CHAPTER 6.0

RECOMMENDATIONS AND PRELIMINARY STORMWATER TREATMENT CONCEPTS

K&A has conducted a preliminary evaluation of potentially suitable stormwater treatment concepts for runoff entering the west end of Asylum Lake from subwatershed #5 discharging via stormwater inlet #1. All BMPs examined here are widely accepted and utilized for sediment and nutrient removal, though some are more appropriate than others for this setting. Several BMP options are discussed below. Accompanying Tables 8-15 can be found at the end of this chapter. All concepts presented here should be considered conceptual and do not infer commitments on the part of any party or entity associated with land ownership in this subwatershed.

6.1 Evaluation of Potential BMPs

Common pollutant reduction estimates for each BMP are presented in Table 8. It should be noted that these values are median pollutant reduction percentages for design purposes that have been derived from published sampling data, modeling and research. A stormwater BMP design may be capable of exceeding these performances; however, the values in the table are considered median values that can be assumed to be achieved when the stormwater BMP is sized, designed, constructed and maintained in accordance with intended specifications.

Further details regarding relative treatment effectiveness, costs, aesthetics, size requirements and maintenance for common stormwater BMPs are presented in Tables 9, 10 and 11.

Sediment Forebay

Sediment forebays are a type of pretreatment BMP used to initially detain stormwater runoff for a short time period to settle out a portion of the suspended material. They are essentially small detention ponds or settling basins, which can be used as stand-alone devices or in combination with other BMPs. Forebays also reduce maintenance needs and maintenance costs by trapping sediment in one small area where it is more easily removed, and further preventing excessive sediment buildup in the other downstream treatment BMPs.

Retention Pond

A retention pond is designed to hold a specific amount of water indefinitely. It is designed as a permanent pool of water (Debo & Reese, 1995), which releases water only through infiltration and evaporation processes. Usually the pond is designed to have drainage leading to another location when the water levels reach the pond capacity, but still maintains water at the design capacity.

Wet Detention Pond

Wet detention ponds are a variation of retention ponds and are designed to maintain an extended volume above a designed permanent pond elevation, with a gradual release of this additional volume. The depth to groundwater in the project area is quite close to the ground surface (based strictly on observations made during field surveys), therefore, it is expected that evaporation would be the primary mechanism of water removal for the permanent pool volume rather than infiltration.

Dry Detention Pond

These are designed as ponds that hold, or detain, stormwater runoff for a specified time period (typically 6-24 hours) after which the volume drains completely. They are commonly used to remove suspended solids from the stormwater prior to release, and for attenuation of peak flows for downstream flood control. Nutrients, heavy metals, and other stormwater pollutants associated with suspended solids may also be removed to a limited extent. Excessive siltation can result in decreased capacity of detention volume.

Wetlands

Stormwater wetlands are another option for treating stormwater runoff. They utilize shallow, inundated vegetation to remove stormwater sediments and nutrients through biological and naturally occurring chemical processes. For stormwater wetlands to function properly, the hydrologic regime must be closely monitored to ensure that the tolerances of the wetland vegetation are not exceeded, and that adequate retention times are provided. Wetlands can be effective components of stormwater treatment, though land requirements may be fairly intensive and seasonal influences may complicate nutrient removal.

Infiltration Basins

An infiltration basin is a shallow depression area created by excavation or berming that captures and slowly infiltrates stormwater runoff into the soil. Infiltration basins can serve large drainage areas (5-50 acres). In an urban setting, they are best used in conjunction with other BMPs which serve to remove sediments that would otherwise clog the bottom soils. The primary advantage of infiltration basins is that they help to preserve the natural water balance of the site, require low maintenance, and can be integrated into the site landscape. They are best sited in areas where there is sufficient surface area and soil infiltration capacity.

Infiltration Trenches

Other common BMPs are those that focus on infiltration as a means of stormwater treatment. A porous medium (typically coarse sand or gravel) is placed in an excavated trench to promote infiltration. These devices are commonly used as on-site treatment options and they are prone to high maintenance requirements unless sediments are properly removed upstream of their use. Successful implementation of this BMP can be limited in areas of shallow groundwater.

Sand Filters

Sand filters treat stormwater by passing the first flush through a coarse sand filter medium. The filtered water is typically collected in an underdrain system (gravel and perforated pipe) and discharged via a surface outfall rather than infiltrating to the groundwater. Sand filters are effective BMPs for removing solids, but are only moderately effective in treating total phosphorus and other nutrients. Due to hydraulic overloading concerns that can damage the filter bed during intense, peak flows, sand filters are usually installed as an off-line BMP. Most sand filters exhibit diminished operational capacity over time due to surface clogging by organic matter, fine silts, and hydrocarbons resulting in higher than average maintenance considerations. These devices are typically used for smaller applications than those considered necessary for this Asylum Lake drainage area.

Grassed Swales

These are vegetated treatment areas that use bioinfiltration and infiltration to treat stormwater (Debo & Reese, 1995). These vegetative BMPs are effective for TSS and metals removal but have limited effectiveness for phosphorus removal. Depth to groundwater and percentage of impervious surfaces in the watershed may complicate the effectiveness of these practices.

Dry swales are distinguished from a simple grassed swale by the addition of carefully selected, highly permeable soil (usually sandy loam), check dams, and an underdrain system. These additional design features ensure that infiltration of stormwater will not only depend on the infiltration rate of the existing natural soils. Only in special circumstances where natural soil and groundwater conditions consistently provide high infiltration will a traditional grassed swale provide the same water quality benefits as a dry swale design.

Another type of swale, a wet swale, is designed to maintain saturated conditions within soils at the bottom of the swale. The purpose of a wet swale is to create an enlongated wetland treatment system that treats stormwater through physical and biological processes. Unlike dry swales, infiltration of stormwater is an undesirable condition in a wet swale because it would prevent saturated conditions necessary to support wetland vegetation.

Filter/Buffer Strips

Filter strips, also known as vegetated buffer strips, use biological means to filter stormwater runoff. Strategically directed runoff flows in a wide sheet across this vegetated area, and is treated by infiltration into the soil and through uptake by the plants. Small berms may be installed at the downstream edge of the filter strip to ensure that water can be detained and filtered into the underlying soils. Filter strips are not designed to attenuate peak stormwater flows, but can be an effective water quality BMP. A dense vegetative cover, long flow path, and low gradient profile provide the most effective removal rates.

Oil and Grit Separators (e.g., Stormceptor® Units)

Stormceptor® units and similar prefabricated structures are specifically-designed to remove trash, sediment and hydrocarbons from stromwater runoff. While relatively expensive to install and maintain, they are necessary for select urban applications where debris, oil and grease may be more problematic. Depending on the amount of runoff and available prefabricated sizing limitations, these BMPs may require installation of multiple units in parallel operation.

BMP Summary

No single BMP is necessarily adequate for treating stormwater from large drainage areas (i.e., greater than 5-10 acres). For larger drainage areas, stormwater BMPs should be selected using a "treatment-train" concept. A treatment-train is a series of BMPs used in conjunction with one another to provide a more comprehensive treatment of stormwater runoff. Each BMP is chosen for its ability to remove or limit specific pollutants, and/or its ability to help regulate changes in hydrology. Furthermore, all BMPs which are selected for use at a given site should be designed based on the observed site-specific characteristics (i.e., soil type, slope, topography, climate, etc). Wherever possible, stormwater BMPs should be designed to be aesthetically pleasing.

6.2 Preliminary Runoff Design Considerations

The following analysis examines critical factors associated with the physical setting of subwatershed 5 that will influence design considerations to effectively treat runoff.

Curve Number and Runoff Volume Estimates

Existing land use information was evaluated by K&A and used to estimate stormwater runoff characteristics for Asylum Lake subwatershed 5 (Figure 2) and stormwater inlet #1 (Figure 3). Based on available land use information, individual land use curve numbers were calculated and area-weighted to produce a composite runoff curve number (RCN) value of 76.6 for this urban drainage area. This composite RCN value was then used to determine estimated runoff produced by various rainfall events. Stormwater runoff volumes were estimated by K&A for runoff entering the west end of Asylum Lake from subwatershed 5. Runoff curve number calculations and estimated runoff volumes are presented in Tables 12 and 13, respectively.

Storm events of various frequencies were used to estimate runoff volumes from subwatershed 5 (Table 13). Based on the available land area west of Asylum Lake and a design goal of capturing the initial 1-inch of rainfall runoff (i.e., "first flush"), a stormwater capture volume of approximately 4.9 acre-feet is attainable for a single storm event.

Stormwater Loading Estimates

Estimated pollutant loads from stormwater runoff were calculated for Asylum Lake subwatershed 5. (Refer to Section 3.0 of this text for a detailed discussion.) Characterizing the quantity of pollutants entering Asylum Lake from this drainage area identifies the level of impact that stormwater runoff is imparting on the lake, but also aids with defining the requirements and focus of stormwater treatment alternatives. Table 14 provides a summary of estimated annual loads for total suspended solids, total phosphorus and total nitrogen associated with stormwater runoff from subwatershed 5 entering Asylum Lake.

6.3 Recommended Treatment Concept

The former trailer park property located at the southwest corner of Stadium Drive and Drake Road, approximately 6.5 acres in size, is now under the control of the WMU Foundation. The Foundation has recently expressed interest in developing a portion of the site and allowing the remaining unused space to be utilized for stormwater treatment. As a result, the recommended treatment concept proposed by K&A is primarily limited to the southern 2.75 acres of the former trailer park property. The fundamental purpose of the recommended treatment concept is to divert stormwater runoff from subwatershed 5 and infiltrate as much stormwater as possible.

Figure 14 provides a schematic illustration of the key treatment system elements that are included in the recommended treatment concept. Several important discussion items related to the schematic illustration are listed below.

- Size of the flow direction (blue) arrows on this schematic conceptually depicts the volume of stormwater passed through each stage of the treatment system (as less volume is passed and greater cumulative volume is infiltrated).
- Stormwater will be diverted from a manhole, located at the northeast corner of Stadium Drive and Drake Road, toward the west onto the WMU Foundation property.
- Untreated stormwater will be directed through a passive, underground trash collection vault structure specifically designed to remove trash, coarse sediment and hydrocarbons from stromwater runoff. This structure will require periodic maintenance to remove litter.
- Stormwater will then be diverted to a sediment forebay. Sand and some silt would be removed through this open basin, approximately 2-4 feet in depth (below the surrounding grade). Long-term periodic cleanout of accumulated sediments may be needed once every 5-10 years. Retention time for this cell would be on the order of 2-3 hours for typical runoff events.
- A 2-4 feet deep retention/infiltration pond will receive stormwater from the sediment forebay. Fine sediments will be settled here (if a 12-24 hour detention time can be established based on size). Limited infiltration and evaporation is expected from this basin.
- Stormwater will then be directed through two, terraced infiltration basins constructed in series. These basins would be constructed to appear as rain gardens with a wide diversity of native prairie and wetland plants. They would be approximately 1-2 feet deep (below surrounding grade). These would be allowed to fill to no more that about 12-14 inches deep, and be constructed to fully drain between storm events.
- To help ensure the maximum fill depth is not exceeded as both infiltration basins fill under extreme or intense storms, an overflow infiltration trench extending south and then east, wrapping around the existing wetland, is also recommended. Significant infiltration capacities have been observed by K&A in other similar infiltration trenches we've constructed.
- Water flowing through the infiltration basins during typical runoff events (that does not overflow to the south), will pass through a final series of infiltration structures. These would rely on the underlying sand lithology separated by filter fabric overlaid with stone. Over time, perimeter vegetative growth would obscure direct observation of these features.
- If infiltration through these latter infiltration basins is exceeded during high volume events, the final discharge of treated water will be vented to the existing wetland drainage ditches. These existing wetlands (or lowlands) are often dry with only periodic inundation. More frequent wetting might occur with direct discharge and/or recharge from treatment system infiltration basins.
- Some modification of these drainage ditch outlets may be needed on the west side of Drake Road.

Figure 15 provides an aerial overlay and preliminary layout of the conceptual treatment-train system. Several important discussion items related to the conceptual layout sketch are listed below.

- Approximately 60% of the northern portion of the upland areas adjacent to Stadium Drive would accommodate a new building with a footprint of 25,000 ft^2 with up to approximately 70 parking spaces.
- Any future parking lot would have its own stormwater capture with integrated on-site rain gardens. Overflows to the larger system will be possible if needed to meet potential Oshtemo Township requirements.

- The recommended treatment concept would utilize the existing terracing to the south of a potential building/parking lot footprint for a stormwater BMP treatment-train.
- Infiltration will be the primary treatment approach with overflows, if any, entering the existing wetland ditches that are connected to Asylum Lake via culverts beneath Drake Road.
- The treatment-train area would be naturalized, accommodating existing landscaping where possible and appropriate, feature walking paths, and blend into the existing natural terrain. From any future, on-site building, this treatment area would be visually pleasing.

This site-specific stormwater treatment approach, heavily favoring infiltration, appears to be the most efficient and effective way to mitigate loads to Asylum Lake. Existing topography and natural features provide opportunities for a terraced BMP layout with gravity conveyance of stormwater throughout the conceptual treatment-train system.

Diverted stormwater runoff would initially be directed on-site and into a trash, oil and grit separator to remove large litter debris and potential hydrocarbon compounds associated with the nearby commercial and impervious areas (subwatershed 5). Flows exiting the trash separator would be subsequently directed into a sediment forebay for removal of medium-coarse suspended sediments. A small retention/infiltration pond would follow the forebay to provide a combination of fine sediment deposition and nutrient reduction. Limited infiltration and evaporation would also occur in the retention/infiltration pond between storm events. Finally, a series of terraced bioinfiltration basins and infiltration trenches would allow stormwater to be naturally returned to the groundwater to maintain the hydrologic regime via recharge. If necessary, a portion of intense storm flows could be diverted into the nearby existing wetland drainage ditches that are connected to Asylum Lake beneath Drake Road. Some modification of these drainage ditch outlets may be needed on the west side of Drake Road.

Estimated Costs

All stormwater BMPs have economies of scale and their associated costs are variable depending on region and site constraints. Estimated implementation costs (preliminary) for the recommended stormwater BMP treatment concept proposed by K&A for Asylum Lake are summarized in Table 15. Capitol construction costs are estimated to be approximately $303,000. In addition, engineering design and permitting costs are estimated to be approximately $60,600. Contingency costs (%10) amount to approximately $30,300. An estimated total for project development of the recommended treatment concept is $394,000. These estimates are based on recent and local projects of similar materials and scope.

Table 8. Design Pollutant Removal Efficiencies (%) for Stormwater BMPs.

Stormwater BMP	Total Suspended Solids	Total Phosphorus	Total Nitrogen	Pathogens	Metals
Dry Detention Basins	30-65	15-45	15-45	<30	15-45
Retention Basins	50-80	30-65	30-65	<30	50-80
Constructed Wetlands	50-80	15-45	<30	<30	50-80
Infiltration Basins[1]	50-80	50-80	50-80	65-100	50-80
Infiltration Trenches/ Dry Wells	50-80	15-45	50-80	65-100	50-80
Porous Pavement	65-100	30-65	65-100	65-100	65-100
Grassed Swales	30-65	15-45	15-45	<30	15-45
Vegetated Filter Strips	50-80	50-80	50-80	<30	30-65
Surface Sand Filters	50-80	50-80	<30	<30	50-80
Other Media Filters	65-100	<30	15-45	<30	50-80
Trash/Oil/Grit Separator	30-60	<5	<5	---	---

Source: U.S. EPA, 1999

Notes:

1. Infiltration basins can be considered 100 percent effective at removing pollutants in the fraction of water that is infiltrated, if the pollutants found in this volume are not discharged directly to surface waters via an overflow spillway. Since infiltrated water does not leave the BMP as a discrete flow, there is no representative way of collecting a true outflow sample.

--- Insufficient data to provide design removal efficiency.

Additional Considerations:

1. BMP performance should not be based on comparisons using percent removal alone. This finding is illustrated by an example where low total suspended solids in influent might result in a low percent removal calculation for suspended solids. The BMP might be performing as intended, even though the percent removal value is low.
2. The chosen performance-evaluation method can affect reported pollutant removal efficiencies.
3. Wet ponds and wetlands are not well represented by storm-by-storm comparisons because paired inflow and outflow might not be related to the same event.
4. Effluent quality is useful for characterizing the effectiveness of the BMP.
5. Downstream response and biological/habitat assessment might be a better gauge of long-term BMP effectiveness for select sites than pollutant removal efficiencies alone.
6. More data are needed for sound statistical analysis, particularly for BMPs other than ponds and wetlands.

Table 9. Relative treatment effectiveness, costs, aesthetics, and size requirements for various stormwater BMPs.

Stormwater BMP	Stormwater Treatment Effectiveness	Relative Cost	Traditional Aesthetics	Proposed Size Requirements (as percent of total)	Remarks
Wet Retention	High	Low/Med	Med	50-100%	Access limitations may be required
Dry Detention	High	Low	Low	--	Not recommended for large watersheds
Sediment Forebay	High	Low	Low	5-10%	Maintenance access required
Wetlands	Moderate	Med/High	High	0-25%	Low maintenance; high natural habitat
Infiltration Basin	High	Low/Med	Med	50-100%	Low maintenance
Infiltration Trench	Moderate/High	Med	Low	--	Not recommended for large watersheds
Sand Filter	Moderate	High	Low	5-10%	High maintenance; off-line treatment
Grassed Swale	Low/Moderate	Low	High	--	Not recommended for large watersheds
Stormceptor® Units[1]	Moderate	High	Med	--	Not recommended for large watersheds

Notes:
1. Stormceptor® is referenced above as an example manufacturer of structural precast BMP water quality devices that can be installed on-line to remove trash, oil and grit from stormwater runoff. These systems are not necessarily stand-alone BMPs and should be used to pretreat stormwater runoff prior to discharging to other BMPs such as ponds, sand filters, or infiltration/exfiltration trenches whenever possible. The above reference is not necessarily intended to constitute an endorsement of the Stormceptor® product.

Table 10. Estimated implementation costs for various stormwater BMPs.

Stormwater BMP	Conceptual Cost (C) Equation[1] ($)	Conceptual Cost[2] ($/ft³)	Remarks
Retention/ Detention Basins and Sediment Forebays	C=168.39xV0.69 (where: V is in m³)	0.50-1.00	Cost range reflects economies of scale in designing this BMP. The lowest unit cost represents approx. 150,000 cubic feet of storage, while the highest is approx. 15,000 cubic feet. Typically, dry detention basins are the least expensive design options among retention and detention practices.
Constructed Wetlands	$18.5(V)^{0.70}$ (where: V is in ft³)	0.60-1.25	Although little data are available to assess the cost of wetlands, it is assumed that they are approx. 25% more expensive (because of plant selection and sediment forebay requirements) than retention basins.
Infiltration Basin	$C=13.9(V/0.02832)^{0.69}$ (where: V is in m³)	1.30	Represents typical costs for a 0.25-acre infiltration basin.
Infiltration Trench	C=1317.1xV0.63 (where: V is in m³)	4.00	Represents typical costs for a 100-foot long trench.
Sand Filter	$10,000-$20,000 /impervious acre	3.00-6.00	The range in costs for sand filter construction is largely due to the different sand filter designs. Of the three most common options available, perimeter sand filters are moderate cost whereas surface sand filters and underground sand filters are the most expensive.
Grass Swale	$5-$15/linear ft	0.50	Swale Based on cost per square foot, and assuming 6 inches of storage in the filter.
Filter Strip	$2,000/drainage acre	0.00-1.30	Based on cost per square foot, and assuming 6 inches of storage in the filter strip. The lowest cost assumes that the buffer uses existing vegetation, and the highest cost assumes that sod was used to establish the filter strip.
Stormceptor® Units[3]	30,000-60,000[4]	30,000-60,000[4]	The expected life of the Stormceptor® is 50 to 100 years (Stormceptor®, 1996).

Source: U.S. EPA, 1999; www.stormceptor.com

Notes:
1. Conceptual costs can be estimated from these equations, where V is the volume of stormwater managed (m³), unless noted otherwise (Schueler, 1987) and (Wiegand et al., 1986). Base year for these cost equations is 1995. Real estate, design, and contingency costs are not included in these estimates. These are provided for conceptual cost estimating purposes only.
2. Base year for these cost data: 1997. Real estate, design, and contingency costs are not included in these estimates. These are provided for conceptual cost estimating purposes only.
3. Stormceptor® is referenced above as an example manufacturer of structural precast BMP water quality devices that can be installed on-line to remove trash, oil and grit from stormwater runoff. These systems are not necessarily stand-alone BMPs and should be used to pretreat stormwater runoff prior to discharging to other BMPs such as ponds, sand filters, or infiltration/exfiltration trenches whenever possible. The above reference is not necessarily intended to constitute an endorsement of the Stormceptor® product.
4. Estimated implementation costs for structural precast trash/oil/grit separator devices are provided in $/acre. Not recommended for large watersheds.

Table 11. Common BMP Maintenance Considerations.

Stormwater BMP	Activity	Schedule
Retention Pond/ Wetland	• Cleaning and removal of debris after major storm events • Harvest excess vegetation • Repair of embankment and side slopes • Repair of control structure	Annual or as needed
	• Removal of accumulated sediment from main cells of pond once the original volume has been significantly reduced	20-year cycle (although can vary)
Sediment Forebay	• Removal of accumulated sediment from forebays or sediment	5-yr cycle, or as needed
Detention Basin	• Removal of accumulated sediment • Repair of control structure • Repair of embankment and side slopes	Annual or as needed
Infiltration Basin	• Cleaning and removal of debris after major storm events • Mowing[1] and maintenance of upland vegetated areas	Annual or as needed
	• Removal of accumulated sediment from forebays or sediment storage areas	3- to 5-year cycle
Infiltration Trench	• Cleaning and removal of debris after major storm events • Mowing[1] and maintenance of upland vegetated areas	Annual or as needed
Sand Filter	• Maintenance of inlets and outlets • Removal of trash and debris from control openings • Repair of leaks from the sedimentation chamber or deterioration of structural components • Removal of the top few inches of sand and cultivation of the surface when filter bed is clogged (only works for a few cycles) • Clean-out of accumulated sediment from filter bed chamber • Clean out of accumulated sediment from sedimentation chamber	Annual or as needed
Grass Swale	• Mowing[1] and litter and debris removal • Stabilization of eroded side slopes and bottom • Nutrient and pesticide use management	Annual or as needed

Table 11. Common BMP Maintenance Considerations *(continued)*.

	• De-thatching swale bottom and removal of thatching • Discing or aeration of swale bottom	
	• Scraping swale bottom, and removal of sediment to restore original cross section and infiltration rate	5-year cycle
Filter Strip	• Seeding or sodding to restore ground cover (use proper erosion and sediment control) • Mowing[1] and litter and debris removal • Nutrient and pesticide use management • Aeration of soil in the filter strip • Repair of eroded or sparse grass areas	Annual or as needed
Stormceptor® Units[2]	• Inspect every six months for the first year to determine the oil and sediment accumulation rate. • Clean out each unit once a year using a conventional vacuum truck, • or when 15 percent of the operating storage volume is filled with solids, • or when oil levels reach 25 mm (1.0 in) or greater (Stormceptor®, 1996) • Sediment capacity of these units generally range from 2.12 to 20.56 m3 (2.77 to 26.87 yd3).	Annual (minimum), or as needed

Source: U.S. EPA, 1999; www.stormceptor.com

<u>Notes</u>:
1. Mowing may be required several times a year, depending on local conditions.
2. Stormceptor® is referenced above as an example manufacturer of structural precast BMP water quality devices that can be installed on-line to remove trash, oil and grit from stormwater runoff. These systems are not necessarily stand-alone BMPs and should be used to pretreat stormwater runoff prior to discharging to other BMPs such as ponds, sand filters, or infiltration/exfiltration trenches whenever possible. The above reference is not necessarily intended to constitute an endorsement of the Stormceptor® product.

Table 12. Asylum Lake Stormwater Treatment Evaluation of Storm Sewer Subwatershed #5.

Storm Sewer Area #5 Land Use	Area (ac)	Percent (%) of Total Area	Landuse RCN	Partial RCN
Low intensity urban	13.566	19.6	81	15.8
High intensity urban	21.794	31.4	89	28.0
Road/parking lot	16.457	23.7	98	23.2
Agriculture	0.000	0.0	59	0.0
Openland/shrub	4.670	6.7	39	2.6
Forest	11.564	16.7	36	6.0
Water	0.000	0.0	100	0.0
Forested Wetlands	0.000	0.0	100	0.0
Sand/soil/bare	1.334	1.9	49	0.9
	69.4	**100.0**		**76.6**

= Composite Runoff Curve Number (RCN) for Storm Sewer Area #5

Table 13. Estimated Rainfall Depths and Runoff Volumes for Storm Sewer Subwatershed #5 of Asylum Lake.

24-Hour Rainfall Frequency[a]	Storm Sewer Area #5 Surface Runoff (inches)	Runoff Volume (ac-ft)
9-mo To 1-yr (2.2")	0.54	3.14
1-yr (2.3")	0.60	3.48
2-yr (2.7")	**0.85**	**4.91**
5-yr (3.3")	1.26	7.28
10-yr (3.9")	1.71	9.86
25-yr (4.5")	2.18	12.60
50-yr (5.1")	2.67	15.45
100-yr (5.7")	3.18	18.39

[a]Precipitation values from "Rainfall Frequency Atlas of the Midwest", Midwestern Climate Center and Illinois State Water Survey, 1992.
Yellow denotes design storm

Table 14. Estimated Annual Stormwater Loading Contribution into Asylum Lake from Storm Sewer Subwatershed #5.

	Total Phosphorus (lbs/yr)	Total Suspended Solids (lbs/yr)	Total Nitrogen (lbs/yr)
Storm Sewer Inlet #1	102	32,620	482
Percent of Total Load to Asylum Lake	38%	43%	33%

Table 15. Estimated Costs for the Asylum Lake Conceptual Treatment-Train System.

Item	Quantity	Unit	Unit Cost	Total Cost
Site Clearing/Prep	3	ac	$4,500	$13,500
Diversion of Storm Sewer	150	ft	$50	$7,500
Drake Road Trench/Resurfacing	1,100	ft2	$12	$13,200
Trash Separators	3	ea	$20,000	$60,000
Storm Manhole Structures	2	ea	$2,500	$5,000
Piping to Forebay	250	ft	$40	$10,000
Sediment Forebay				
Inflow Structure	1	ea	$1,500	$1,500
Excavation	1,300	cyd	$4	$5,200
Berming (2-ft high)	705	ft	$30	$21,150
Outflow Structure	1	ea	$1,500	$1,500
Wet Detention Pond				
Inflow Structure	1	ea	$1,500	$1,500
Excavation	960	cyd	$4	$3,840
Berming (2-ft high)	655	ft	$30	$19,650
Outflow Structure	1	ea	$1,500	$1,500
Infiltration Basins (2)				
Inflow Structure	2	ea	$1,500	$3,000
Excavation	4085	cyd	$4	$16,340
Berming (2-ft high)	1500	ft	$30	$45,000
Outflow Structure	2	ea	$1,500	$3,000
Infiltration Beds (2)				
Inflow Structure	2	ea	$1,500	$3,000
Excavation	890	cyd	$4	$3,560
Berming (2-ft high)	960	ft	$30	$28,800
Outflow Structure	2	ea	$1,500	$3,000
Infiltration Trench	1,150	ft	$15	$17,250
Plantings/Lanscaping	3	ac	$5,000	$15,000

Construction Subtotal	$302,990
10% Contingency	$30,299
20% Engineering/Design	$60,598

Estimated Total Project Development **$393,887**