Southwick Creek Stormwater Management Plan
Conceptual Design Report
Final Draft

Prepared for

Geneva Lakes Environmental Agency,

Village of Williams Bay

and

Wisconsin Department of Natural Resources

by

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SOUTHWICK CREEK STORMWATER MANAGEMENT PLAN
CONCEPTUAL DESIGN REPORT

Introduction

Southwick Creek is a man-made stream channel that drains an 853-acre watershed on the north side of Lake Geneva (Figure 1). The stream drains the northern portion of Village of Williams Bay. Southwick Creek is a groundwater feed stream that supports a resident and lake run population of Brown Trout. Fish kills during summer months have been the concern of the Wisconsin Department of Natural Resources and the community. The land use and pollutant loadings in the watershed were evaluated in a report entitled Southwick Creek Watershed Project Phase 1 Final Report, prepared by Hey and Associates, Inc. (1996). The purpose of this report is to develop a conceptual design for a stormwater treatment system that addresses the runoff from subbasins 400 and 500 identified in the Phase-1 report (Figure 1). The study area includes a 232-acre section of the Village north of and west of HWY 67.

Water Quality Problems

Water quality problems in Southwick Creek fall into four categories; changes to stream flow, loss of stream habitat, high summer temperatures, and nonpoint source pollution.

As the Village of Williams Bay was converted from forest and wetland to agricultural and finally urban land use, the surface of the landscape changed. In the past, greater amounts of water infiltrated into the ground and remained in wetland storage. Historically, stormwater reached the stream courses over long periods of time. With the changes in surface cover due to urbanization and the associated increase in impervious surfaces, such as parking lots, roads, driveways, and roofs, more of the rainfall today is intercepted and becomes surface runoff. These changes all effect the hydrologic budget of the drainage area. A hydrologic budget is a quantitative statement of the hydrologic cycle used to equate the components of precipitation, evaporation, runoff, and infiltration. Figure 2 illustrates the changes that urbanization can have on the hydrologic budget.

As seen in Figure 2, as urbanization takes place and more of the land surface is paved over with rooftops, driveways, parking lots and streets, infiltration rates decreased and less water goes into groundwater storage. As groundwater storage decreases, the groundwater seepage that contributes flow to local streams during dry periods also has decreased. The result is lower stream base flow. The end result is less fish and wildlife habitat in Southwick Creek.

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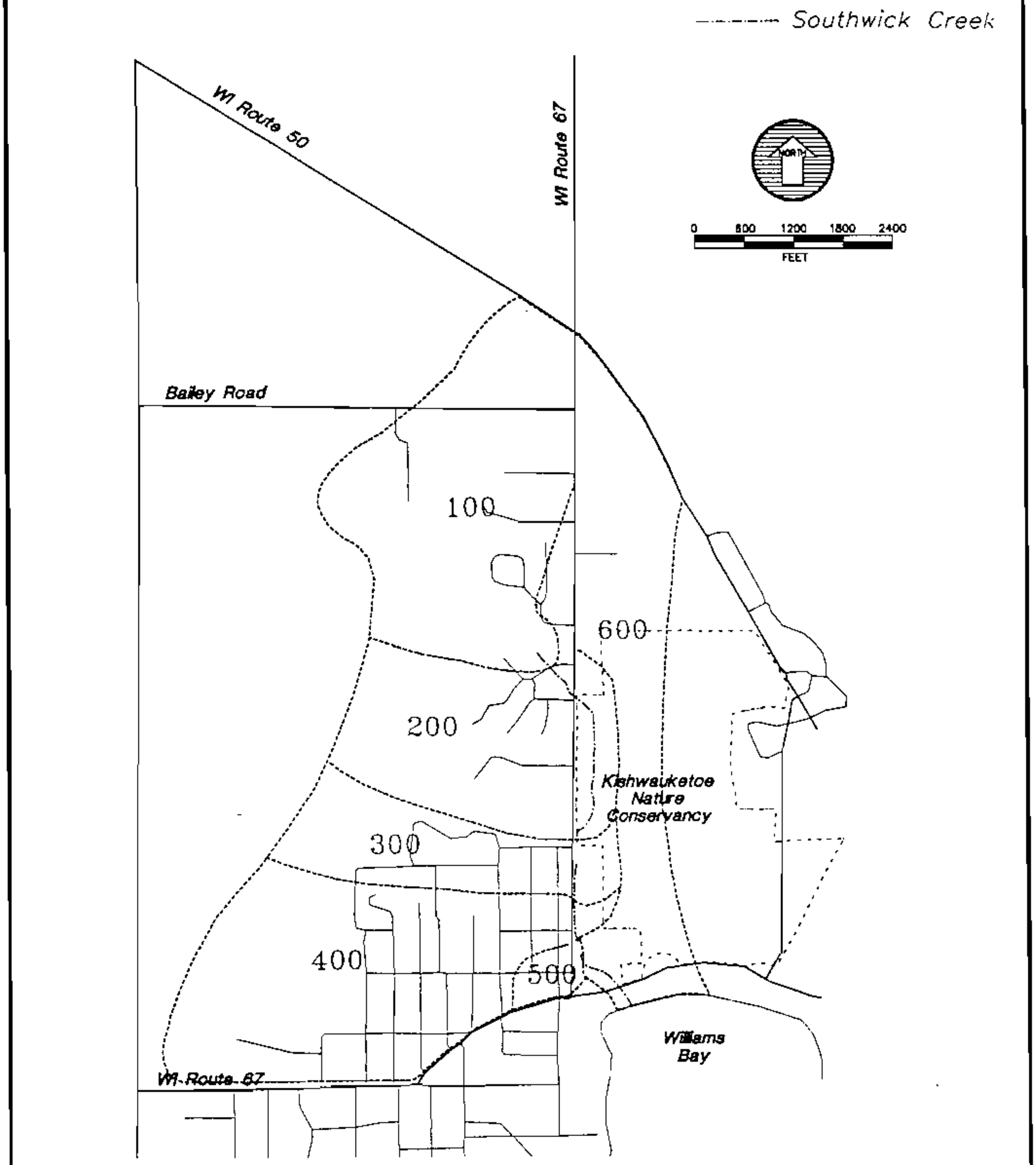
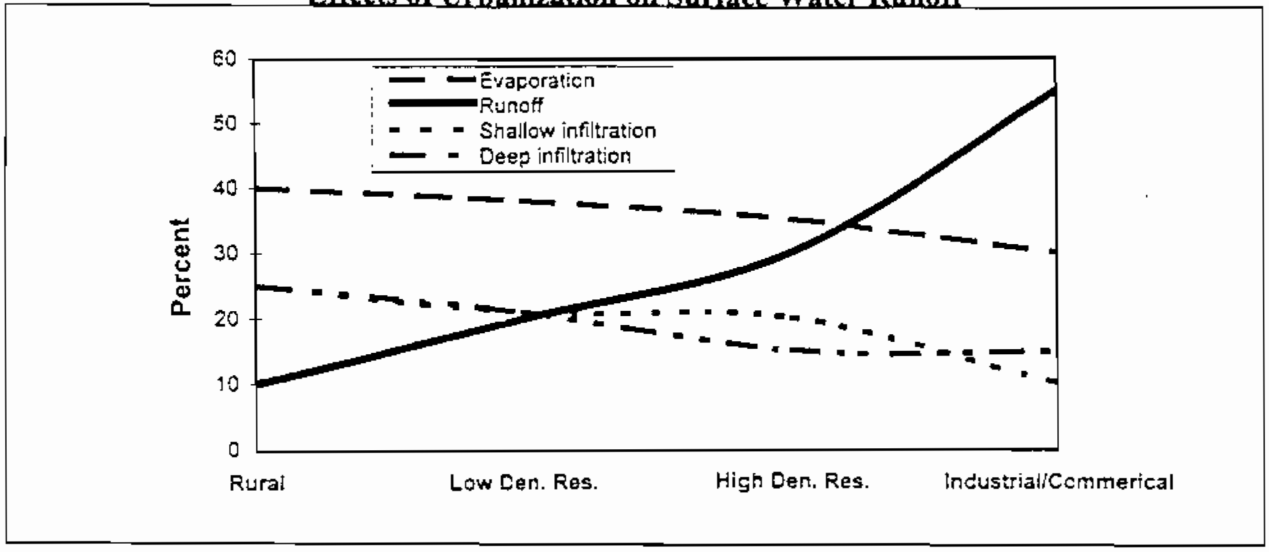


Southwick Creek Stormwater Management Plan Phase II	Figure 1 Watershed and Subbasin Boundaries	Hey and Associates, Inc.

FIGURE 2
Effects of Urbanization on Surface Water Runoff



Source: Minnesota Pollution Control Agency

With less water being held in groundwater and wetland storage, more water is running off the land surface. As shown in Figure 2 as the density of urbanization increases the rate of runoff increases. In the past, it took water days or weeks for water to reach the stream. Today, larger volumes of surface runoff reach the stream in hours, instead of days. The result is higher stream flows and velocities during rain events.

Urbanization increases the amount of pollution in surface water runoff. This pollution, called nonpoint source pollution, is the result of man's activities on the land surface. There are two main reasons why urbanization increases pollutant loads in runoff. First of all, the volume and rate of runoff are increased as an area is developed, providing a larger capacity to transport pollutants. The second reason is that more materials are made available for movement by the runoff as the intensity of the land use increases.

Monitoring of 20 major cities as part of the National Urban Runoff Program (NURP) study has shown that the runoff from various land uses are similar regardless where they are located in the country. The NURP monitoring has shown that sampling of individual communities is not necessary to document a potential source of pollution. The NURP study concluded that mapping of the urban land covers and using developed land surface pollutant relationships could identify pollutant sources. Monitoring in Milwaukee and Madison have shown problem pollutants in urban surface water runoff to include sediment, nutrients, chlorides, bacteria, oil and grease, heavy metals, pesticides, biological demanding compounds (BOD) and volatile organic compounds (VOCs). The major sources of these pollutants are outlined in Table 1.

TABLE 1
Major Sources of Urban Surface Water Pollutants

Pollutant	Major Source
Sediment	Construction sites, agricultural runoff
Nutrients (Nitrogen and Phosphorus)	Fertilizers, soil erosion
Chlorides	Road salt
Bacteria	Pet waste, wildlife
Oil and grease	Automobile
Heavy metals	Automobile
Pesticides	Lawn care, agriculture
VOCs	Automobile, home heating

Source: Novotny and Olem, 1994

The amount of pollutants that come off the land surface is a factor of land use, the amount of imperviousness, and automobile traffic. Sub-basis 400 and 500 are currently greater than 90% developed with urban land use. The Land use mixture is summarized in Table 2.

TABLE 2
Land Use Mixture in Subbasins 400 and 500

Sub-basin	Land Use Type (acres)				
	Residential	Commercial	Industrial	Open Space	Total
400	207.0	4.5	8.6	0.5	220
500	3.4	8.0	0	0	11.4

Source: Hey and Associates, 1996.

Table 3 outlines typical annual pollutant export from the study area.

TABLE 3
Annual Pollutant Export from Study Area

Subbasin	Acres (acres)	Pollutant Loadings in lbs/yr						
		Susp. Solids	Soluble P	Total P	COD	Copper	Lead	Zinc
400	220.6	53,165	35.3	68.4	30,884	2.2	66.2	50.7
500	11.4	33,870	4.0	30.0	28,340	2.1	82.0	23.0
Others	621.5	145,300	81.0	179.4	103,658	8.6	246.4	124.0
Total	853.5	232,336	120.3	277.8	162,882	12.9	394.6	197.7

Source: Hey and Associates, 1996.

Pollutants from the Village of Williams Bay study area are contributing to degraded water quality conditions in Southwick Creek and Lake Geneva.

In addition to containing pollutants, runoff from the urban surfaces in the study area has impacted the cold water stream by raising the temperature during summer months. As rainfall washes down urban surfaces such as streets and parking lots, it absorbs temperature from the warm pavement. When mixed with the water of the stream, the runoff raises the stream temperature. Trout, which inhabit Southwick Creek, are sensitive to high temperatures and rapid change in temperature. During summer periods when groundwater flow to the Southwick Creek is at its lowest, the potential impacts of surface runoff on temperature are the greatest.

Project Goals and Objectives

The Southwick Creek Advisory Committee as part of Phase-1 of this project developed the following goals and objectives for Southwick Creek and its watershed:

1. Reduce pollutant loads discharged from Southwick Creek into Lake Geneva.
2. Protect Southwick Creek from further degradation when future development occurs.
3. Protect and where possible restore trout habitat in Southwick Creek.
4. Maintain the greenway corridor along Southwick Creek.

To meet the above goals the following water quality criteria will need to be meet:

1. Maintain in stream concentrations of suspended solids to less than 25 mg/l during dry weather periods and 80 mg/l at all times. The Working Party on Water Quality for European Freshwater Fish (Alabaster, 1982) have recommended the following suspended solids criteria:

   (a.) There is no evidence that concentrations of suspended solids less than 25 mg/l have any harmful effects on fisheries.

   (b.) It should be usually possible to maintain good or moderate fisheries in waters, which normally contain 25-80 mg/l suspended solids. Other factors being equal, however, the yield of fish from such waters might be somewhat lower than those in category (a).

   (c.) Waters normally containing from 80-400 mg/l suspended solids are unlikely to support good freshwater fisheries, although fisheries may sometimes be found at the lower concentration of this range.

   (d.) At best, only poor fisheries are likely to be found in waters, which normally contain more than 400 mg/l suspended solids.

2. Maintain instream temperatures below 70 ^{o}F (21^{o}C) at all times to protect instream Brown trout populations.

3. Maintain instream dissolved oxygen levels above 7.0 mg/l during spawning season, and 6.0 mg/l at all times (Wisconsin Administrative Code NR 102).

4. The pH shall be within the range of 6.0 to 9.0, with no change greater than 0.5 units outside of the estimated natural seasonal maximum and minimum (Wisconsin Administrative Code NR 102).

5. Maintain a stream base flow in Southwick Creek of 0.8 cfs to protect fish habitat.

6. Instream concentrations of the following heavy metals should not exceed the following acute and chronic toxicity (Wisconsin Administrative Code NR 102):

Total Recoverable Metal	Acute* Toxicity (ug.l)	Chronic* Toxicity (ug/l)
Cadmium	9.65	-
Chromium (+3)	3181	152.10
Copper	30.45	21.57
Lead	208.90	54.71
Nickel	2434	270.80
Zinc	220.70	220.70

* Based on a instream hardness of 200 mg/l

7. Reduce phosphorus export to Lake Geneva from Southwick Creek by 50%.

To help meet the above water quality criteria the following alternatives would need to be addressed for subbasins 400 & 500:

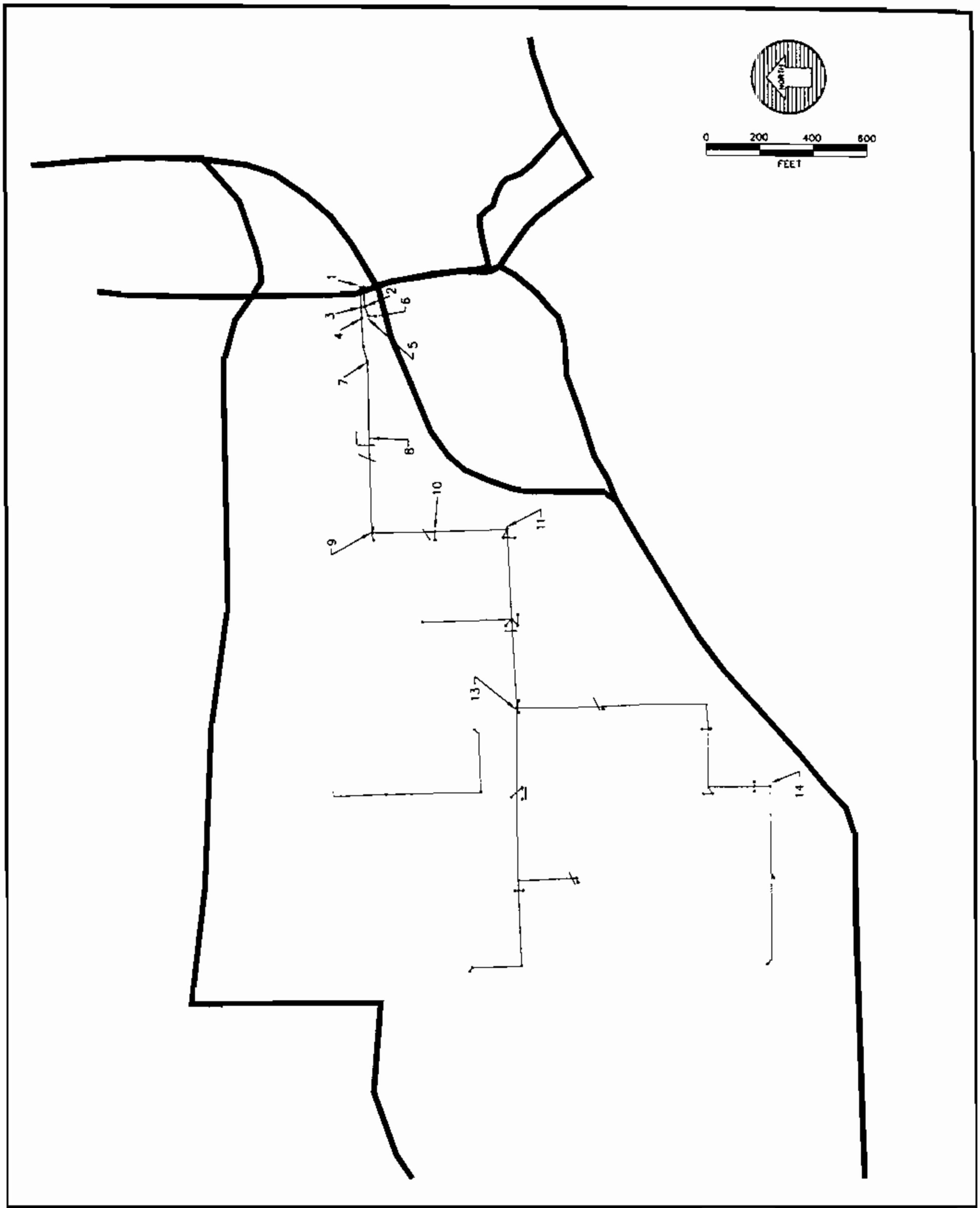
1. Alternatives to reduce the annual export of stormwater related pollutants

2. Alternatives to reduce the thermal impacts on Southwick Creek by either modifying the discharge characteristics or location.

As part of the project, the Southwick Creek Advisory Committee has requested that the option of discharging treated stormwater from the study area into the Kishwauketoe Nature Conservancy be explored. The purpose of the discharge would be to provide additional water to the wetland as part of a larger restoration effort being sponsored by the Conservancy.

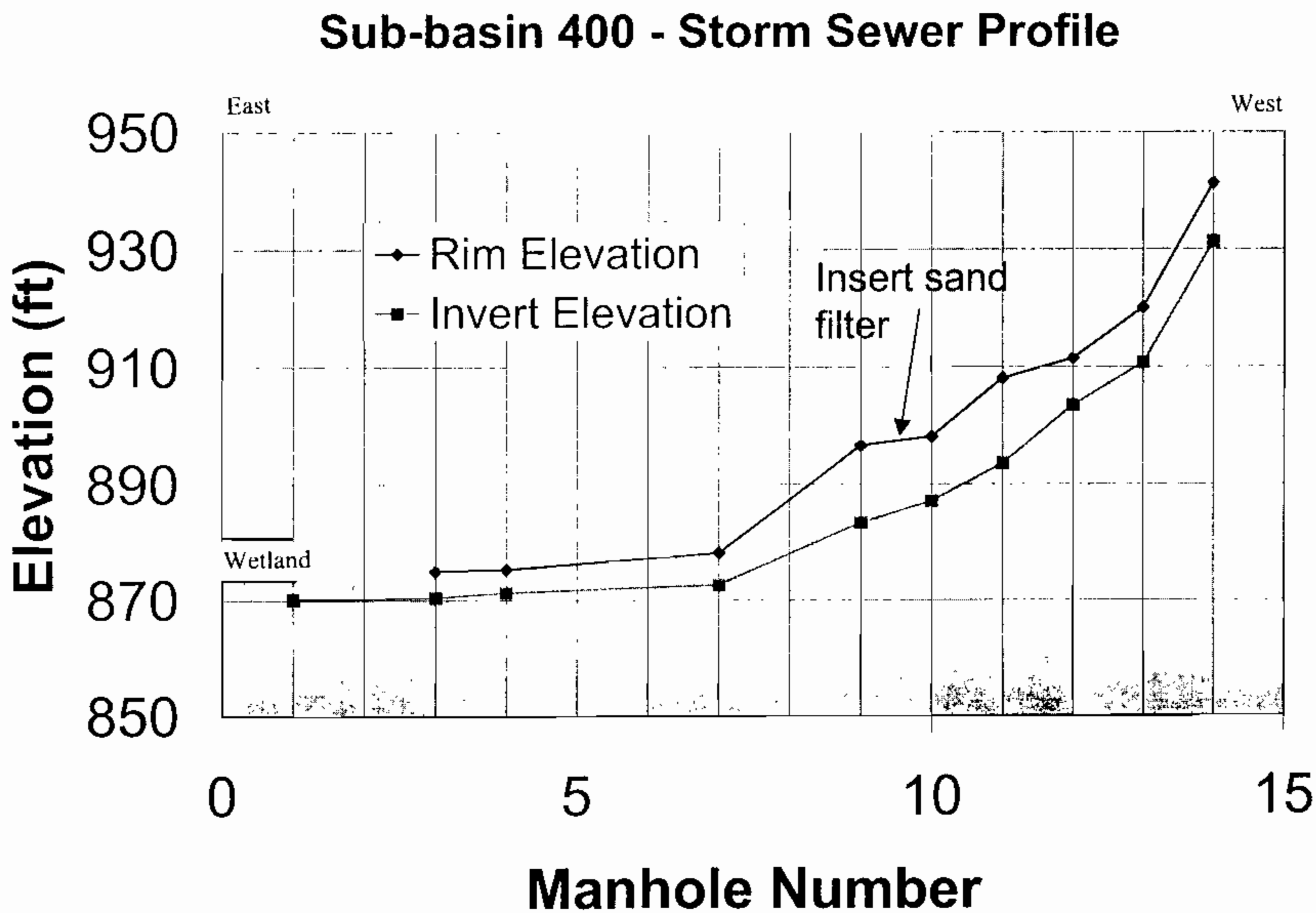
Physical Setting and Site Constraints

As outlined above, sub-basis 400 and 500 are currently 100% developed with urban land use. The Land use mixture is summarized in Table 2. The limited availability of unused land limits the siting opportunities for stormwater management practices. Open space in the watershed is limited to a 0.5-acre Village owned lot on the corner of Williams and Olive Streets and a narrow strip of land at the lower end of the watershed located between Southwick Creek and STH 67.



Southwick Creek Stormwater Management Plan Phase II	Figure 3 Map of Storm Sewer System	Hey and Associates, Inc.

Figure 4



Sub-basin 400 - Storm Sewer Profile
East
West
Wetland
Rim Elevation
Invert Elevation
Insert sand
filter
Elevation (ft)
950
930
910
890
870
850
0
5
10
15
Manhole Number

As stated above, the Southwick Creek Advisory Committee has asked that this plan explore opportunities of discharging treated stormwater from subbasins 400 & 500 into the Kishwauketoe Nature Conservancy. Two issues effect the feasibility of this alternative; the physical location of subbasins with regards to Southwick Creek, and the elevation of the storm sewer system that drain these areas. The two study subbasins are located on the west side of Southwick Creek. The Kishwauketoe Nature Conservancy is located on the east side of Southwick Creek. To discharge into the Conservancy, stormwater from subbasins 400 & 500 would have to be piped across the creek or the creek would have to be moved to the east.

As part of the project the staff of Hey and Associates and the Geneva Lake Environmental Agency surveyed the storm sewer system that drains sub-basin 400. The results of the survey are shown on Figures 3 and 4. As can be seen sub-basin 400 discharges into Southwick Creek at an elevation below the land surface of the Kishwauketoe Nature Conservancy. Due to the flat grade of storm sewer and higher elevation of the Conservancy, a gravity siphon under the stream would not be feasible. The only feasible alternative to move stormwater from the west side of the Southwick Creek up into the Conservancy area is by pumping. The cost of pumping will be discussed in the alternative section of this report. The U. S. Geological Survey on contract with Geneva Lakes Environmental Agency is monitoring Instream temperature in Southwick Creek. Table 4 summarizes the daily maximum instream temperature for the summer month of 1998. The table shows that during the summer months of 1998 on average the daily maximum temperature exceeded 21 °C two to three times per month. Typically these temperature increases were associated with runoff events and were short lived, lasting for only a few hours. On all dates the mean daily temperature was below the 21 °C temperature criteria.

Potential Stormwater Management Alternatives

INTRODUCTION

Stormwater management practices for urban and urbanizing areas fall into two categories; practices to control the runoff from new development, and practices to treat the runoff from existing areas. Management practices for new development are ones that control stormwater at the source through development standards such as lot characteristics, drainage system types, and local on-site storage. Management practices for existing development are those that must be retrofitted into the existing urban landscape to control existing sources of water and pollutants. Management practices for existing development are often limited by location and density of existing buildings, roads and utilities, and, therefore, must take advantage of limited space and site conditions. The study area for the Southwick Creek Stormwater Management Plan is currently 99% developed with little room for further development. Therefore, management alternatives in this report will focus on practices that address existing sources of water and pollutants.

Studies of urban runoff by the U. S. Environmental Protection Agency (EPA), as part of the National Urban Runoff Program (NURP), have shown that the amount of pollution generated off the land surface is directly proportional to the quantity of runoff (Pitt, 1991). To meet the goals and objectives outlined above both the rate and volume of surface runoff need to be addressed.

Table 4
Maximum Daily Stream Temperatures in Southwick Creek

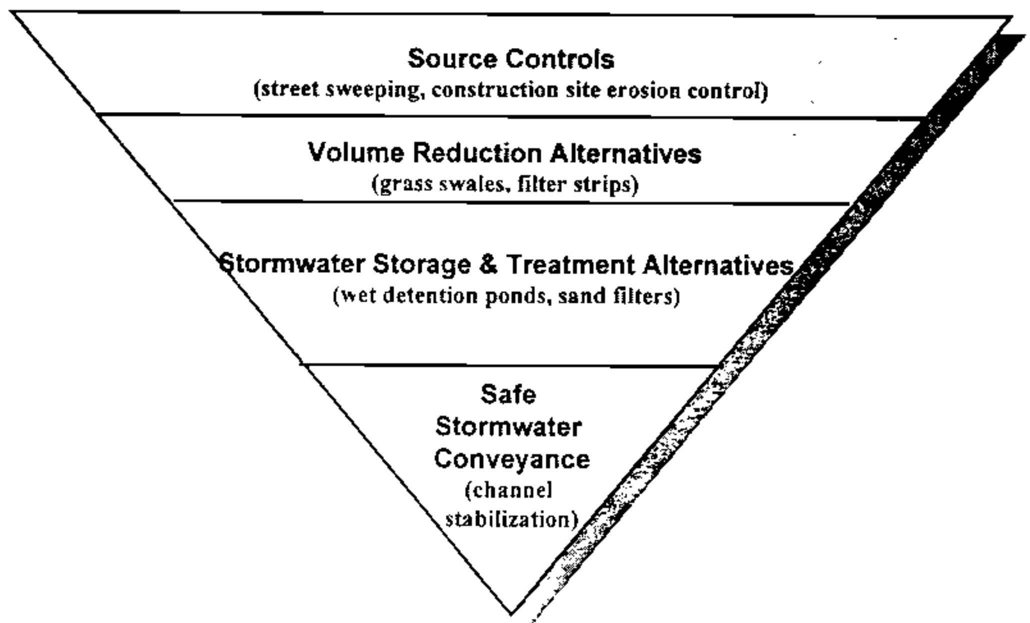
June 1998		July 1998		August 1998		September 1998	
Date	Maximum Temp (°C)	Date	Maximum Temp (°C)	Date	Maximum Temp (°C)	Date	Maximum Temp (°C)
6/1/98	15.0	7/1/98	16.3	8/1/98	16.4	9/1/98	16.5
6/2/98	15.3	7/2/98	16.5	8/2/98	16.1	9/2/98	15.3
6/3/98	13.6	7/3/98	**22.6**	8/3/98	16.5	9/3/98	15.3
6/4/98	13.5	7/4/98	15.3	8/4/98	18.1	9/4/98	16.0
6/5/98	12.4	7/5/98	15.9	8/5/98	**22.3**	9/5/98	16.6
6/6/98	13.0	7/6/98	17.6	8/6/98	17.1	9/6/98	**22.1**
6/7/98	14.2	7/7/98	17.2	8/7/98	**23.7**	9/7/98	**23.2**
6/8/98	13.2	7/8/98	15.3	8/8/98	16.8	9/8/98	14.8
6/9/98	14.5	7/9/98	16.2	8/9/98	17.2	9/9/98	15.1
6/10/98	14.6	7/10/98	16.0	8/10/98	17.4	9/10/98	15.8
6/11/98	18.8	7/11/98	16.1	8/11/98	16.4	9/11/98	16.4
6/12/98	19.0	7/12/98	16.2	8/12/98	16.6	9/12/98	16.7
6/13/98	16.0	7/13/98	16.5	8/13/98	16.2	9/13/98	16.9
6/14/98	15.0	7/14/98	17.2	8/14/98	19.9	9/14/98	19.4
6/15/98	16.0	7/15/98	17.6	8/15/98	16.7	9/15/98	18.0
6/16/98	15.7	7/16/98	17.0	8/16/98	16.5	9/16/98	16.4
6/17/98	16.3	7/17/98	16.9	8/17/98	16.5	9/17/98	16.2
6/18/98	19.8	7/18/98	17.0	8/18/98	15.6	9/18/98	16.1
6/19/98	16.4	7/19/98	20.5	8/19/98	15.8	9/19/98	16.5
6/20/98	17.1	7/20/98	**23.3**	8/20/98	16.9	9/20/98	16.9
6/21/98	17.1	7/21/98	**24.2**	8/21/98	16.9	9/21/98	14.7
6/22/98	16.3	7/22/98	16.4	8/22/98	**22.7**	9/22/98	14.4
6/23/98	16.9	7/23/98	16.4	8/23/98	18.5	9/23/98	14.2
6/24/98	18.3	7/24/98	16.1	8/24/98	17.3	9/24/98	13.8
6/25/98	**23.4**	7/25/98	16.1	8/25/98	20.3	9/25/98	15.8
6/26/98	19.4	7/26/98	16.5	8/26/98	16.8	9/26/98	17.8
6/27/98	19.6	7/27/98	16.8	8/27/98	16.1	9/27/98	17.1
6/28/98	**21.5**	7/28/98	17.8	8/28/98	18.1	9/28/98	15.6
6/29/98	17.2	7/29/98	16.7	8/29/98	17.2	9/29/98	16.1
6/30/98	16.5	7/30/98	16.2	8/30/98	16.5	9/30/98	16.6
		7/31/98	16.1	8/31/98	16.1		

To effectively control urban stormwater runoff, management alternatives need to be reviewed in a hierarchy, from alternatives that control the water and pollutants at their source, to practices that treat the water before it is discharged to the downstream waterways. The typical hierarchy of stormwater controls is illustrated in Figure 5.

FIGURE 5

STORMWATER MANAGEMENT HIERARCHY

(examples provided)



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

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

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

The various stormwater management practices, their constraints, and effectiveness will be described in this section. This section includes estimated cost for the outlined stormwater management practices. The capital costs for construction used were derived from the report Cost of Urban Stormwater Pollution Control Measures published by the Southeastern Wisconsin Regional Planning Commission (SEWRPC, 1991, updated to 1998 dollars). The SEWRPC costs were updated from 1991 to 1998 dollars by using an inflation factor of 1.2 obtained from the publication *Engineering News Record.*

SOURCE CONTROLS

CONSTRUCTION SITE EROSION CONTROL

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

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

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

Feasibility of Alternative

Currently the western portion of Subbasin 400 is under development. It is important that the Village of Williams Bay enforce the erosion control requirements under the Wisconsin Uniform Building Code and their recently adopted Stormwater Management Ordinance to assure excess sediment is not discharged downstream. The erosion control provisions are enforced through the Village Building Inspector.

STREET SWEEPING

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

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

The effectiveness of street sweeping is a function of the type of equipment, effectiveness of the operator, presence or absence of parked cars along the curb, time of the year, traffic volumes, and frequency of sweeping. Table 5 outlines the effectiveness of street sweeping for the removal of sediment based on sweeping frequency in Milwaukee, Wisconsin.

TABLE 5
Sediment Removal Effectiveness of Street Sweeping

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

Source: SEWRPC, 1991

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

<u>Feasibility of Alternative</u>

Table 6 outlines the potential suspended solids reductions that can be achieved through street sweeping at various frequencies in the study area. The greatest pollution reductions are achieved by sweeping the commercial area on STH 67. Sweeping commercial areas 4 times per month provides a 13.4% reduction in the total suspended solids loading. Sweeping HWY 67 provides 79% of the total reduction produced by sweeping. As stated above, for sweeping to be effective the street must have a curb. Approximately 102-acres of the study area is served by roadside ditches. Sweeping of residential areas provides only a 2.1% reduction when done four times per month.

TABLE 6
Potential Suspended Solids Reductions by Various Street Sweeping Frequencies

Subbasin	Sweeping Frequency Per Month					
	1.0		2.0		4.0	
	Lbs./yr	% of total	Lbs./yr	% of total	Lbs./yr	% of total
400	847	1.6	1,550	2.9	2,604	4.9
500	6,282	18.5	8,523	25.2	11,579	34.2
Both Subbasins	**7,129**	**8.2**	**10,073**	**11.6**	**14,183**	**16.3**

Source: Hey and Associates, Inc.

The cost of street sweeping ranges from $15.48 to $32.64 per curb mile. Capital costs for mechanical street sweepers range from $78,000 to $114,000, and vacuum sweepers range from $132,000 to $144,000 (SEWRPC, 1991, updated to 1998 dollars). Using these costs, Table 7 outlines the potential operation and maintenance cost to sweep the entire study area at various frequencies from April through October.

TABLE 7
Range of Annual Operation Cost for Various Sweeping Frequencies

Subbasin	Sweeping Frequency Per Month		
	1.0	2.0	4.0
400 & 500 (1.7 curb miles)	$185 - $412	$390 - $782	$740 - $1,560

Source: Hey and Associates, Inc.

Currently the Village sweeps the curb and gutter portions of the watershed weekly during the summer months

Tests are being conducted on several new lines of "high efficiency" sweepers. These new sweepers are designed to pick up smaller particle sizes and more contaminants off the pavement surface. Preliminary results of the equipment's efficiencies are outlined in Table 8. The Wisconsin Department of Transportation is conducting a study of a high efficiency sweeper manufactured by Schwarze, Inc. on the interstate system in Milwaukee starting in 1999.

TABLE 8
Preliminary Results of Efficiency Tests on High Efficiency Sweepers

Land Use	Percent Sediment Removal by Frequency of Street Sweeping Using High Efficiency Sweeper (Times Per Month)		
	1.0	2.0	4.0
Residential	51%	63%	79%
Arterial Road	49%	62%	76%

Source: (Sutherland, et al 1998)

FERTILIZER MANAGEMENT

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

Feasibility of Alternative

Ninety percent of the study area is made up of residential properties. Many of the properties have managed lawns. A public education program on proper fertilizer management is recommended. Educational materials are available from the University of Wisconsin Extension. The education program should be conducted in a partnership effort between the Geneva Lakes Environmental Agency and the Village of Williams Bay.

LEAF LITTER CONTROL

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

Feasibility of Alternative

The Village of Williams Bay currently operates a leaf collection program in the fall of the year. Residents are asked to rake the leaves to the curb on specified days in which the Village collects the leaves. Collected leaves are composted by the Village and provided to local residents as mulch. This Village sponsored program helps in reducing the amount of leaf litter that enters the drainage system and Southwick Creek.

PET WASTE CONTROL

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

Feasibility of Alternative

The Village of Williams Bay has an adopted a pet waste ordinance.

CONTROL OF WASTE DUMPING

Many people falsely believe that the storm sewer inlet in the street leads to the local wastewater treatment plant and that waste dumped down these inlets will be treated. The truth is that dumping material, such as used oil, down an inlet is like dumping the material right into the local lake or stream. In Wisconsin, the University of Wisconsin Extension has developed a storm sewer stenciling program to educate people where the storm sewer leads and that waste should not be dumped down inlets. The program involves stenciling a statement such as "Dump no Waste-Leads to Stream" on the curb next to the inlet. In addition, a leaflet explaining the program and what local residents can do to protect water quality is left at the door of near by homes. Materials to conduct the program are available to local municipalities and civic organizations.

Feasibility of Alternative

The Village of Williams Bay currently conducts a storm sewer-stenciling program. An annual program of inspecting the stencils should be conducted. As stencils become faded they should be repainted.

Volume Reduction Alternatives

GRASSED SWALES

Conventional grassed swales are earthen channels that convey stormwater. Swales remove pollutants from urban stormwater runoff by filtration through the grass and infiltration through soil (Ferguson, 1994). The filtering capacity of the vegetation is dependent on the depth of flow. Typically, when the flow depth is above the top of the vegetation, filtering is minimal. Typical pollutant removals for grass swales are outlined in Table 9.

TABLE 9
Percent Pollutant load Reduction by Grass Swales

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

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

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

The cost of a typical grass swale with a 3-foot bottom width and 1-foot depth is estimated at $11.70 per foot (SEWRPC, 1991, updated to 1998 dollars).

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

Feasibility of Alternative

Grass swales are currently being used on approximately 102-acres, or 22% of the study area and are providing water quality benefits. The grass swales are located in the new development at the west end of the watershed. The eastern two thirds of the study area is 99% developed and is drained by curbs, gutters, and storm sewers. Land for new grass swales is not available, making this alternative unfeasible.

FILTER STRIPS

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

The rate of pollution removal is a function of the length, slope, soil, and permeability of the filter strip. Strips are effective in removing sediment and sediment associated pollutants such as bacteria, particulate nutrients, pesticides and metals. At least a 40% removal of sediment can be expected from strips as narrow as 25 feet, and strips 90 to 300 feet wide may remove all of the sediment load, depending on the soil permeability and sediment source (SEWRPC, 1991, updated to 1998 dollars).

The distance at which 100% of the sediment is removed by a filter strip is called the "critical distance" (Novotny and Olem, 1994). In a study using Bermuda grass, 100% of the sand, silt and clay were removed in distances of 10 feet (3 meters), 50 feet (15 meters), and 400 feet (122 meters) respectively.

General guidelines for grass filter strips are outlined in Table 10.

TABLE 10
Guidelines for Grass Filter Strip Design

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

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

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

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

Feasibility of Alternative

Within the highly developed watershed grass filters strips have limited applicability due to the degree of existing development. The only potential use would along parking lots to filter surface runoff before it enters the drainage system. As commercial or industrial property redevelops, the feasibility of installing grass filter strips should be explored.

INFILTRATION BASINS

An infiltration basin is a water impoundment constructed over permeable soils. The purpose of the basin is to temporarily store surface water runoff from a specific design storm and allow it to infiltrate through the bottom and sides of the basin. Pollutants are removed by the filtering action of the soil. Infiltration basins also provide for groundwater recharge, reduced volumes of runoff, and reduced peak discharges. Table 11 outlines typical long-term pollutant removal rates for infiltration basins and trenches.

TABLE 11
Typical Long-Term Pollution Removal Rates for Infiltration Trenches and Basins

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

Source: Schueler, 1987

For infiltration basins to be feasible, the subsoils needs to have an infiltration rate of 0.27 inches per hour or greater (MPCA, 1989). This corresponds to soils in the A and B hydrologic soil classification which includes silt loam, loam, sandy loam and sandy soils.

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

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

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

General guidelines for the design of infiltration basins are summarized in Table 12

TABLE 12
Guidelines for Infiltration Basin Design

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

Source: (MPCA), 1989)

Maintenance needs include inspections annually and after large storms, mowing at least twice a year, debris removal, erosion control and control of nuisance odor or mosquito problems. Deep tilling may be needed at 5 to 10 year intervals to break up a clogged surface layer. The tilled surface would then need to be graded and revegetated. In some cases an underdrain pipe may be needed to maintain adequate drawdown conditions. Accumulated sediments may also have to be removed by light equipment. The average annual operation and maintenance costs are about three to four percent of the capital cost (SEWRPC, 1991, updated to 1998 dollars).

Feasibility of Alternative

There is a currently one-combination detention pond/infiltration basin in the western portion of the study area. Land for additional infiltration basins is not available.

INFILTRATION TRENCHES

A conventional infiltration trench is a shallow, excavated trench that has been backfilled with stone to create an underground reservoir. Stormwater runoff diverted into the trench gradually exfiltrates from the bottom of the trench into the subsoil and eventually into the water table. Stormwater is treated by the soil adjacent to the trench. Infiltration trenches work similar to infiltration basins and have similar pollutant removal capacities. General guidelines for the design of infiltration trenches are summarized in Table 13.

TABLE 13
Guidelines for Infiltration Trench Design

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

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

Infiltration trench costs range from $42.00 to $500.00 per lineal foot depending on the trench width and depth (SEWRPC, 1991, updated to 1998 dollars).

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

Maintenance includes inspections annually and after large storms, buffer strip maintenance and mowing, and rehabilitation of the trench when clogging begins to occur. Surface clogging can be relieved by replacing the top layer of the trench but bottom clogging requires the removal of all of the filter and stone aggregate. Estimated annual operation and maintenance costs range from $285 for a three foot deep, four foot wide, 100 foot long trench, to $615 for a six foot deep, 10 foot wide, 100 foot long trench (SEWRPC, 1991, updated to 1998 dollars).

Feasibility of Alternative

Soils in the study area are a mixture of highly permeable Miami loam and silt loam in the western portion of the watershed, and low permeable Houghton muck and St Charles silt loam in the eastern half. High groundwater levels characterize the Houghton muck and St Charles silt loam soils. Portions of the storm sewer system that drains subbasin 400 is located in the Miami soils and could be replaced with perforated pipes to encourage infiltration. Of the 5,565-feet of storm sewer in subbasin 400, 2,475-feet are located in permeable soils, 3,090-feet are located in areas of high water table. All of the storm sewers in subbasin 500 are located in high water table soils. Replacement of the storm sewer in permeable soils would treat the runoff from approximately 60-acres, or 27% of the 220-acre subbasin. Installation of this practice would reduce the suspended solids loading to Southwick Creek by less than 5%. The cost of replacing the 2,475-feet of storm sewer with perforated pipe is estimated at $155,000.

POROUS PAVEMENT

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

Pollutant removal using porous pavement, based on two monitoring studies, has been shown to control 80% of suspended sediment, 60% of the total phosphorus, 80% of nitrogen, and high levels of trace metals and organic matter (Schueler, et.al., 1991). General guidelines for the design of porous pavement are summarized in Table 15.

TABLE 15
Guidelines for Porous Pavement Design

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

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

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

The capital cost of a conventional asphalt parking lot is approximately $48,000 per acre. The additional cost for a porous asphalt parking lot is estimated to range from $48,000 to $93,600 per acre in Southeastern Wisconsin. Annual maintenance cost for cleaning is estimated at $240.00 per acre (SEWRPC, 1991, updated to 1998 dollars).

Feasibility of Alternative

Applicability of this alternative is limited in the study watershed to low traffic volume parking lots, driveways, and patios. Determining potential locations for use of porous pavement would require in site specific analysis.

Stormwater Storage and Treatment Alternatives

WET DETENTION PONDS

Wet detention ponds are impoundments that have a permanent pool of water and also have the capacity to temporarily store stormwater runoff until it is released in a safe manner. The capacity to hold runoff and release it at a lower rate than incoming flows has made detention ponds a popular practice for flood control and stormwater management. Ponds with a properly designed permanent pool can trap sediment and prevent it from being scoured off the bottom by future storms. Dry detention ponds have lower pollutant removal efficiencies than wet bottom ponds, as sediment can be scoured off the bottom by incoming flows. Table 16 outlines typical pollutant removal for various detention pond types.

TABLE 16
Pollutant Removal Capacities of Various Detention Pond Designs

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

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

Wet detention ponds are effective at removing sediment-related pollutants. Pollutants removed by wet detention ponds include sediment, nutrients, heavy metals, oxygen demanding compounds (BOD), hydrocarbons, and bacteria. An expanded list of typical pollutant removal efficiencies for wet detention ponds is outlined in Table 17.

TABLE 17
Pollutant Removal Efficiencies of
Wet Detention Ponds

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

Source: Walker, 1987

Pollutant removal in wet detention ponds is primarily due to the settling of particulate pollutants and sediment due to gravity. The state of Wisconsin has developed a detention pond sizing methodology that is outlined in the Draft Wisconsin Stormwater Manual, Part Two: Technical Design Guidelines for BMP's (WDNR, 1995).

The methodology recommended in the Wisconsin Stormwater Manual is based on data from the National Urban Runoff Project (NURP) and sizes the pond based on land use characteristics of the drainage area and particle size distribution of the runoff. To achieve a 90% removal efficiency of 5 micron and larger particles, Wisconsin has developed a sizing method that sizes the permanent pool based on a percent of the drainage area and type of land use. Table 18 outlines the percent of each land use in a drainage area that is required as a permanent pool. To meet the 90% removal efficiency, the pond must have a minimum depth of 3 feet, and have live storage to retain the runoff from the first 1.5 inches of rainfall. The outlet structure is sized to maintain overflow velocities below the settling velocity of the smallest target particle size.

TABLE 18
Percent of Drainage Area Required as
Wet Detention Permanent Pool

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

Source: Pitt, 1991

To reduce maintenance cost, wet detention ponds can be constructed with a forebay to trap coarse sediments in a location from which they can be easily removed. The cost of a wet detention pond varies greatly depending on the basin size and design, site constraints, and the cost of the land. Capital costs have been estimated to range from as low as $28,000 for a 0.25 acre basin to $342,000 for a five acre basin (SEWRPC, 1991, updated to 1998 dollars).

Routine maintenance tasks include lawn care, basin inspections, debris removal, erosion control and nuisance plant control. Periodic maintenance tasks include inlet and outlet repairs and sediment removal. The estimated annual operation and maintenance cost for a wet detention basin is about three to five percent of the capital cost (SEWRPC, 1991, updated to 1998 dollars).

Feasibility of Alternative

There is currently one detention/infiltration basin in the study area, which treats the new residential development in the western portion of subbasin 400. A detention pond to treat the eastern portion of the watershed would need to be approximately 1.8-acres in size. Land on the west side of Southwick Creek to construct a wet detention basin is not available due to the existing urban development. Placement of the basin on the east side of Southwick Creek in the Kishwauketoe Conservancy would require stormwater pumping and would place the basin in a mapped wetland. Based on discussions with the WDNR, it is unlikely that a detention pond in the wetland would receive regulatory approval. This alternative is not feasible for the study area.

EXTENDED DETENTION PONDS

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

As illustrated in Table 16, extended detention basins have lower pollutant removal rates than wet detention ponds, but are a feasible alternative where a permanent pool is not safe and pollution control is needed. The extended detention ponds are normally "dry" between storm events and do not have any permanent standing water.

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

<u>Feasibility of Alternative</u>

As with a wet detention pond, installation of an extended detention basin in the study area is not feasible due to the limited available space.

STORMWATER WETLANDS

Conventional stormwater wetlands are shallow pools that create growing conditions suitable for the growth of marsh plants. These constructed stormwater wetlands are designed to maximize pollutant removal through the processes outlined in Table 19.

TABLE 19
Biofiltration Process of Stormwater Wetlands

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

The effectiveness of natural and constructed wetlands to remove stormwater pollutants is outlined in Table 20.

TABLE 20
Percent Pollutant Removal by Constructed and Natural Wetlands

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

Source: (Strecker et. al. 1992)

As can be seen from Table 20, construction wetlands can perform better than natural wetlands for some pollutants, such as phosphorus, ammonia, and some heavy metals when properly designed. The performance of a constructed wetland system is dependent on pollutant loading, hydraulic loading, detention time and pollutant up take of the system. As a general rule of thumb a treatment wetland needs to be sized between 2 and 5% of the watershed area (Schaefer, at al., 1996).

Constructions cost for stormwater wetlands vary greatly, and are difficult to predict except on a case by case basis. Generally stormwater wetlands cost slightly higher than traditional detention ponds.

Feasibility of Alternative

On the west side of Southwick Creek land is not available for a wetland treatment system. A wetland system could be developed in the Kishwauketoe Conservancy, however stormwater would need to be pumped from the storm sewer out fall to the treatment area. As shown on Figure 4, the Kishwauketoe Conservancy sits at or above the elevation of the storm sewer that drains subbasin 400. The land surfaces from STH 67 west to Elmhurst Court is also at or lower than much of the Kishwauketoe Conservancy, making relayment of the storm sewer or installation of a siphon not feasible.

WDNR has recommended that water quality treatment devices be designed for the runoff generated from the first 1½-inches of rainfall. Studies have shown that the cumulative runoff from the first 1½-inches of rainfall generate 80% of all the particulate pollutants that wash off an urban area. The peak flow during this storm is estimated at 30-cfs, with a mean flow of 15-cfs. A stormwater pumping station sized to pump the peak flow would cost between $500,000 and $750,000. The system would need to be designed with a bypass to divert larger storms into Southwick Creek.

The Wisconsin Department of Natural Resources (WDNR) currently classifies the Kishwauketoe Conservancy as a wetland area. To use the Conservancy for stormwater treatment the following WDNR and local stormwater ordinance conditions would need to be met:

1. Construction of the system would not involve any excavation or physical disturbance to the existing wetland.

2. Any changes in wetland hydrology would not adversely impact on the existing plant community.

3. Stormwater discharged to the wetland would be pre-treated to remove suspended solids.

A wetland treatment system to treat the study area would need to be approximately 8.8-acres in size. To meet the criteria above the best way to distribute the stormwater into the existing wetland without physical disturbance would be through a force main discharging to a perforated stormwater distribution pipe, which would spread the water over the existing wetland in thin sheet flow. Figure 6 illustrates a system with a sand pre-filter, stormwater pumping station and force main distribution system.

CATCH BASINS

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

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

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

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

Feasibility of Alternative

The Village of Williams Bay current has an active program of catch basin cleaning. Every spring a contractor, for a cost of $6,000 per year, cleans all of the catch basins in the Village. Within the study area there are approximately 50 to 60 storm sewer inlets. The incremental cost of cleaning the inlets with the study area is estimated between $500 and $1,080 per year.

SAND FILTERS

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

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

Construction cost for sand filters range from $3.60 to $12.00 per cubic foot of runoff treated (Schueler, et. al 1991). For comparison purposes sand filters cost about 2 to 3 times the cost of infiltration trenches.

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

Feasibility of Alternative

A sand filter designed to treat the first 1½-inch of rainfall by removing 100% of the 20-um and larger sized particles, assuming a 4-feet deep bed of sand, would be approximately 1.8 to 2.0 acres in size. Maintenance of the system would involve either periodic replacement of the sand media as it becomes clogged, or installation of a back flushing system. Using the above cost per cubic foot of runoff treated, the cost of the system is estimated at $930,000 to $3,094,500.

STORMWATER DIVERSION

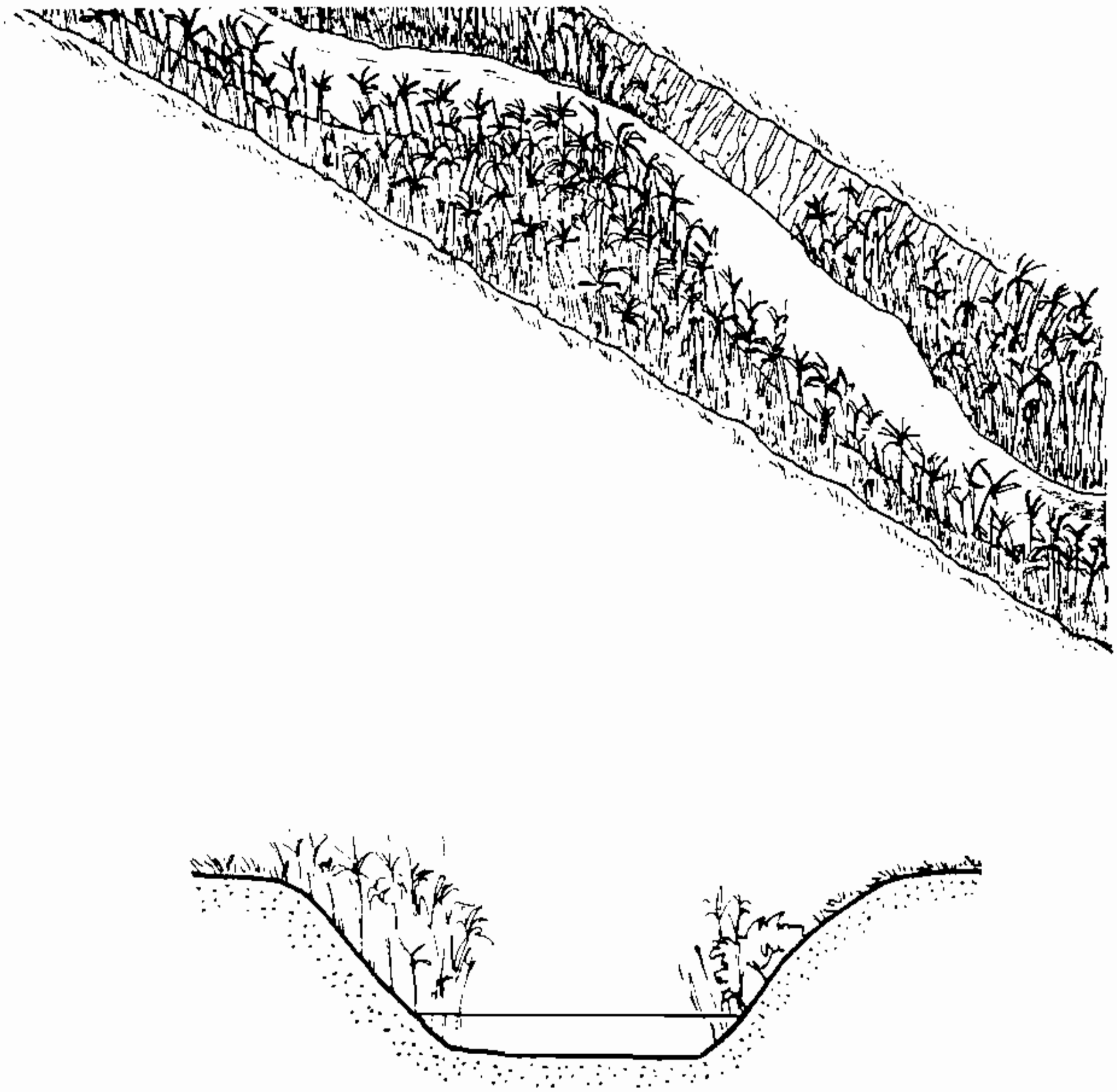
An alternative to address the negative impacts of stormwater discharges to Southwick Creek would be to separate the creek from the stormwater. There are two approached to separating the stormwater discharges from Southwick Creek, install a storm sewer diversion, or move the creek.

Installation of a diversion pipe from the current outlet near the water treatment plant directly to Lake Geneva would be difficult to accomplish due to the flat terrain in the area. A diversion pipe would have to placed almost completely flat. Flat pipes have maintenance problems as sediment accumulates due to low velocities. While this alternative would help protect Southwick Creek it will not address water quality issues in Lake Geneva.

Moving Southwick Creek away from the stormwater discharge is a second alternative to separating the cold water fishery from the urban runoff. Today Southwick Creek is in a degraded state. The stream is channelized (straightened) through the entire reach east of STH 67. At two locations the stream is enclosed in long lengths of pipe. Erosion of the artificial banks that have been cut into peat soils is a major problem. A new stream channel to the east of the existing channel could be constructed with features that provide better habitat for aquatic organisms and could address the current streambank erosion problem. Figures 7 and 8 illustrate two potential locations for a relocated stream.

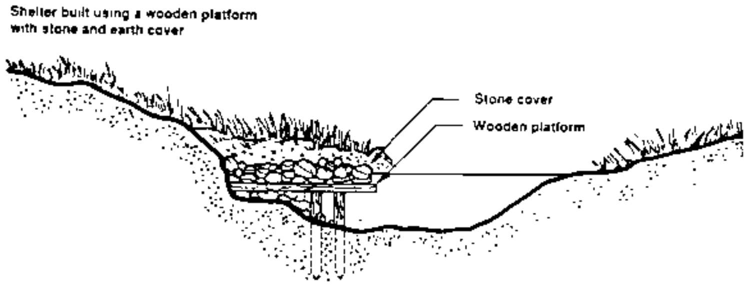
Figure 7 (Alternative B) illustrates an alternative of combining a relocated stream with treatment of the stormwater through a pre-treatment sand filter and wetland discharge through force main into a perforated distribution pipe. Figure 8 (Alternative C) illustrates a combined alternative of a relocated stream with wetland treatment system in the lower portion of the Kishwauketoe Conservancy.

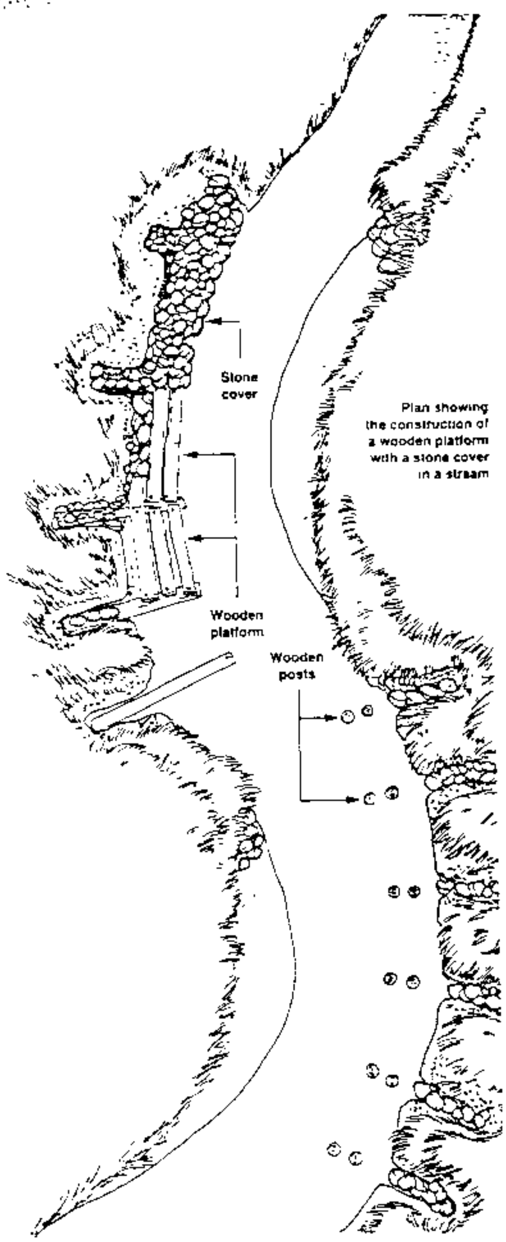
Figure 9 illustrates a typical section and plan view of a new channel design with undercut banks to provide cover for the Brown trout. Under both of the channel relocation scenarios, the old channel would be left in place to provide a high flow bypass for stormwater during flood events. The cost of the relocated channel, including excavation, hauling away the material, and install habitat and bank stabilization is estimated at $150 per lineal foot, or $450,000 for Alternative B and $525,000 for Alternative C.



Vegetated Channel Section

Southwick Creek *Stormwater Management Plan Phase II*	*Figure 9* *Typical Channel Cross-Section*	*Hey and Associates, Inc.*





Artificial Wooden Platform

Southwick Creek *Stormwater Management Plan Phase II*	*Figure 9 Continued* *Typical Channel Cross-Section*	*Hey and Associates, Inc.*

Summary

Table 21 (next page) summarizes the feasibility and cost of the alternatives discussed above. The Village of Williams Bay currently is implementing several housekeeping practices including fall leaf collection, pet waste control, control of dumping waste in storm sewers, and catch basin cleaning. Many alternatives such as grass swales, grass filter strips, infiltration basins and detention basins are in place in new developments at the west end of the study area. Installation of these practices in the eastern portion of the study is limited due to a lack of available space.

Construction of a wetland filter system east of Southwick Creek would require stormwater to be pumped due to the elevation of the existing storm sewer system and land surface at the lower end of the drainage area. A sand filter system sized to treat the study area would be approximately 1.8 to 2.0-acres in size and would need to be installed east of STH 67 due a lack of available space in the existing urban development.

Relocation of Southwick Creek to the east into the Kishwauketoe Conservancy could result in a stream channel with better habitat for the resident and migrating trout population. Relocation of Southwick Creek will require state and federal water regulation permits and will require an environmental assessment worksheet to be prepared.

TABLE 21
Potential Management Alternatives for Subbasins 400 & 500 in Southwick Creek Watershed

Alternative	Technically Feasible		Cost	Comments
	Yes	No		
SOURCE CONTROLS				
Construction Site Erosion Control			NA	Does not address temperature issues.
Street Sweeping			$740 - $1,560/yr	Suspend solids reduction is estimated at 16.3% if area is swept once per week from April through October. Does not address temperature issues.
Fertilizer Management			NA	Does not address temperature issues.
Leaf Litter Control			NA	Village currently has a program in place. Does not address temperature issues.
Pet Waste Control			NA	Village currently has a program in place. Does not address temperature issues.
Control of Dumping Waste			NA	Village currently has a program in place. Does not address temperature issues.
VOLUME REDUCTION ALTERNATIVES				
Grassed Swales			NA	Are used in upper watershed. Not feasible in lower watershed due to lack of available space.
Grass Filter Strips			NA	Not feasible due to lack of space.
Infiltration Basins			NA	Not feasible due to lack of space.
Infiltration Trenches/Exfiltration Sewers			$155,000	Would treat only 60-acres, or 27% of the study area. Reduces suspended solids by less than 5%. Would require approximately 2,500-feet of storm sewer to be replaced.
Porous Pavement			NA	Not feasible due to type of land use.
STORMWATER STORAGE AND TREATMENT ALTERNATIVES				
Wet Detention Ponds			NA	Not feasible due to lack of space.
Extended Detention Ponds			NA	Not feasible due to lack of space.

TABLE 21 (cont.)
Potential Management Alternatives for Subbasins 400 & 500 in Southwick Creek Watershed

Alternative	Technically Feasible		Cost	Comments
	Yes	No		
STORMWATER STORAGE AND TREATMENT ALTERNATIVES (CONT.)				
Stormwater Wetlands (with stormwater pumping station)			$500,000 to $750,000	Would require WDNR approval. Cost includes construction. Annual operation and maintenance is estimated at $20,000 per year.
Catch Basin Cleaning			$480 to $1,080 per year	Village currently has a program in place. Does not address temperature issues.
Sand Filters			$930,000 to $3,094,500	Only feasible as a pre-treatment device due to lack of available space.
STORMWATER DIVERSION				
Diversion pipe			NA	Not feasible due to flat topography.
Relocated channel			$450,000 to $525,000	Would require WDNR and USACOE permits.
COMBINATION OF ALTERNATIVES				
Alternative A (Sand filter, pump, and wetland filter)			NA	Site for sand filter is too small.
Alternative B (Sand filter, pump, wetland filter, relocated stream)			$1,880,000 to $4,294,500	Would require purchase of private upland property for the sand filter. Would require WDNR and USACOE permits.
Alternative C (Pump, wetland filter, and relocated channel)			$1,955,000 to $4,369,500	Would require WDNR and USACOE permits.

Recommendations

Management of stormwater in the Southwick Creek watershed needs to be technically, politically and financially feasible to be implemented. While several management alternatives maybe technically feasible, the capital cost of their installation likely exceeds local resources. Table 22 includes a list of recommendations that is felt best meets the goals of this plan and is within the financial resources of the local community.

TABLE 22
Stormwater Recommendations

Alternative	Cost	Implementing Agency
1. Continue construction site erosion control.	NA	Village of Williams Bay
2. Continue fall leaf collection program.	NA	Village of Williams Bay
3. Continue enforcement of pet waste ordinance.	NA	Village of Williams Bay
4. Continue public education on lawn fertilizer use and dumping of waste.	NA	Village of Williams Bay and Geneva Lakes Environmental Agency
5. Continue spring catch basin cleaning program.	\$500 - \$1,080/yr	Village of Williams Bay
6. Continue weekly street sweeping program.	\$740 - \$1,560/yr	Village of Williams Bay
7. Relocate Southwick Creek to the east into the Kishwauketoe Conservancy	\$450,000 to \$525,000	Village of Williams Bay, WDNR, sportsman clubs, and local property owners associations.

Next Steps

The following is an outline of the next steps necessary to implement the plan recommendations:

1. Adoption of Management Plan by the Village of Williams Bay, Geneva Lakes Environmental Agency, and Wisconsin Department of Natural Resources (WDNR).

2. Village of Williams Bay continue implementation of recommendations 1 through 6 in Table 22.

3. To implement recommendation number 7, the Southwick Creek relocation and restoration, the following steps should be undertaken.

    a. The Village of Williams Bay and the WDNR should enter into an intergovernmental agreement stating their interest in cooperatively working on a restoration project for Southwick Creek.

b. The WDNR Southeast Region staff should prepare a work planning and budget request for a stream restoration project on Southwick Creek through the Bureau of Fisheries Management and Habitat Protection.

c. WDNR should conduct a stream appraisal of Southwick Creek to determine the current habitat conditions and identify areas in need of restoration and protection.

d. Prepare a preliminary restoration plan.

e. Have preliminary plan reviewed by regulatory agencies (WDNR, USACOE, and Walworth County) for compliance with current regulations.

f. Identify potential funding sources, including federal and state grants, sportsman clubs, conservation organizations, and property owner associations.

g. Prepare final plans and necessary permits applications.

h. Acquire final project approvals from cooperating parties.

i. Implement project.

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