.50	37.4	36	0.0033	39.0	5.3	881.1	879.9	884.5	883.5
	q-4	Outfall	100	- -	14.0	8.55	0.31	5.53	0.50	0.50	38.7	36	0.0033	39.0	5.4	879.9	879.6	883.5	- -
Component Q-2																			
Village Drive	q-5	q-6	320	4.5	4.5	6.00	1.21	6.14	0.50	0.50	13.8	24	0.0038	14.2	4.4	881.6	880.4	885.0	883.5
Village Drive	q-6	q-7	130	1.8	6.3	7.21	0.54	5.83	0.50	0.50	18.4	30	0.0023	19.5	4.0	880.4	880.1	883.5	883.3
Village Drive	q-7	q-8	110	0.7	7.0	7.75	0.42	5.70	0.50	0.50	19.9	30	0.0027	21.0	4.4	880.1	879.8	883.3	883.0
	q-8	Outfall	80	0.6	7.6	9.17	0.26	5.61	0.50	0.50	21.3	30	0.0038	25.0	5.1	879.8	879.5	883.0	- -
Component Q-3																			
Sussex Road	q-9	q-10	230	3.1	3.1	5.00	0.81	6.42	0.50	0.50	9.95	21	0.0050	11.5	4.7	879.6	878.5	883.0	881.7
Sussex Road	q-10	q-11	250	3.0	6.1	5.81	0.89	6.20	0.50	0.50	18.9	30	0.0032	23.0	4.7	878.5	877.7	881.7	881.0
Sussex Road	q-11	Outfall	230	4.3	10.4	6.70	0.57	5.96	0.50	0.50	31.0	36	0.0032	38.0	5.4	877.7	876.9	881.0	- -
Hydrologic Unit S																			
Component S-1																			
	s-1	s-2	400	3.5	3.5	5.00	1.15	6.42	0.80	- -	18.0	24	0.0065	18.2	5.8	905.5	902.9	910.5	908.0
	s-2	s-3	600	7.7	11.2	6.15	1.49	6.10	0.80	0.80	54.7	42	0.0048	55.0	6.7	902.9	900.0	908.0	905.0
	s-3	s-4	400	9.9	21.1	7.64	0.83	5.73	0.80	0.80	96.7	48	0.0050	100.0	8.0	900.0	898.0	905.0	908.0
	s-4	Outfall	100	- -	21.1	8.47	- -	5.55	- -	0.80	93.7	48	0.0530	330.0	18.0	898.0	892.6	908.0	- -
Component S-2																			
	s-5	s-6	280	7.2	7.2	10.00	0.88	5.23	0.32	0.32	16.7	24	0.0055	17.0	5.3	894.0	892.5	900.0	898.5
	s-6	s-7	330	5.2	12.4	10.88	1.06	5.07	0.32	0.32	20.1	27	0.0045	22.0	5.2	892.5	891.0	848.5	896.5
	s-7	Outfall	320	4.3	16.7	11.94	0.83	4.88	0.32	0.32	26.0	27	0.0066	26.0	6.4	891.0	888.8	896.5	

Appendix A (continued)

Hydrologic Unit, Component, and Location	From Manhole Number	To Manhole Number	Length (feet)	Incremental Area (acres)	Cumulative Area (acres)	Time of Concentration (minutes)	Time in Sewer (minutes)	Intensity (inches per hour)	Runoff Coefficient	Weighted Runoff Coefficient	Design Flow (cfs)	Size (inches)	Slope (feet per foot)	Flow Capacity (cfs)	Velocity (feet per second)	Invert Elevation Upper	Invert Elevation Lower	Rim Elevation Upper	Rim Elevation Lower
Hydrologic Unit T																			
Component T-1																			
CMStP&P Railroad Right-of-way	t-1	t-2	250	16.8	16.8	10.00	0.30	5.23	0.30	0.30	36.4[d]	24	0.0360	43.0	13.7	936.0	927.0	941.0	932.0
CMStP&P Railroad Right-of-way	t-2	t-3	300	1.7	18.5	0.30	0.46	5.18	0.50	0.32	40.6[d]	27	0.0200	42.0	10.8	927.0	921.0	932.0	928.0
CMStP&P Railroad Right-of-way	t-3	t-4	320	3.6	22.1	10.76	0.50	5.09	0.50	0.35	49.4[d]	30	0.0160	51.0	10.6	921.0	915.8	928.0	922.0
CMStP&P Railroad Right-of-way	t-4	t-5	470	3.5	25.6	11.26	0.81	5.00	0.50	0.37	57.4[d]	36	0.0120	57.5	9.7	915.8	910.0	922.0	916.0
Maple Avenue	t-5	t-6	260	14.7	40.3	12.07	0.38	4.80	0.60	0.45	98.2[d]	42	0.0130	105.0	11.4	910.0	906.5	916.0	910.5
Maple Avenue	t-6	t-7	460	32.4	72.7	12.45	0.64	4.80	0.31	0.39	146.1[d]	48	0.0100	148.0	11.9	906.5	901.9	910.5	907.5
Maple Avenue	t-7	t-8	350	8.2	80.9	13.09	0.59	4.70	0.31	0.38	154.5[d]	54	0.0065	156.0	9.8	901.9	899.6	907.5	904.0
Maple Avenue	t-8	t-9	240	6.7	87.6	13.68	0.38	4.61	0.30	0.37	159.4[d]	54	0.0075	165.0	10.6	899.6	897.8	904.0	901.0
Maple Avenue	t-9	t-10	220	36.1	123.7	14.06	0.35	4.55	0.29	0.35	204.8[d]	60	0.0070	206.0	10.6	897.8	896.3	901.0	899.5
Maple Avenue	t-10	t-11	520	9.7	133.4	14.41	1.06	4.50	0.31	0.35	220.1[d]	72	0.0029	225.0	8.2	896.3	894.8	899.5	900.0
	t-11	Outfall																	
Sumac Lane	t-12	t-8	370	4.5	4.5	10.00	2.13	5.23	0.29	0.29	6.8	21	0.0019	7.0	2.9	899.7	899.0	902.5	904.0
	t-13	t-14	400	2.8	2.8	5.00	1.36	6.42	0.29	0.29	5.2	15	0.0090	6.0	4.9	905.6	902.0	910.0	904.9
Hickory Lane	t-14	t-15	480	7.3	10.1	6.36	1.78	6.04	0.29	0.29	17.7	27	0.0033	18.0	4.5	902.0	900.4	904.9	908.3
Park Court	t-15	t-16	400	3.3	13.4	8.14	1.48	5.62	0.29	0.29	21.8	30	0.0030	22.0	4.5	900.4	899.2	908.3	900.8
Park Court	t-16	t-17	250	9.2	22.6	9.62	0.83	5.31	0.29	0.29	34.8	36	0.0028	35.0	5.0	899.2	898.5	900.8	899.5
	t-17	t-18	410	1.8	24.4	10.45	1.71	5.15	0.29	0.29	36.4	42	0.0015	38.0	4.0	898.5	897.9	899.5	898.0
	t-18	t-9	400	4.4	28.8	12.16	1.52	4.85	0.29	0.29	40.5	42	0.0018	41.0	4.4	897.9	897.2	898.0	901.0
Component T-2																			
Main Street	t-19	t-20	200	6.0	6.0	10.00	0.64	5.23	0.17	0.17	5.3	15	0.0160	9.5	4.0	942.0	938.8	946.0	946.6
Main Street	t-20	t-21	150	2.1	8.1	10.64	0.38	5.11	0.85	0.35	14.5	21	0.0160	20.0	9.1	938.8	936.4	941.6	938.0
Main Street	t-21	Outfall	60	1.4	9.5	11.02	0.14	5.04	0.85	0.42	20.1	24	0.0100	22.0	7.0	936.4	935.8	938.0	937.0
Hydrologic Unit U																			
Component U-1																			
	u-1	u-2	450	10.3	10.3	20.00	2.14	3.82	0.29	0.29	11.4	24	0.0026	11.7	3.5	945.7	944.5	949.0	949.5
	u-2	u-3	400	4.2	14.5	22.14	1.71	3.61	0.29	0.29	15.2	27	0.0025	15.5	3.9	944.5	943.5	949.5	948.0
	u-3	u-4	400	8.5	23.0	23.85	1.01	3.46	0.29	0.29	23.1	27	0.0070	26.0	6.6	943.5	940.7	948.0	944.0
	u-4	u-5	430	5.7	28.7	24.86	1.75	3.38	0.29	0.29	28.2	36	0.0020	29.0	4.1	940.7	939.9	944.0	944.0
	u-5	Outfall	220	3.7	32.4	26.61	0.85	3.24	0.29	0.29	30.4	36	0.0023	31.0	4.3	939.9	939.4	944.0	- -
Component U-2																			
	u-10	u-11	350	4.7	4.7	15.00	1.10	4.42	0.31	0.31	6.4	15	0.0090	6.5	5.3	946.5	943.4	950.5	947.5
	u-11	u-8	350	2.1	6.8	16.10	1.08	4.27	0.34	0.32	9.3	18	0.0090	9.5	5.4	943.4	940.2	947.5	944.5
Main Street	u-6	u-7	410	0.6	0.6	2.00	2.97	7.42	0.48	0.48	2.1	15	0.0020	2.9	2.3	943.6	942.8	947.0	945.2
Main Street	u-7	u-8	360	2.8	3.4	4.97	1.22	6.42	0.35	0.37	8.1	18	0.0066	8.6	4.9	942.8	940.4	945.2	944.5
Main Street	u-8	u-9	290	15.7	25.9	17.18	0.80	4.14	0.31	0.27	28.9	30	0.0058	30.0	6.0	940.2	938.5	944.5	942.0
Main Street	u-9	Outfall	80	3.8	29.7	17.98	0.14	4.04	0.52	0.30	36.0	30	0.0080	37.0	9.3	938.5	937.9	942.0	940.0

Appendix A (continued)

Hydrologic Unit, Component, and Location	From Manhole Number	To Manhole Number	Length (feet)	Incremental Area (acres)	Cumulative Area (acres)	Time of Concentration (minutes)	Time in Sewer (minutes)	Intensity (inches per hour)	Runoff Coefficient	Weighted Runoff Coefficient	Design Flow (cfs)	Size (inches)	Slope (feet per foot)	Flow Capacity (cfs)	Velocity (feet per second)	Invert Elevation		Rim Elevation	
																Upper	Lower	Upper	Lower
Hydrologic Unit V Component V-1																			
	v-1	v-2	350	14.5	14.5	20.00	0.64	3.82	0.29	- -	16.1	21	0.0206	21.9	9.1	942.9	936.7	948.0	941.0
	v-2	v-3	500	9.3	23.8	20.64	1.00	3.76	0.29	0.29	25.9	24	0.0130	26.1	8.3	936.7	930.2	941.0	935.0
	v-3	v-4	400	6.8	30.6	21.64	0.56	3.66	0.29	0.29	32.4	24	0.0275	37.1	11.8	930.2	919.2	935.0	923.5
	v-4	v-5	370	3.4	34.0	22.20	0.44	3.61	0.29	0.29	35.7	24	0.0400	44.3	14.1	919.2	904.4	923.5	909.0
	v-5	v-6	320	5.7	39.7	22.64	0.45	3.57	0.29	0.29	41.3	27	0.0240	46.9	11.8	904.4	896.7	909.0	902.0
	v-6	v-14	450	9.2	48.9	23.09	0.86	3.53	0.29	0.29	49.9	36	0.0089	61.5	8.7	896.7	892.7	902.0	895.0
	v-14	Outfall	250	36.9	85.8	23.95	0.45	3.45	0.29	0.29	85.8	42	0.0080	88.5	9.2	892.7	890.7	895.0	- -
	v-7	v-6	310	7.7	7.7	15.00	0.83	4.42	0.29	- -	9.9	18	0.0112	11.0	6.2	900.3	996.8	904.0	902.0
	v-8	v-9	370	3.3	3.3	15.00	1.76	4.42	0.29	- -	4.2	15	0.0044	4.3	3.5	932.7	931.1	937.0	937.0
	v-9	v-10	400	2.3	5.6	16.76	1.71	4.19	0.29	0.29	6.8	18	0.0045	6.9	3.9	931.1	929.3	937.0	935.0
	v-10	v-11	300	8.0	13.6	18.47	0.66	3.99	0.29	0.29	15.8	21	0.0137	18.3	7.6	929.3	925.2	935.0	930.0
	v-11	v-12	300	7.5	21.1	19.13	0.48	3.91	0.29	0.29	23.8	21	0.0270	25.3	10.5	925.2	917.2	930.0	922.0
	v-12	v-13	260	7.5	28.6	19.61	0.31	3.86	0.29	0.29	32.0	21	0.0470	33.7	14.0	917.2	905.0	922.0	910.0
	v-13	v-13a	200	0.8	29.4	19.92	0.24	3.83	0.29	0.29	32.6	21	0.0450	33.0	13.8	905.0	896.0	910.0	902.0
	v-13a	v-14	300	1.6	31.0	20.16	0.57	3.81	0.29	0.29	34.2	27	0.0110	35.0	8.8	896.0	892.7	902.0	895.0
Hydrologic Unit X Component X-1																			
Waukesha Avenue	x-1	x-2	480	9.0	9.0	10.00	0.71	5.23	0.40	- -	18.8	24	0.0100	22.3	7.1	889.3	884.5	894.0	890.5
Waukesha Avenue	x-2	x-3	500	42.9	42.9	11.35	1.44	4.98	0.33	0.33	70.6	48	0.0026	72.0	5.8	884.5	883.2	890.5	892.0
	x-3	Outfall	450	6.7	49.6	12.79	1.53	4.74	0.40	0.35	72.4	54	0.0016	76.0	4.9	883.2	882.5	892.0	884.0
Hydrologic Unit Y Component Y-1																			
	y-1	y-2	500	10.0	10.0	15.00	1.08	4.42	0.29	- -	12.8	18	0.0170	13.5	7.7	888.0	879.5	892.0	883.0
	y-2	Outfall	170	6.0	16.0	16.08	0.42	4.27	0.29	0.29	19.8	24	0.0090	21.0	6.8	879.5	878.0	883.0	878.0

[a] *Reflects the discharge from a detention basin.*

[b] *Portions of the area tributary to HUD Component D-3 and to Component D-7 are in the process of development, with detailed design of the attendant storm sewer system completed. Upon review of the previously completed storm sewer system design, it was determined that the proposed design should be incorporated directly as an element of the recommended stormwater management plan. Accordingly, no design computations are shown for this component.*

[c] *A contribution of 5 cubic feet per second is added to the calculated peak flow to account for a discharge from the detention pond.*

[d] *Includes 10.0 cubic feet per second contribution from detention basin located in the shopping region.*

Source: SEWRPC.

Appendix B

PLANS AND PROFILES OF DRAINAGEWAY AND OPEN CHANNEL COMPONENTS OF THE MAJOR STORMWATER DRAINAGE SYSTEM

Map B-1

LOCATION OF COMPONENTS FOR WHICH PLANS AND PROFILES HAVE BEEN PREPARED

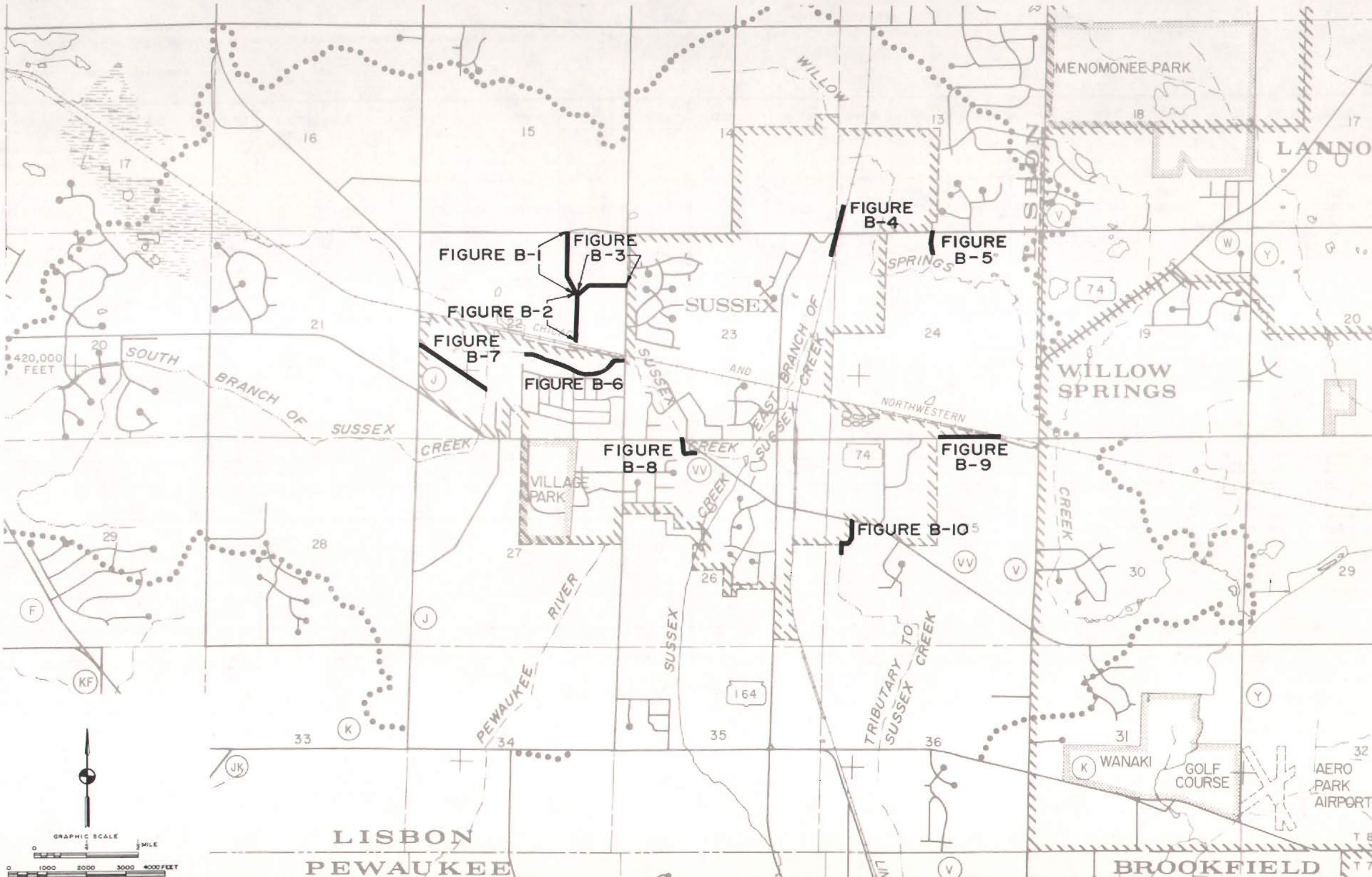


Figure B-1

PLAN AND PROFILE OF PROPOSED CHANNEL FROM GOOD HOPE ROAD TO AN UNNAMED TRIBUTARY OF SUSSEX CREEK (Hydrologic Unit B, Component B-1)

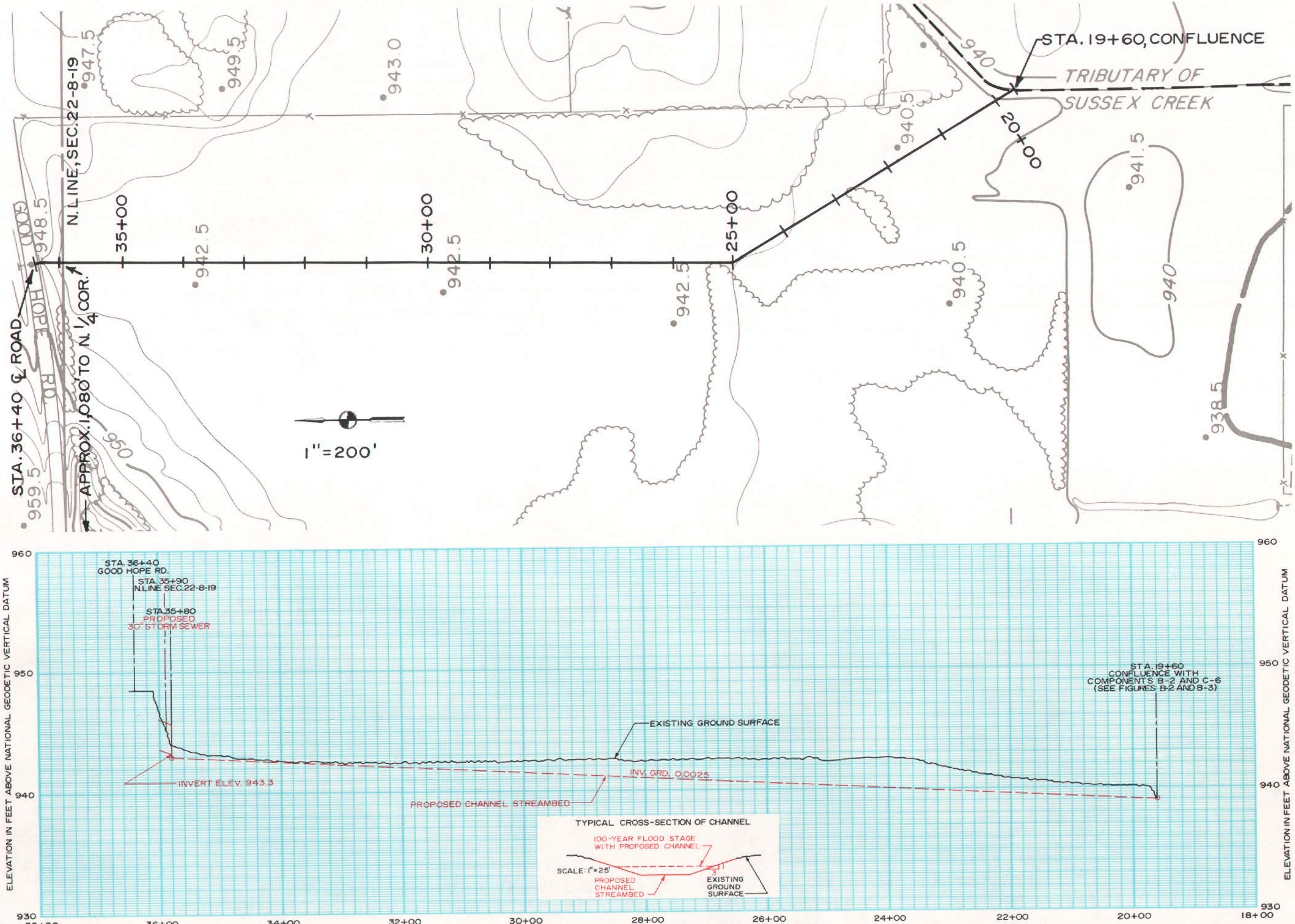


Figure B-2

PLAN AND PROFILE OF PROPOSED CHANNEL IMPROVEMENT OF A PORTION OF AN UNNAMED TRIBUTARY OF SUSSEX CREEK (Hydrologic Unit B, Component B-2)

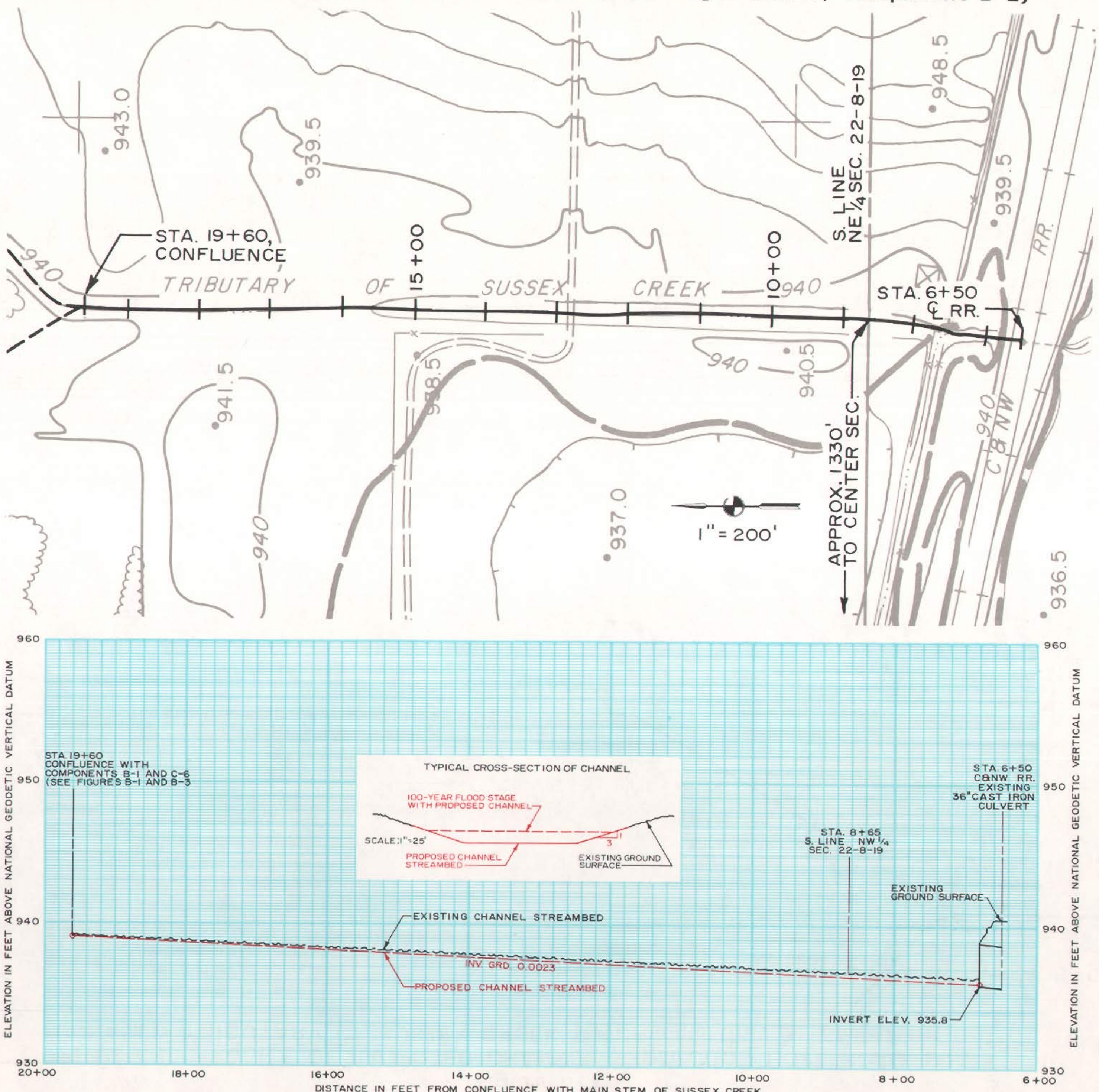


Figure B-3

PLAN AND PROFILE OF PROPOSED CHANNEL IMPROVEMENT OF A PORTION OF AN UNNAMED TRIBUTARY OF SUSSEX CREEK (Hydrologic Unit C, Component C-6)

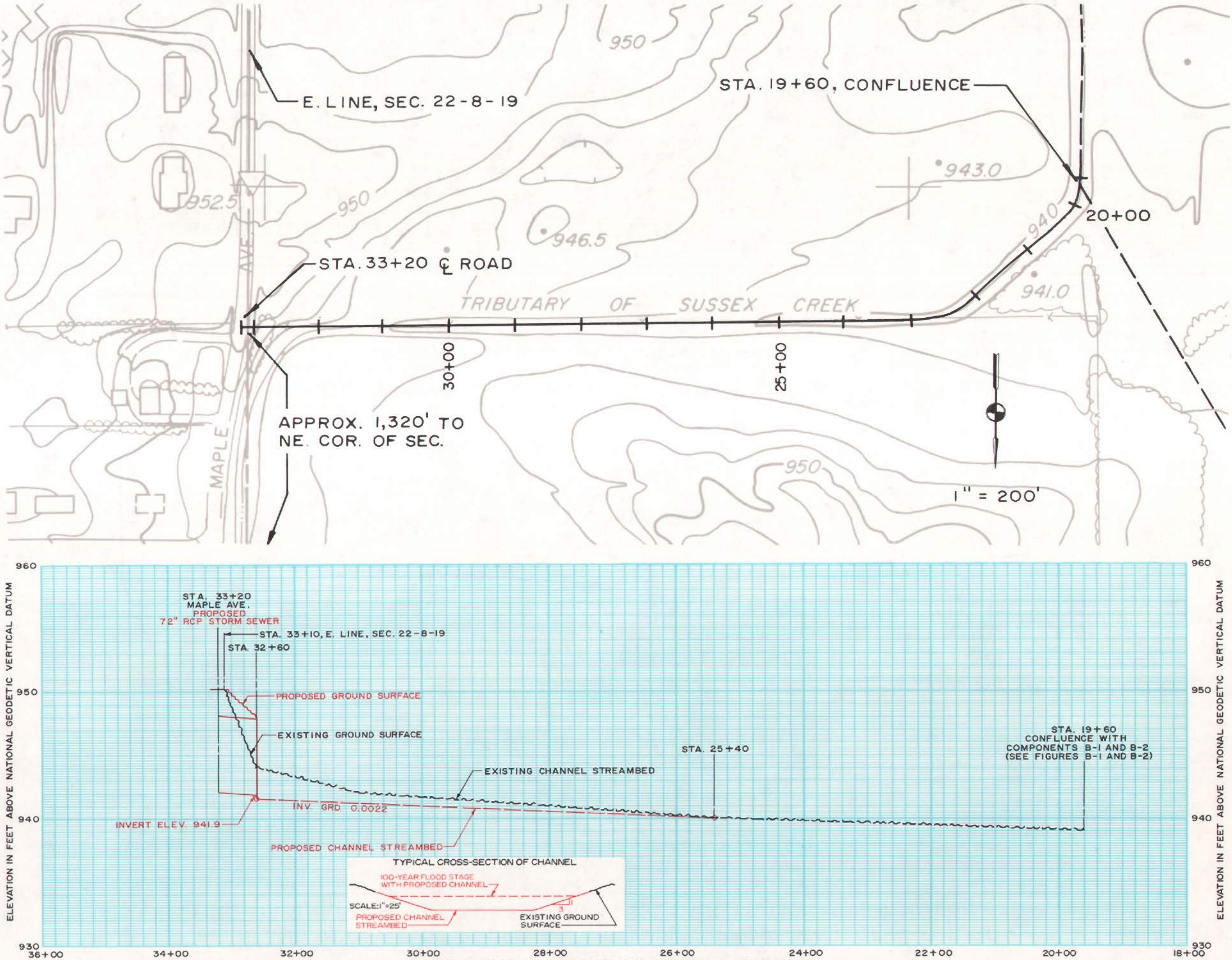


Figure B-4
PLAN AND PROFILE OF PROPOSED CHANNEL IMPROVEMENT OF A PORTION OF AN EXISTING DRAINAGEWAY TRIBUTARY TO SUSSEX CREEK (Hydrologic Unit D, Component D-9)

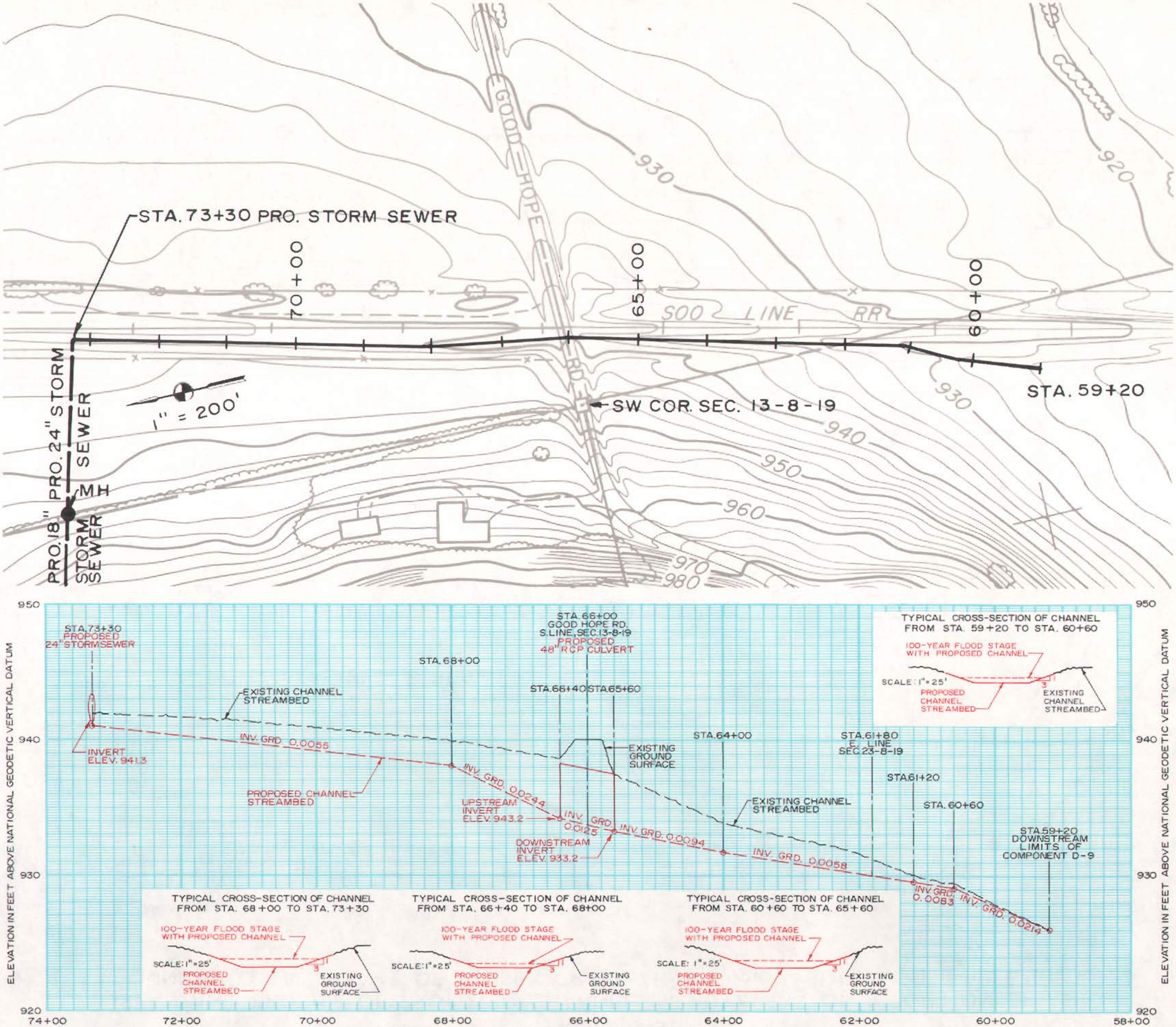


Figure B-5

PLAN AND PROFILE OF PROPOSED CHANNEL FROM GOOD HOPE ROAD TO AN UNNAMED TRIBUTARY OF WILLOW SPRINGS CREEK (Hydrologic Unit G, Component G-1)

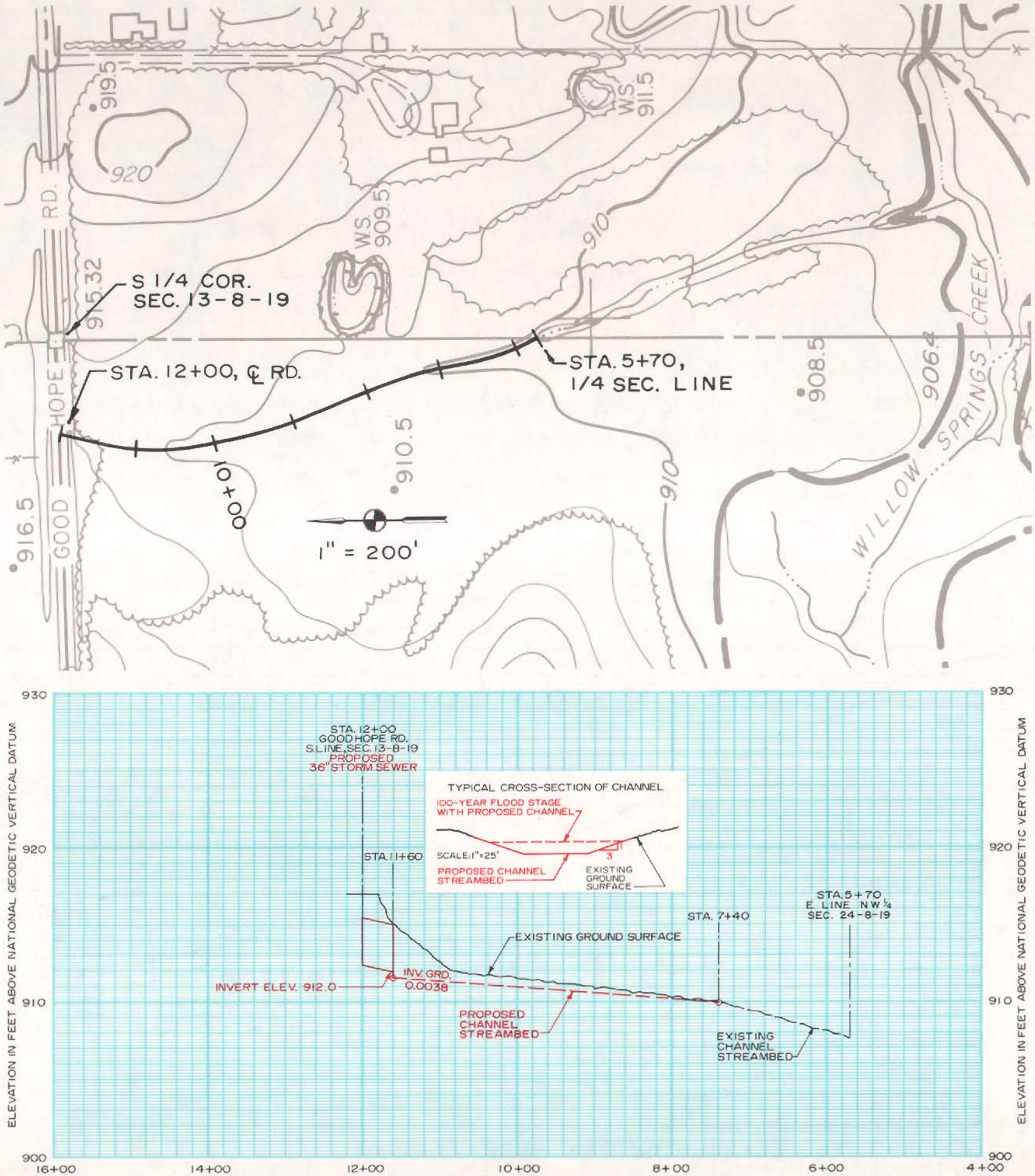


Figure B-6

PLAN AND PROFILE OF PROPOSED CHANNEL IMPROVEMENT OF A PORTION OF SUSSEX CREEK (Hydrologic Unit K, Component K-1)

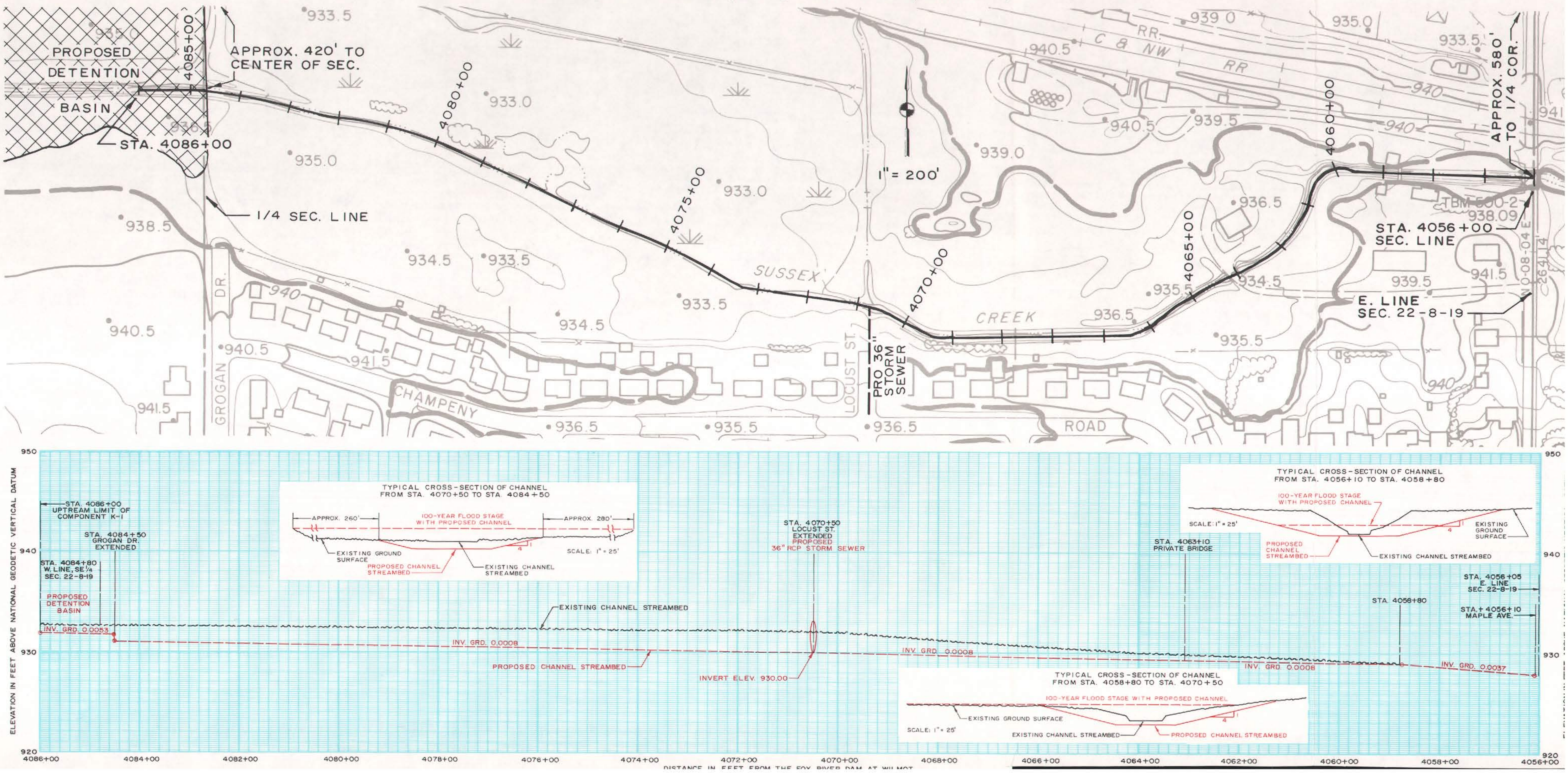
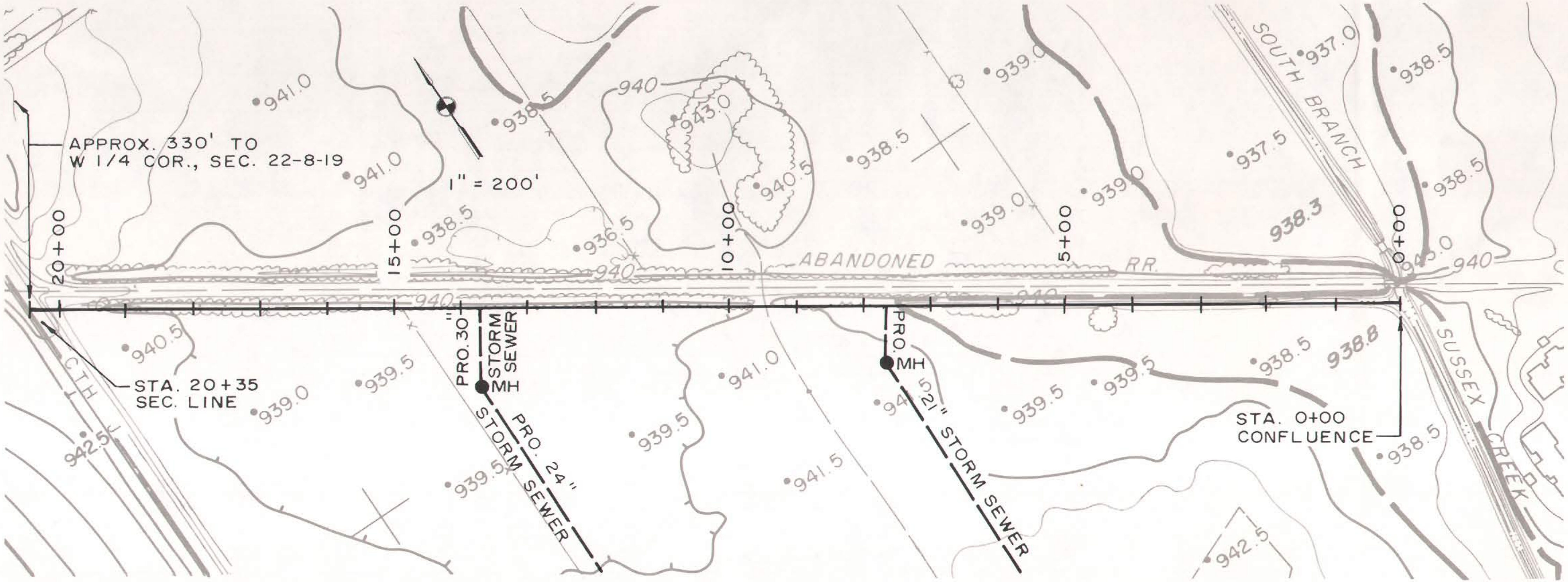


Figure B-7

PLAN AND PROFILE OF PROPOSED CHANNEL FROM CTH J TO SOUTH BRANCH OF SUSSEX CREEK (Hydrologic Unit L, Component L-4)



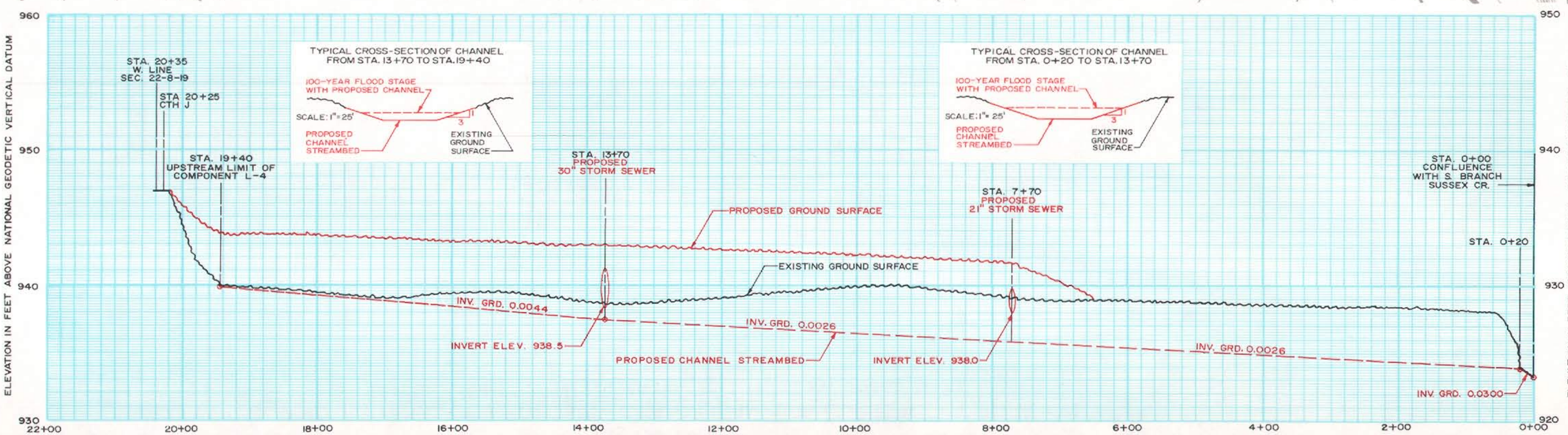


Figure B-8

PLAN AND PROFILE OF PROPOSED CHANNEL IMPROVEMENT OF A PORTION OF SUSSEX CREEK (Hydrologic Unit N, Component N-2)

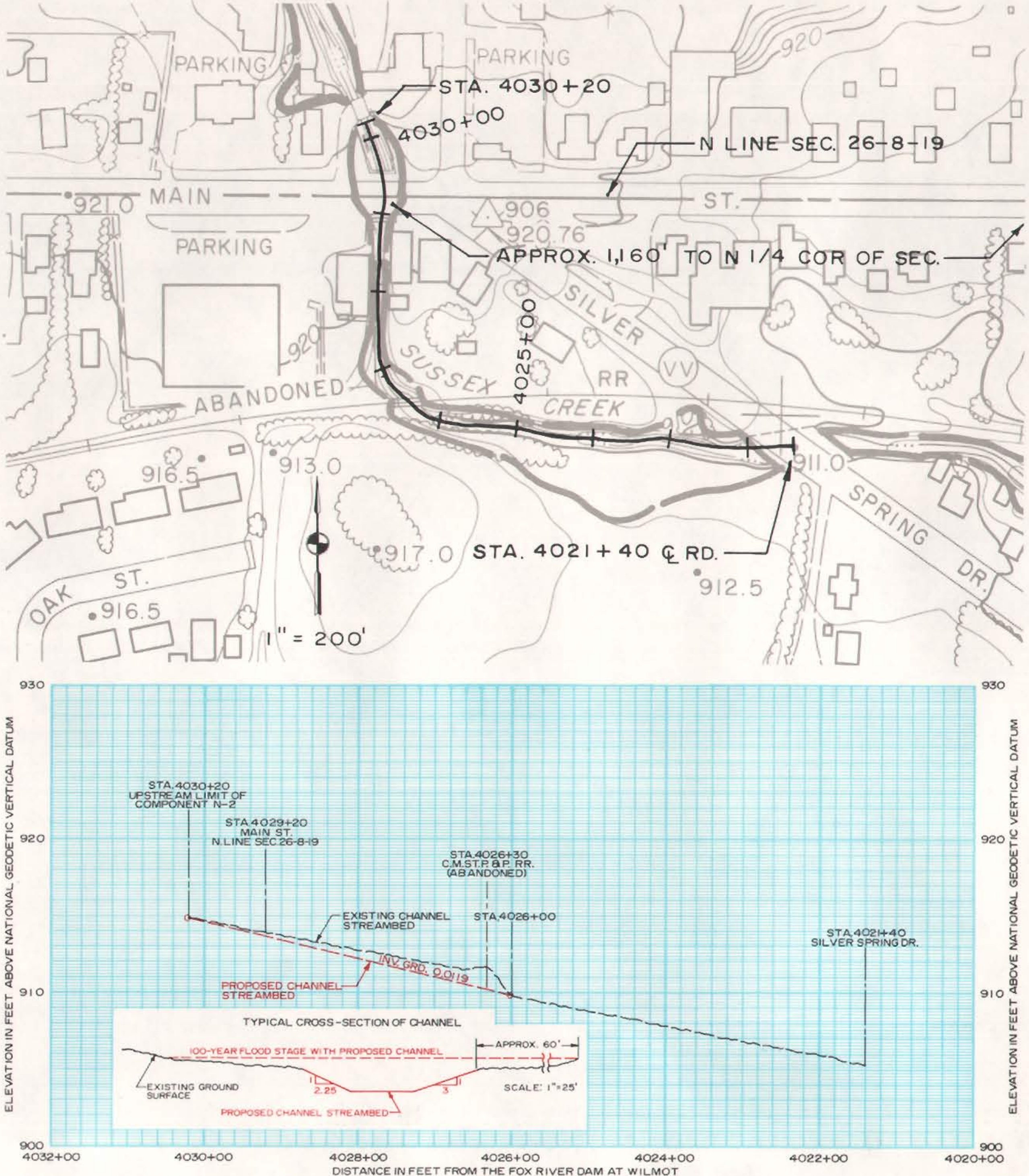


Figure B-9

PLAN AND PROFILE OF PROPOSED CHANNEL IMPROVEMENT OF A PORTION OF AN UNNAMED TRIBUTARY OF WILLOW SPRINGS CREEK (Hydrologic Unit P, Component P-2)

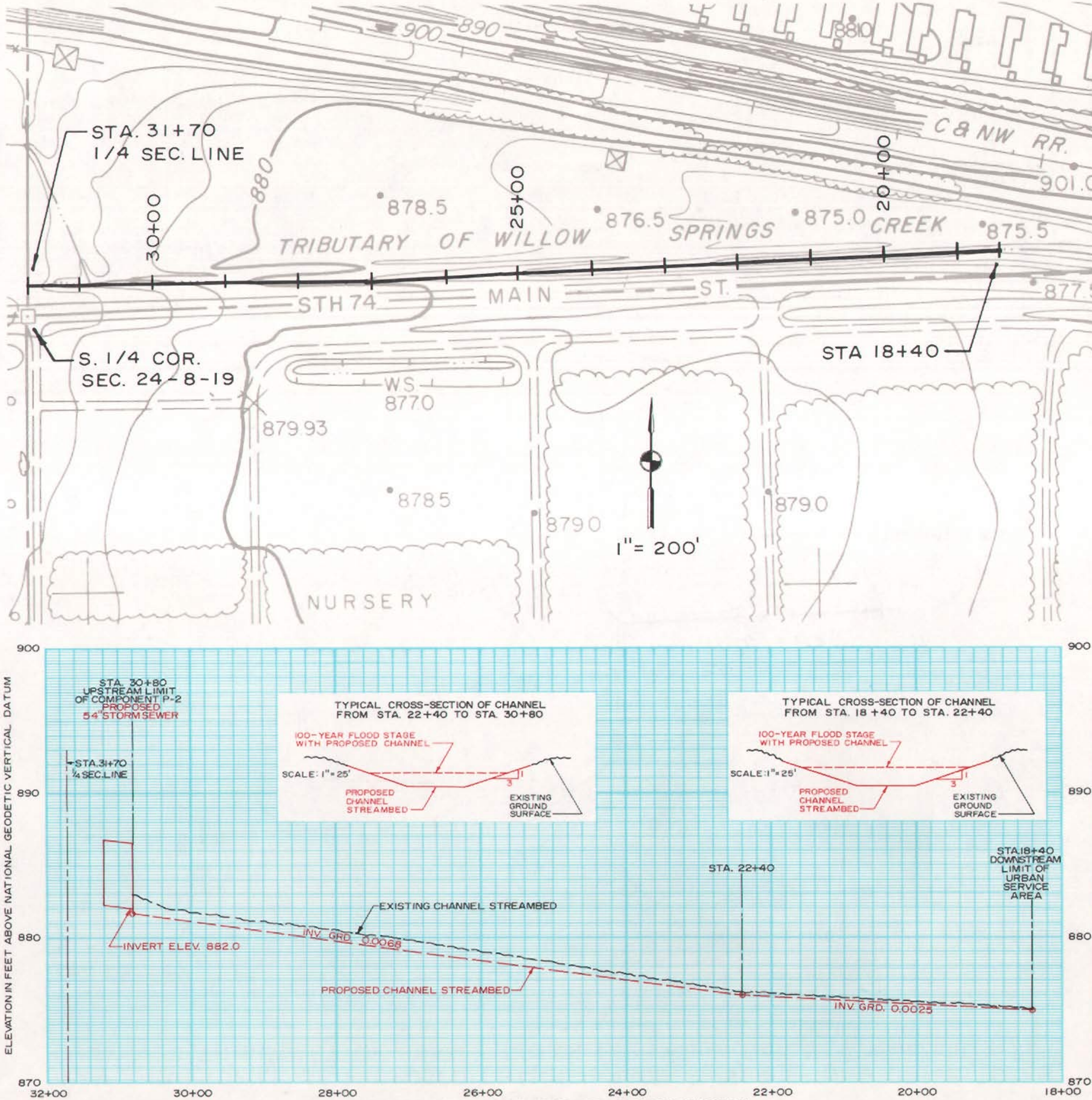
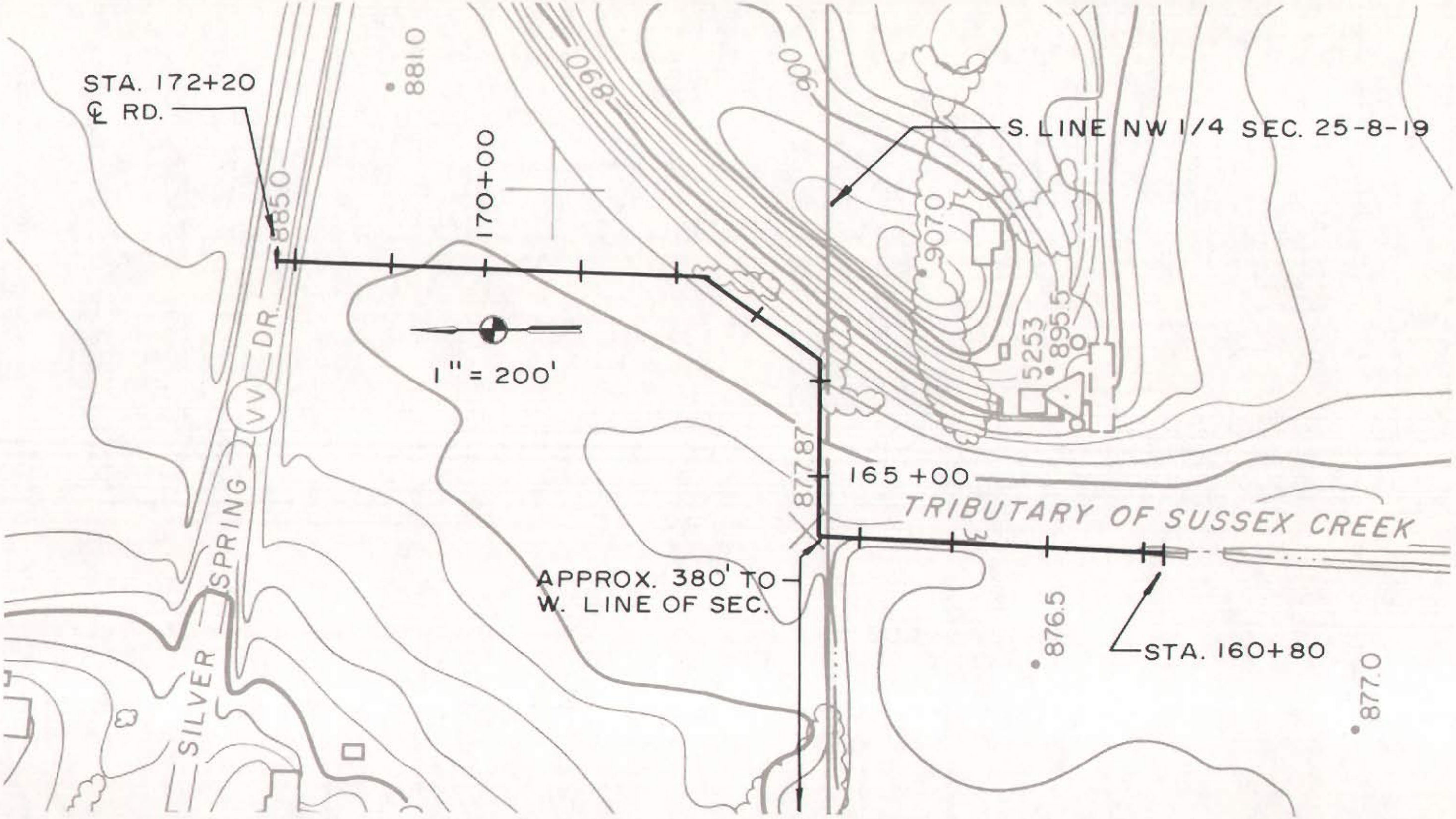
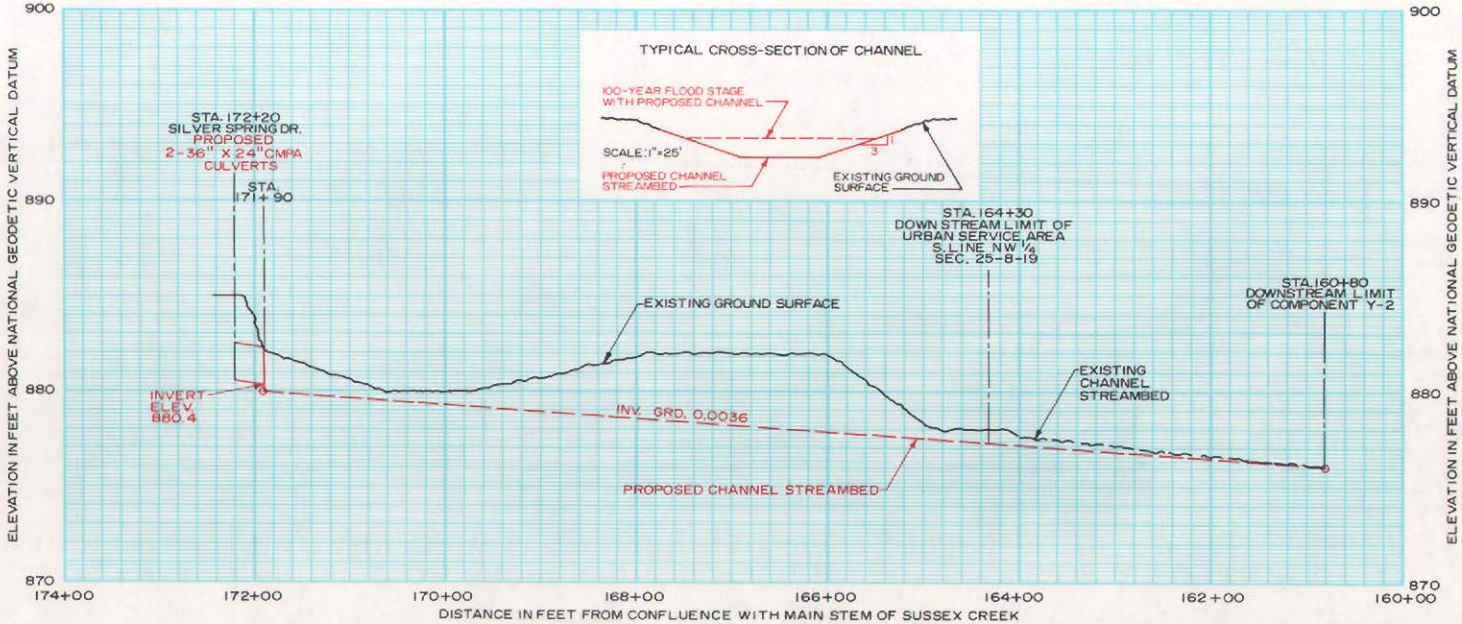


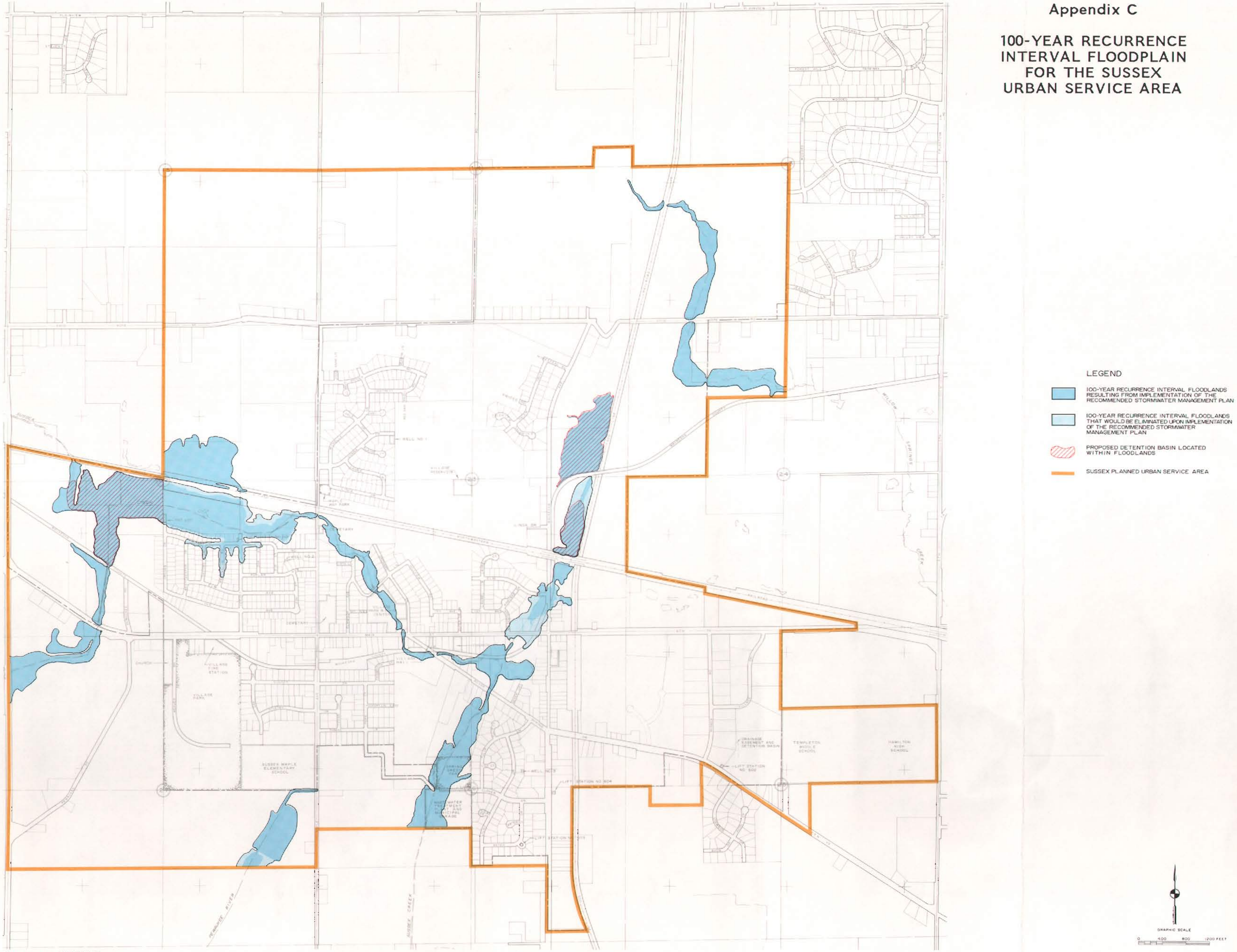
Figure B-10
PLAN AND PROFILE OF PROPOSED CHANNEL FROM SILVER SPRING DRIVE TO AN UNNAMED TRIBUTARY OF SUSSEX CREEK (Hydrologic Unit Y, Component Y-2)





Appendix C

100-YEAR RECURRENCE INTERVAL FLOODPLAIN FOR THE SUSSEX URBAN SERVICE AREA



Source: SEWRPC.

LEGEND

- EXISTING STORM SEWER
- PROPOSED STORM SEWER
- EXISTING STORM SEWER TO BE REPLACED
- EXISTING MANHOLE
- PROPOSED MANHOLE
- EXISTING CATCH BASIN OR INLET
- PROPOSED CHANNEL IMPROVEMENTS
- PROPOSED OPEN CHANNEL
- EXISTING DETENTION BASIN
- PROPOSED DETENTION BASIN
- SUBBASIN BOUNDARY--EXISTING CONDITIONS
- SUBBASIN BOUNDARY--FUTURE CONDITIONS
- HYDROLOGIC UNIT BOUNDARY
- A — HYDROLOGIC UNIT IDENTIFICATION LETTER
- A-1 — COMPONENT IDENTIFICATION NUMBER
- 957.2 — PROPOSED CENTERLINE STREET GRADES
- EXISTING CULVERT
- SUBBASIN DISCHARGE POINTS
- VILLAGE OF SUSSEX CORPORATE LIMITS

MH 26-7 — MANHOLE NUMBER
RIM 920.82 — MANHOLE ELEVATION
42" E 914.41 — EAST INVERT ELEVATION
36" W 914.41 — WEST INVERT ELEVATION

18" 321' 0.0071 — SLOPE; SEWER LENGTH; SEWER DIAMETER

NOTE: EXISTING SYSTEM IN LOCUST ST. SOUTH OF ELM ST. TO IVY ST. AND IN IVY ST. WEST OF LOCUST ST. TO BE ABANDONED.

SOUTHEASTERN WISCONSIN REGIONAL PLANNING COMMISSION

BASE MAP PREPARED BY PHOTOGRAPHIC REDUCTION OF 1"=200', 2' CONTOUR INTERVAL, TOPOGRAPHIC MAPS WHICH WERE COMPILED TO NATIONAL MAP ACCURACY STANDARDS BY STEREOPHOTOGRAMMETRIC METHODS.

SW 1/4 SEC. 13, SE 1/4 SEC. 14, SEC. 22, SEC. 23, NW, SW 1/4'S SEC. 24, SEC. 26; NE 1/4 SEC. 27; NE, NW 1/4'S SEC. 35--SOURCE VILLAGE OF SUSSEX, DATE OF PHOTOG: NOV., 1974.

NE, NW, SE 1/4'S SEC. 13, NE, NW, SW 1/4'S SEC. 14; SEC. 15; NE, SE 1/4'S SEC. 16; NE, SE 1/4'S SEC. 21; NE, SE 1/4'S SEC. 24; SEC. 25; NW, SW, SE 1/4'S SEC. 27; NE, SE 1/4'S SEC. 28; NE 1/4 SEC. 33, NE, NW 1/4'S SEC. 34; NE, NW 1/4'S SEC. 36--SOURCE: WAUKESHA CO., DATE OF PHOTOG: APR., 1981.

MAP 22

RECOMMENDED STORMWATER MANAGEMENT PLAN FOR THE VILLAGE OF SUSSEX AND ENVIRONS: 2000

WAUKESHA COUNTY, WISCONSIN

GEOD. NORTH GRID NORTH +01° 13' 13"

SCALE: 1" = 400'
CONTOUR INTERVAL: 2'

400 0 400 800 1200
SCALE IN FEET

COMBINATION SCALE AND SEA LEVEL REDUCTION FACTOR: 0.99989776

HORIZONTAL DATUM IS BASED ON THE WISCONSIN STATE PLANE COORDINATE SYSTEM, SOUTH ZONE.

VERTICAL DATUM IS NATIONAL GEODETIC VERTICAL DATUM OF 1929.

BASE MAP DESIGN: K. W. BAUER	
DRAWN BY: R. H. HEINEN	DATE: FEB. 2, 1984
CHECKED BY: L. H. KREBLIN	DATE: FEB. 3, 1984
APPROVED BY: [signature]	DATE: FEB. 4, 1984
DATE OF LAST REVISION:	