HURON-CLINTON metroparks

Huron-Clinton Metropolitan Authority
Stormwater Management Plan

September 2019

Prepared by: OHM

Huron-Clinton Metropolitan Authority

Stormwater Management Plan Executive Summary

Introduction

The Huron-Clinton Metropolitan Authority (HCMA) received a grant from the State of Michigan Stormwater, Asset Management, and Wastewater (SAW) funding program in 2016 and subsequently retained OHM Advisors to perform a comprehensive review and analysis of the existing stormwater conveyance system and develop a stormwater management plan (SWMP) for improvement and maintenance projects that prioritize reduction of impacts on water quality. This SWMP includes concepts and preliminary details for the design, construction, and operation and maintenance of the HCMA stormwater system, which allows for safe conveyance of runoff during wet weather events. Streambank and shoreline assessments, as well as stormwater conveyance structures such as outfalls, culverts, and oil and grit separators were also investigated during reconnaissance-level evaluations for this SWMP.

This SWMP contains a review of the existing stormwater conveyance system of each park under the Huron-Clinton Metropolitan Authority as well as identification of areas of concern, recommendations for physical improvements intended to increase water quality, and related preliminary cost opinions.

Project Overview

The first step in the planning process was conducting a field study. The primary objective of the field study was to collect baseline data regarding existing stormwater system conditions and to gather an understanding of community and stakeholder desires and concerns. Data was collected along stream channels and shorelines within park boundaries, culverts under 50 feet in length, outfalls, and oil and grit separators. Detailed baseline condition information can be found in the individual park reports. Overall, the system was found to be in fair condition, with some areas of high erosion on streams and shorelines, blocked or damaged culverts and outfalls, and areas of invasive species.

After completion of field conditions assessments, park specific capital improvement recommendations were made regarding stormwater conveyance structure maintenance and replacement, streambank restoration, shoreline protection, and green infrastructure projects that are intended to enhance water quality and stormwater conveyance. The general recommendation to HCMA is to take advantage of the funding opportunities available to a large park system for green infrastructure improvements and streambank and shoreline restoration to produce the greatest improvement in water quality. Routine maintenance of stormwater conveyance structures such as outfalls, culverts, and oil and grit separators will ensure water continues to flow unobstructed to these improvements and away from park infrastructure such as trails and parking lots. Capital improvement projects outlined in this report can also be used to engage stakeholders and promote environmental stewardship, creating opportunities for education that will create a healthier watershed even outside of the park system.

SWMP Background, Methodology, and Summary

The Huron-Clinton Metropolitan Authority is a regional park system established in 1940 in Southeast Michigan that is designed to provide excellent recreational and educational opportunities in addition to serving as steward for the natural resources within the system. HCMA is a regional special park district encompassing parts of Livingston, Macomb, Oakland, Washtenaw, and Wayne counties. Currently, the 13 Metroparks cover almost 25,000 acres in the Huron and Clinton River watersheds. For this project approximately 94 miles of streambank, 65 miles of shoreline, 191 outfalls, and 600 culverts were assessed using the methodologies outlined in the sections below.

Outfall and Culvert Inspection Summary

As part of field inspection, 191 outfalls and 600 culverts were inspected for structural soundness and conveyance functionality and were GPS located. Each structure was given a unique identifier according to the following format: Structure Abbreviation-Park Abbreviation-Number. The abbreviation SDC (Stormwater Discharge Culvert) is used for outfalls and the abbreviation CUL (Culvert) is used for culverts. A table of park name abbreviations can be found at the end of this document (Table 14). Each structure was rated for overall condition, where *new* is the highest rating and *failing* is the lowest rating. Structures rated *failing* or *poor* are in need of immediate replacement or repair. Structures that are 75% blocked or more are in need of immediate clean out. Structures that have developing blockages (49-74%) will likely need future cleanout, but currently still function at an acceptable level for the purpose of this project. Information was collected to determine the type of surface located above the culvert, culvert diameter and material, and the type of bank stabilization present around the culvert. Data was also recorded to determine outfall diameter, material, and the note any water quality issues present. While every effort was made to locate all outfalls and culverts within the Metroparks system, it may be necessary to add to the GIS database as additional culverts or outfalls are discovered or constructed. The park-wide repair costs presented in Tables 1 (culverts) and 2 (outfalls) are estimated based on structure condition, diameter, and length (outfall assumption is that 50 feet of pipe will need to be replaced). Structure-specific replacement costs, locations, and information can be found in each park report and the included maps.

Table 1. Summary of Culvert Condition and Maintenance Needs.

Culvert Rating	Number of Culverts	Culverts Needing Immediate Cleanout	Culverts Needing Future Cleanout	Culverts Needing Replacement or Repair
New	17	0	0	0
Fair	257	6	34	0
Moderate	182	22	53	0
Poor	81	35*	19*	81
Failing	55	27*	5*	55
Total:	592	89	115	138
Cost Opinion:		**$4,906**	**$17,822**	**$739,908**

* Culverts that will likely be replaced instead of cleaned out.

Table 2. Summary of Outfall Condition and Maintenance Needs.

Outfall Rating	Number of Outfalls	Outfalls Needing Immediate Cleanout	Outfalls Needing Future Cleanout	Outfalls Needing Replacement or Repair
New	16	0	0	0
Fair	96	0	7	0
Good	45	1	12	0
Poor	24	9*	3	23
Failing	10	1*	3	10
Total:	191	11	25	33
Cost Opinion:		**$175**	**$3,975**	**$216,250**

* Outfalls that will likely be replaced instead of cleaned out.

Stormwater gravity mains (STG) were televised by DVM Utilities Inc and the process of rating and prioritizing repairs for these structures is outlined in the Geogaphic Information Systems section of this document.

Shoreline Summary

As part of the field study, 65 miles of shoreline were inspected to determine shoreline type and assess erosion severity. Overall shoreline condition was rated according to the severity of slumping present. A rating of *major* indicates that there is severe erosion causing bank destabilization, likely contributing to undercutting and a bank angle at or above 90 degrees. These areas have been given unique site identifiers and need immediate restoration attention to prevent further damage and deterioration of the shoreline. Site identifiers are structured as follows: SLR-Park Name-Number where SLR stands for Shoreline Rehabilitation and park abbreviations can be found in Table 14 at the end of this document. If funds permit, areas rated *minor* should be considered for restoration in the future to prevent further degradation of bank stability. While the occurrence of invasive species was noted during inspections and some areas were also recommended for treatment, measuring extents and density is beyond the scope of effort for this plan and therefore no specific opinion of probable costs have been developed for invasive species treatment. Occurrence of invasive species is noted on individual park shoreline maps. See Table 3 below for a preliminary restoration cost opinion summary and Table 4 for descriptions of each shoreline type recorded. Refer to the GIS package for more information on where each type of shoreline is found in the system. Restoration costs are estimated based on slumping severity, length of shoreline needing restoration, and the restoration method recommended for the area. See the pages 5-6 for detailed cost opinions.

Table 3. Summary of Park-wide Shoreline Erosion Condition and Restoration Costs

Erosion Condition	Length of Shoreline (ft)
Major	16,119
Minor	167,510
None	153,283
Total:	**336,912**
Park-wide Restoration Cost Details A-D:	**$234,358**
Park-wide Restoration Cost Detail E (Invasive Species Removal):	**$3,000/acre**

Table 4. Shoreline Type Descriptions based on NOAA Shoreline Assessment Manual, 4th Edition.

Shoreline Type	Description
Vegetated Low Banks	Low banks with grasses or trees and tree roots exposed to water that are occasionally flooded by high water. These are usually formed by typical turf grass.
Freshwater Marsh	Grassy wetlands composed of emergent vegetation where resident flora and fauna are abundant. These usually contain taller native grasses in combination with wetland emergent plants like rushes and sedges.
Scrub Shrub Wetland	Composed mainly of small trees and shrubs whose lower leaves are typically flooded during high water. Generally highly productive, serving as nursery habitat and supporting a great diversity of plant and animal species.
Sand Beach	Flat to moderately sloping beach with fine to medium grain sand that is relatively hard packed.
Riprap	Shorelines composed of cobble to boulder sized blocks of rock or concrete used for shoreline protection or breakwaters.
Eroding scarps in Unconsolidated Sediments	A very steep bank or slope made of and surrounded by loose particulate material such as sand, clay, gravel, etc.
Sheltered Solid Man-made Structures	Solid, man-made structures like sea walls or piers that are constructed of concrete, wood, or metal and are built to protect the shoreline, often of single lots or areas that are less exposed to boat wakes and other rapid removal processes. Often there can be dense attachments of animal or plant life present due to the decrease in removal stressors.
Exposed Solid Man-made Structures	Solid, man-made structures like sea walls or piers that are constructed of concrete, wood, or metal and are built to protect the shoreline from erosion by waves, boat wakes, and currents. They are exposed to rapid natural removal processes because of this, and often there are few attached animals or plants present.

OPINION OF PROBABLE CONSTRUCTION COST

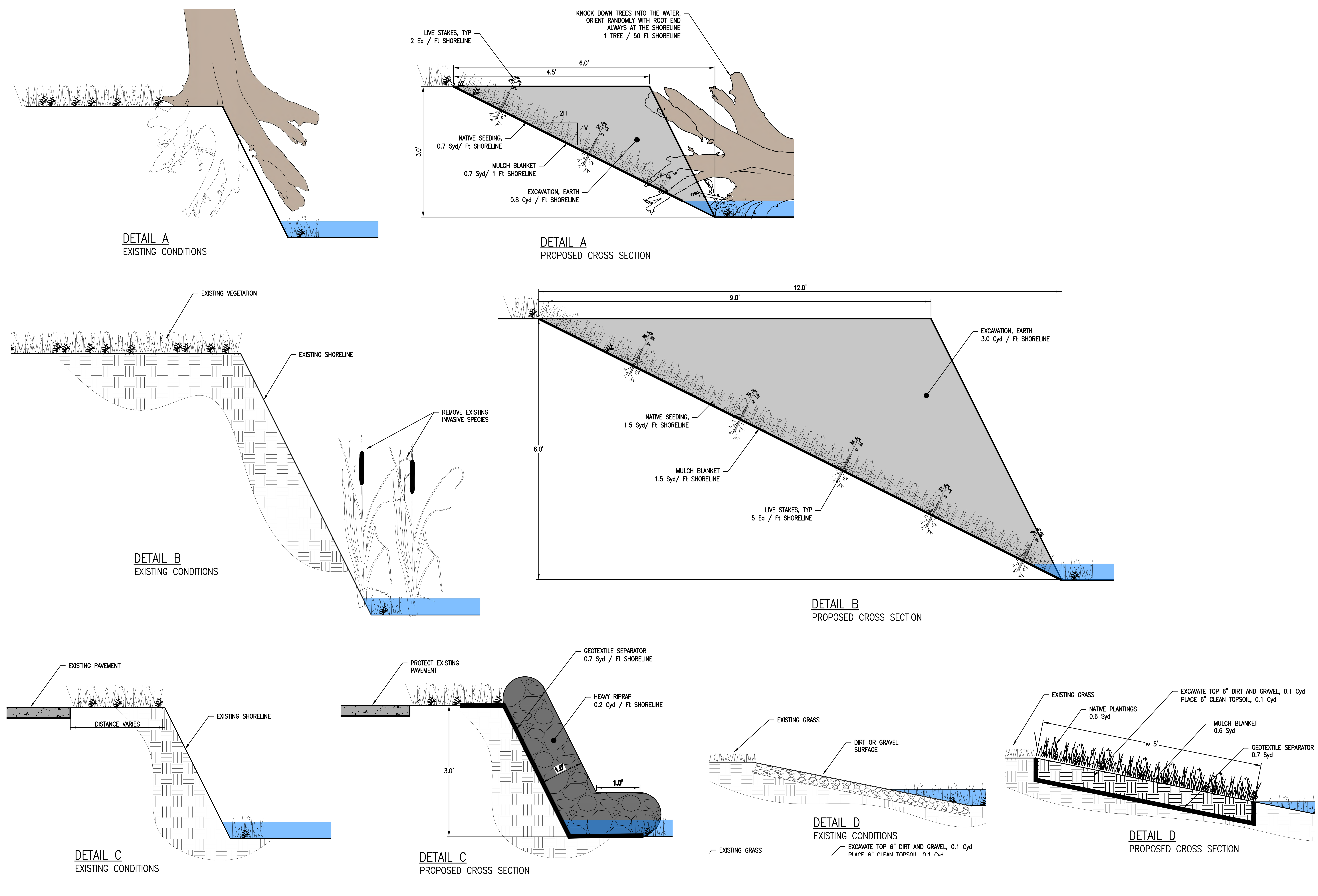
ORCHARD, HILTZ & McCLIMENT, INC.
34000 Plymouth Road, Livonia, Michigan, 48150
Telephone: (734) 522-6711 FAX: (734) 522-6427

PROJECT: Lakeshore Stabilization
LOCATION: Huron Clinton Metroparks
WORK: Lakeshore Stabilization

DATE: June 27, 2019
PROJECT #: 0659-18-0010
ESTIMATOR: MPB
CHECKED BY:
CURRENT ENR:

ITEM CODE	DESCRIPTION	UNIT	TOTAL	UNIT PRICE	COST
	DETAIL A - Cost/Ft				
2020004	Tree, Rem, 6 inch to 18 inch	Ea	0.02	$ 100.00	$ 2.00
2050016	Excavation, Earth	Cyd	0.8	$ 10.00	$ 8.00
8160027	Mulch Blanket	Syd	0.7	$ 1.00	$ 0.70
8167011	Native Seeding	Syd	0.7	$ 5.00	$ 3.50
8507050	Live Stakes	Ea	2	$ 0.10	$ 0.20
8507051	Contingency, 30%, Detail A	LSUM	1	$ 4.32	$ 4.32
	DETAIL B - Cost/Ft				
2050016	Excavation, Earth	Cyd	3	$ 10.00	$ 30.00
8160027	Mulch Blanket	Syd	1.5	$ 1.00	$ 1.50
8167011	Native Seeding	Syd	1.5	$ 5.00	$ 7.50
8507050	Live Stakes	Ea	5	$ 0.10	$ 0.50
8507051	Contingency, 30%, Detail B	LSUM	1	$ 12.00	$ 12.00
	DETAIL C - Cost/Ft				
3080005	Geotextile, Separator	Syd	0.7	$ 1.25	$ 0.88
8130007	Riprap, Heavy, LM	Cyd	0.2	$ 100.00	$ 20.00
8507051	Contingency, 30%, Detail C	LSUM	1	$ 6.30	$ 6.30
	DETAIL D - Cost/Ft				
2050016	Excavation, Earth	Cyd	0.1	$ 10.00	$ 1.00
3080005	Geotextile, Separator	Syd	0.7	$ 1.25	$ 0.88
8160027	Mulch Blanket	Syd	0.6	$ 1.00	$ 0.60
8160064	Topsoil Surface, Furn, 6 inch	Syd	0.1	$ 4.00	$ 0.40
8167011	Native Seeding	Syd	0.6	$ 5.00	$ 3.00
8507051	Contingency, 30%, Detail D	LSUM	1	$ 1.80	$ 1.80
	DETAIL E - Cost/Ft				
8507012	Invasive Species Removal	Acre	0.0005	$ 3,000.00	$ 1.38
8507051	Contingency, 30%, Detail E	LSUM	1	$ 0.41	$ 0.41

UNIT PRICE - DETAIL A	$ 19.00
UNIT PRICE - DETAIL B	$ 52.00
UNIT PRICE - DETAIL C	$ 27.00
UNIT PRICE - DETAIL D	$ 8.00
UNIT PRICE - DETAIL E	$ 2.00



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OHM-ADVISORS.COM

REVISIONS:

DATE | PROJ.NUMBER | ENG | PROJ.MGR | CADD | COUNTY | CITY/VILLAGE/TOWNSHIP | SCALE H: 1"=40' V: 1"=4' | HORIZ DATUM | VERT DATUM

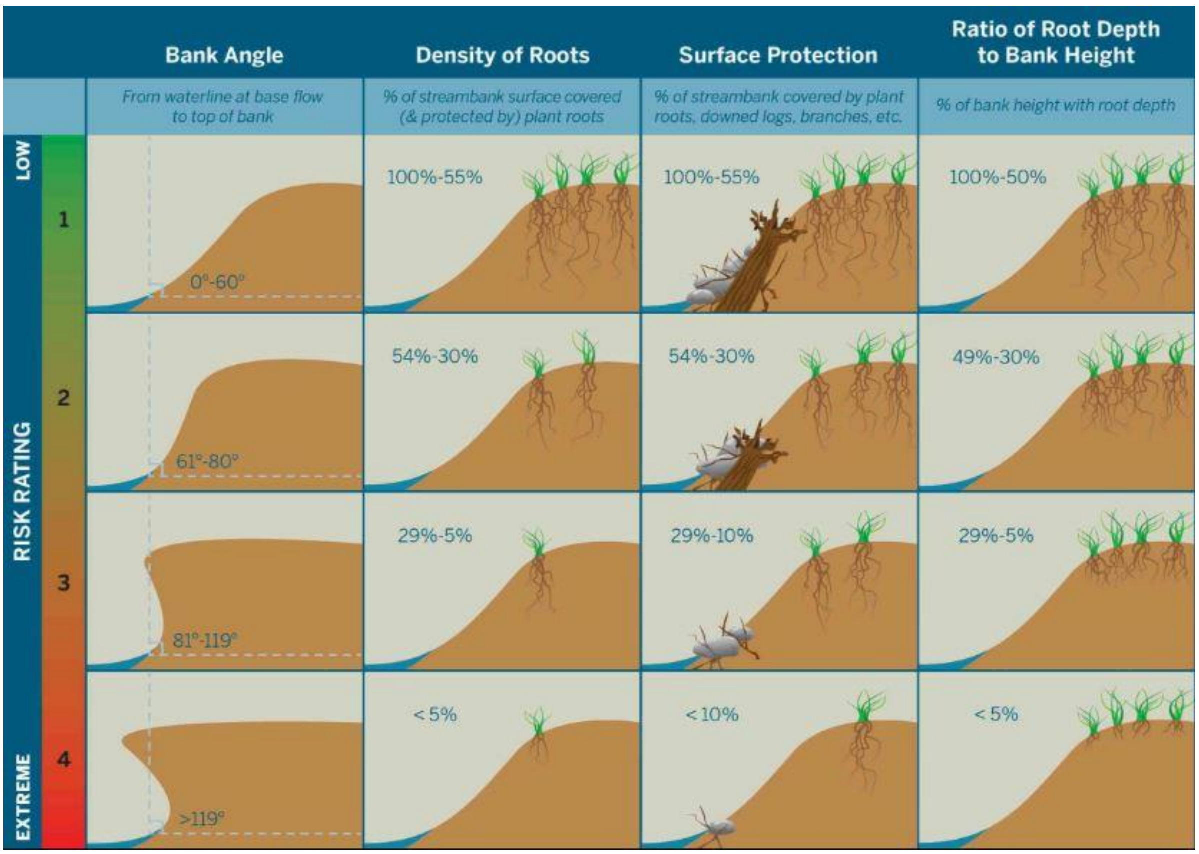
HURON CLINTON METRO AUTHORITY
SHORELINE STABILIZATION
REMOVAL AND ACCESS PLAN
SHORELINE STABILIZATION DETAILS

SHEET 1 OF 1

Streambank Summary

Ninety-four (94) miles of streambank were inspected using the Rosgen Modified Bank Erosion Hazard Index (BEHI) to assess erosion severity. Bank condition was rated according to the modified BEHI protocol found in Figure 1, where *low* areas are in the best condition and *very high* (*extreme*) areas are in the worst condition.

Figure 1. Illustration of Modified BEHI parameters used to assess streambank erosion severity courtesy of The Freshwater Trust Riparian Condition Survey & Quantification Protocol.



Bank angle is measured in degrees from the water line to the top of the bank. The closer to zero the bank angle is, the lower the erosion score. Root density is the percentage of the streambank surface that is protected by plant roots. The closer root density is to 100%, the lower the erosion potential and associated BEHI score. Surface protection is the percentage of streambank that is protected or covered in some way. This may include plant roots, downed logs, branches, or other natural features. The closer the surface protection is to 100%, the lower the erosion score. Ratio of root depth to bank height is the percentage of the bank height that is held in place by plant roots. This measure assesses the depth of the roots into the bank rather than the spread of the roots along the surface. The closer this number is to 100%, the lower the erosion score. A rating of *very high* indicates that immediate restoration attention is needed to prevent damage to infrastructure present near the stream. Areas rated *high* and *very high* were given unique identifiers and should be considered for restoration in the immediate future to avoid further degradation of water quality and bank stability. Identifiers are structured as follows: SSS-Park Abbreviation-Number where SSS means Streambank Stabilization Site. Park abbreviations can be found in Table 14.

The length of streambank that falls within each BEHI erosion condition is shown in each park report, along with the estimated restoration costs for lengths of stream recommended for restoration. The type of bank stabilization present, any obstructions restricting greater than 50% of stream flow, and any points of interest along park system streams were also recorded and this information, along with scores for each BEHI method category can be found in the GIS database. Restoration costs in Table 5 are estimated based on the BEHI score, stream segment length, and best recommended practice type for the erosion severity present. More detail on these cost opinions can be found on pages 9-10. For restoration costs broken down by individual stream segment, please see the maps included in each park report.

Table 5. Summary of Park-wide Streambank Erosion Condition and Restoration Costs

Erosion Condition	Length (ft)	
Very High	5,309	$7,974,000
High	78,514	$41,055,000
Moderate	219,130	$1,035,000
Low	177,134	$0
Very Low	17,812	$0
Total:	**497,899**	**$50,064,000.00**

Figure 2. Photo of high erosion at Kensington Metropark.

OPINION OF PROBABLE CONSTRUCTION COST

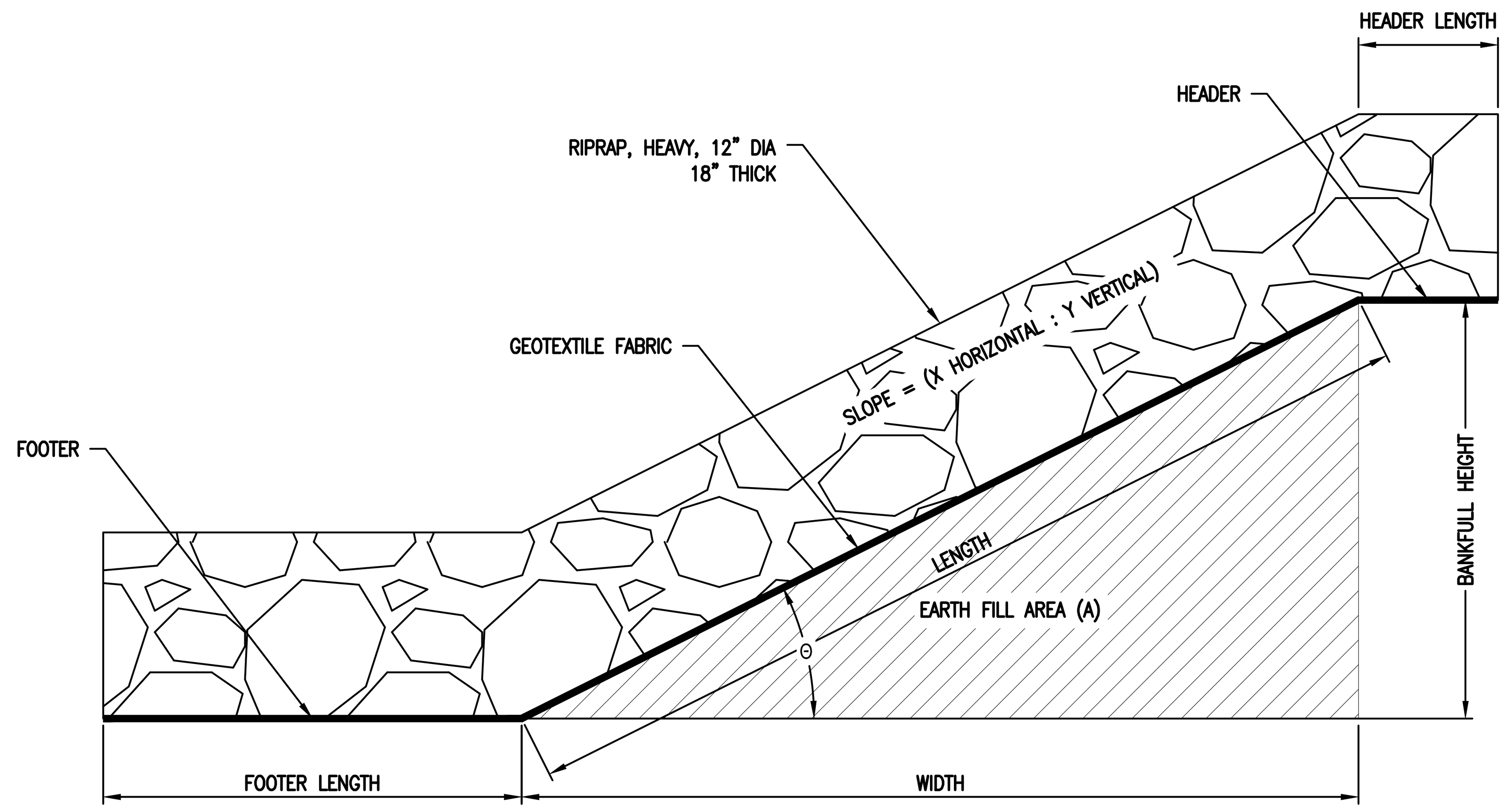
ORCHARD, HILTZ & McCLIMENT, INC.
34000 Plymouth Road, Livonia, Michigan, 48150
Telephone: (734) 522-6711 FAX: (734) 522-6427

PROJECT: Streambank Stabilization
LOCATION: Huron-Clinton Metroparks
WORK: Streambank Stabilization

DATE: June 27, 2019
PROJECT #: 0659-18-0010
ESTIMATOR: MPB
CHECKED BY:
CURRENT ENR:

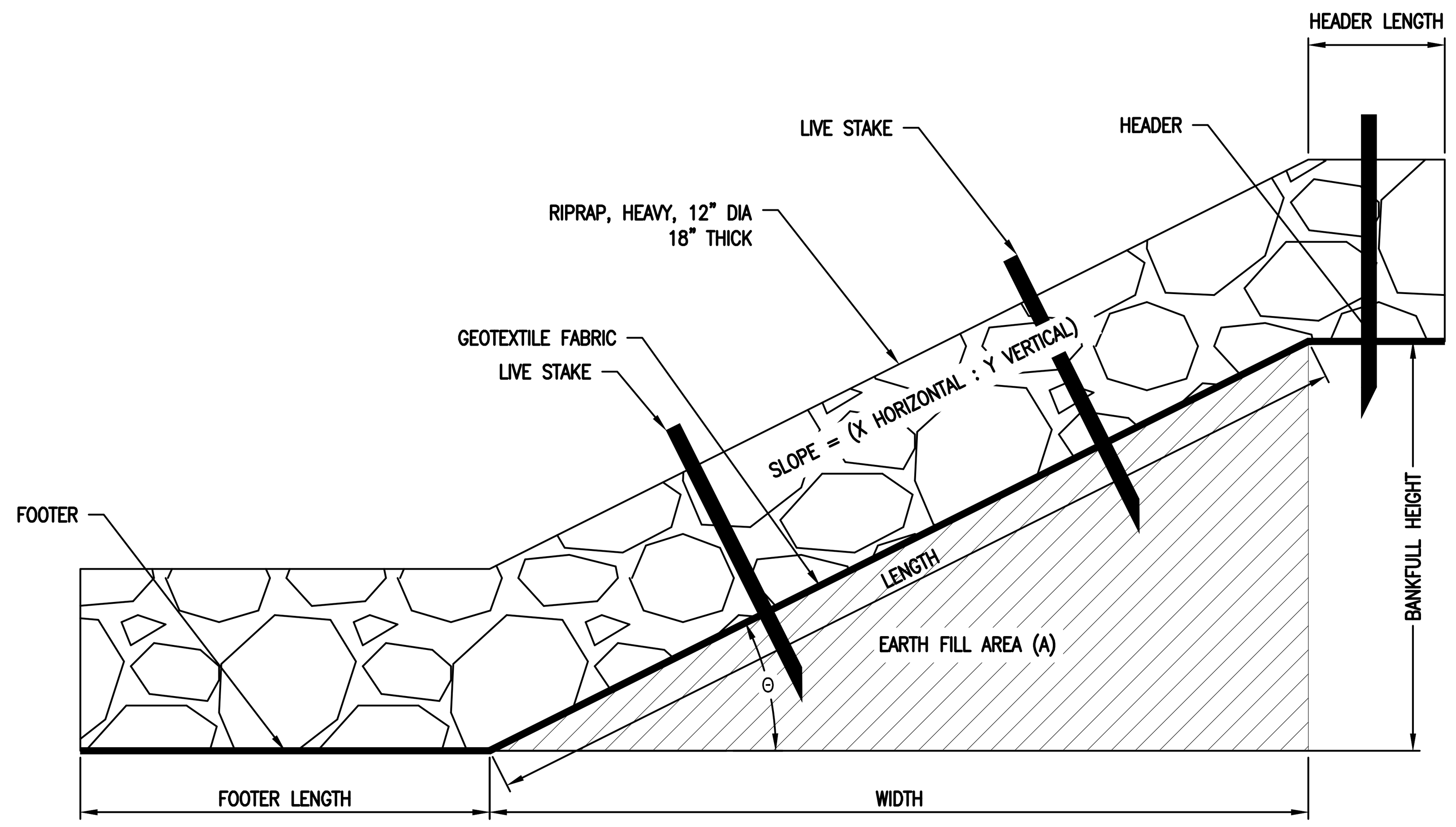
ITEM CODE	DESCRIPTION	UNIT	TOTAL	UNIT PRICE	COST
	VERY LOW BEHI - Coir Block with Live Stakes (Cost/Ft) - 4 Ft Bank Height				
2050016	Excavation, Earth	Cyd	1	$ 10.00	$ 10.00
8160027	Mulch Blanket	Syd	2	$ 1.00	$ 2.00
8507001	Coir Block	Ft	2	$ 60.00	$ 120.00
8507012	Live Stakes	Acre	5E-05	$ 1,400.00	$ 0.07
8507051	Contingency, 30%, Very Low	LSUM	1	$ 39.60	$ 39.60
	LOW BEHI - Coir Block with Live Stakes (Cost/Ft) - 5 Ft Bank Height				
2050016	Excavation, Earth	Cyd	2	$ 10.00	$ 20.00
8160027	Mulch Blanket	Syd	3	$ 1.00	$ 3.00
8507001	Coir Block	Ft	2	$ 60.00	$ 120.00
8507012	Live Stakes	Acre	5E-05	$ 1,400.00	$ 0.07
8507051	Contingency, 30%, Low	LSUM	1	$ 42.90	$ 42.90
	MODERATE BEHI - Soil Lifts with Vegetation (Cost/Ft) - 6 Ft Bank Height				
2050016	Excavation, Earth	Cyd	5	$ 10.00	$ 50.00
8507001	Coir Block	Ft	6	$ 60.00	$ 360.00
8507050	Plantings, Plugs	Ea	15	$ 1.00	$ 15.00
8507051	Contingency, 30%, Moderate	LSUM	1	$ 127.50	$ 127.50
	HIGH BEHI - Soil Lifts with Live Stakes (Cost/Ft) - 8 Ft Bank Height				
2050016	Excavation, Earth	Cyd	4	$ 10.00	$ 40.00
8507001	Coir Block	Ft	8	$ 60.00	$ 480.00
8507012	Live Stakes	Acre	0.001	$ 1,400.00	$ 1.40
8507051	Contingency, 30%, High	LSUM	1	$ 156.30	$ 156.30
	VERY HIGH BEHI - Soil Lifts with Live Stakes (Cost/Ft) - 10 Ft Bank Height				
2050016	Excavation, Earth	Cyd	6	$ 10.00	$ 60.00
8507001	Coir Block	Ft	10	$ 60.00	$ 600.00
8507012	Live Stakes	Acre	0.001	$ 1,400.00	$ 1.40
8507051	Contingency, 30%, Very High	LSUM	1	$ 198.30	$ 198.30
	EXTREME BEHI - Soil Lifts with Live Stakes (Cost/Ft) - 12 Ft Bank Height				
2050016	Excavation, Earth	Cyd	9	$ 10.00	$ 90.00
8507001	Coir Block	Ft	12	$ 60.00	$ 720.00
8507012	Live Stakes	Acre	0.001	$ 1,400.00	$ 1.40
8507051	Contingency, 30%, Extreme	LSUM	1	$ 243.30	$ 243.30

UNIT PRICE FOR VERY LOW BEHI - Coir Block with Live Stakes (Cost/Ft)	$ 172.00
UNIT PRICE FOR LOW BEHI - Coir Block with Live Stakes (Cost/Ft)	$ 186.00
UNIT PRICE FOR MODERATE BEHI - Soil Lifts with Vegetation (Cost/Ft)	$ 553.00
UNIT PRICE FOR HIGH BEHI - Soil Lifts with Live Stakes (Cost/Ft)	$ 678.00
UNIT PRICE FOR VERY HIGH BEHI - Soil Lifts with Live Stakes (Cost/Ft)	$ 860.00
UNIT PRICE FOR EXTREME BEHI - Soil Lifts with Live Stakes (Cost/Ft)	$ 1,055.00



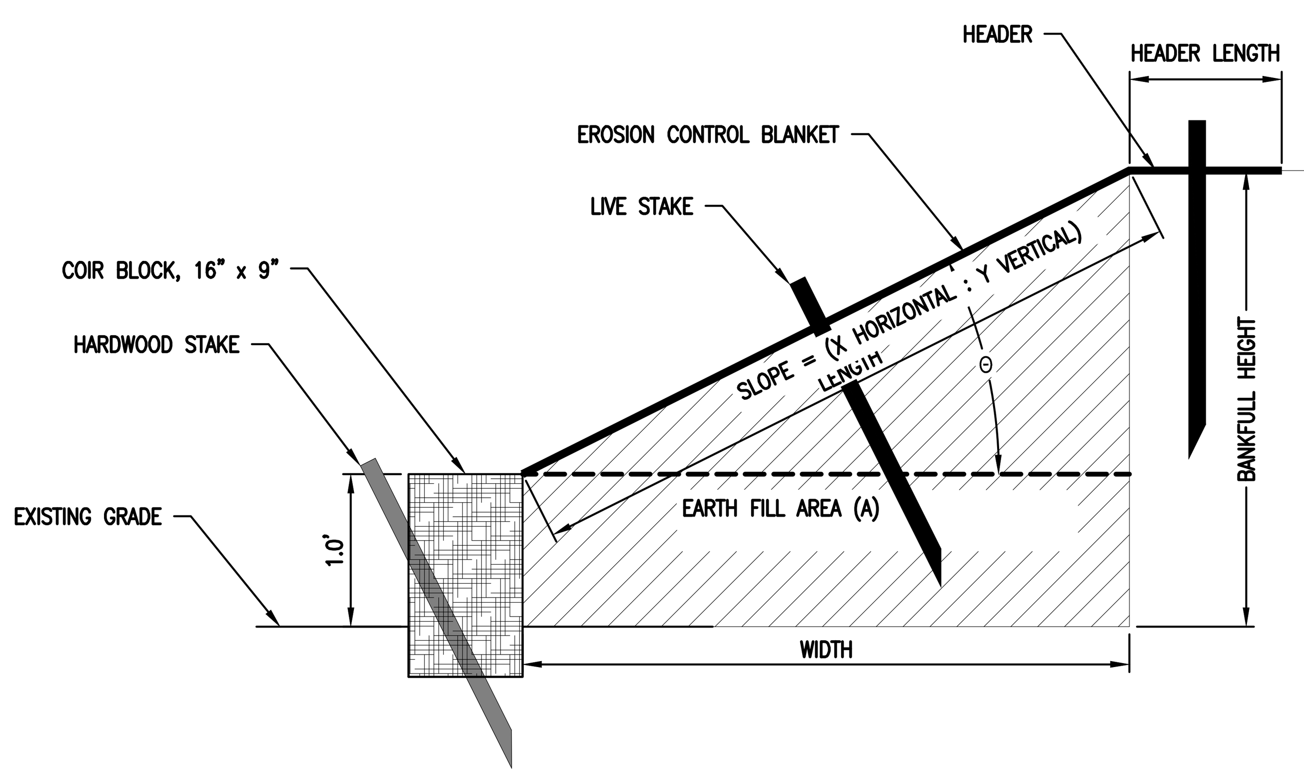
A. RIPRAP

$A = \frac{1}{2} \times WIDTH \times HEIGHT$
$TAN\Theta = 1/SLOPE$
$\Theta = ARCTAN(1/SLOPE)$
$TAN\Theta = HEIGHT/WIDTH$
$WIDTH = HEIGHT/TAN\Theta = HEIGHT/TAN(ARCTAN(1/SLOPE))$
$WIDTH = HEIGHT/(1/SLOPE)$
$A = \frac{1}{2} \times (HEIGHT/(1/SLOPE)) \times HEIGHT$
$A = \frac{1}{2} \times HEIGHT^2 \times SLOPE$
$SIN\Theta = HEIGHT/LENGTH$
$LENGTH = HEIGHT/SIN\Theta$
$LENGTH = HEIGHT/SIN(ARCTAN(1/SLOPE))$



B. RIPRAP WITH LIVE STAKES

$A = \frac{1}{2} \times WIDTH \times HEIGHT$
$TAN\Theta = 1/SLOPE$
$\Theta = ARCTAN(1/SLOPE)$
$TAN\Theta = HEIGHT/WIDTH$
$WIDTH = HEIGHT/TAN\Theta = HEIGHT/TAN(ARCTAN(1/SLOPE))$
$WIDTH = HEIGHT/(1/SLOPE)$
$A = \frac{1}{2} \times (HEIGHT/(1/SLOPE)) \times HEIGHT$
$A = \frac{1}{2} \times HEIGHT^2 \times SLOPE$
$SIN\Theta = HEIGHT/LENGTH$
$LENGTH = HEIGHT/SIN\Theta$
$LENGTH = HEIGHT/SIN(ARCTAN(1/SLOPE))$



C. COIR BLOCK WITH LIVE STAKES

$A = \frac{1}{2} \times WIDTH \times HEIGHT$
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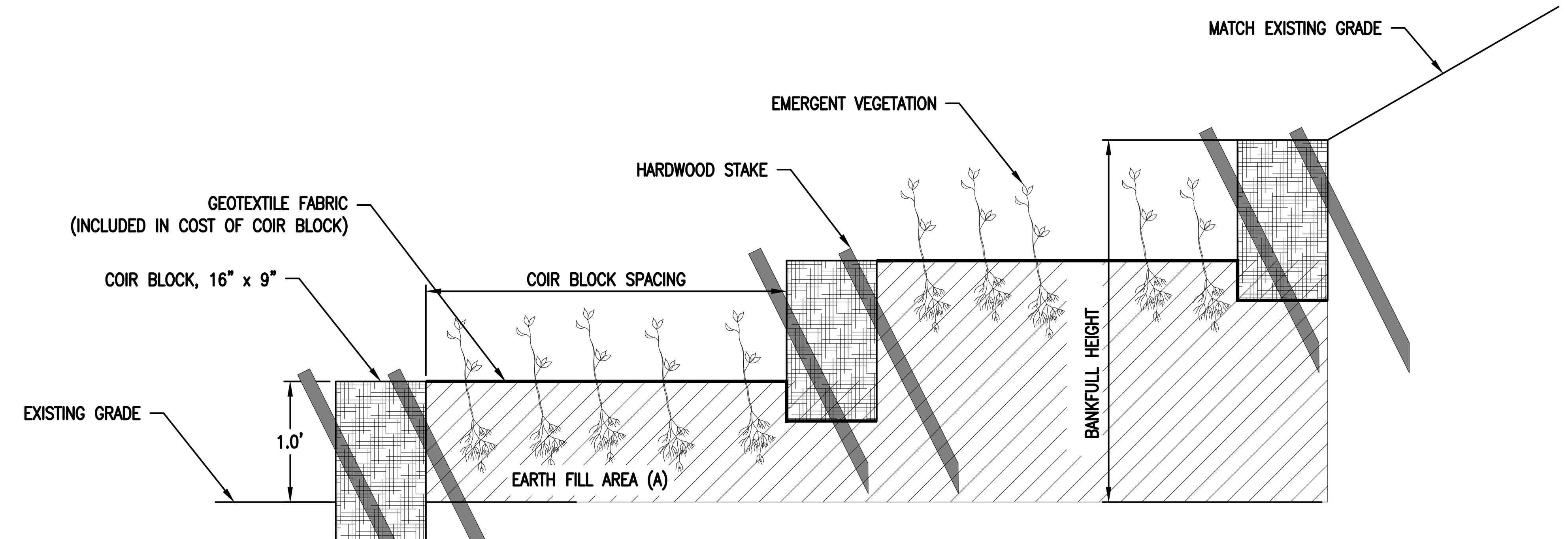
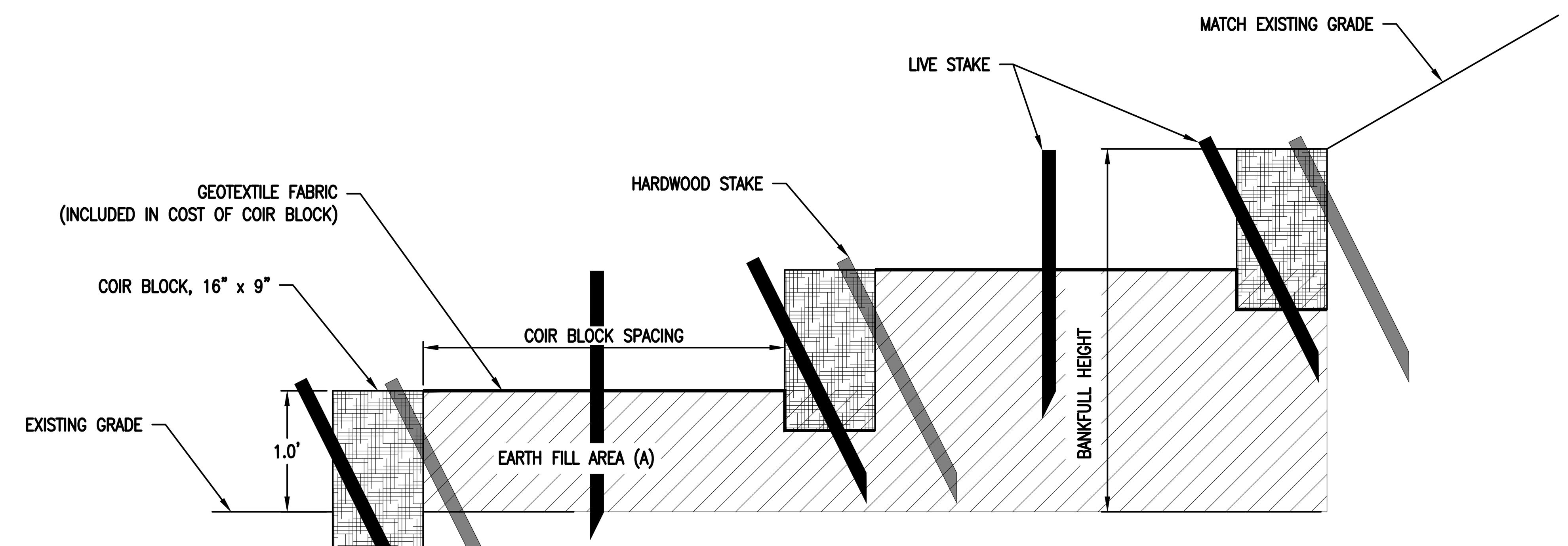
$\Theta = ARCTAN(1/SLOPE)$
$TAN\Theta = HEIGHT/WIDTH$
$WIDTH = (HEIGHT-1)/TAN\Theta = (HEIGHT-1)/TAN(ARCTAN(1/SLOPE))$
$WIDTH = (HEIGHT-1)/(1/SLOPE)$
$A = ((HEIGHT-1)/(1/SLOPE)) \times 1\ FT) + (\frac{1}{2} \times ((HEIGHT-1)/(1/SLOPE)) \times (HEIGHT-1))$
$A = ((HEIGHT-1)/(1/SLOPE)) + (\frac{1}{2} \times (HEIGHT-1)^2 \times SLOPE)$
$SIN\Theta = HEIGHT/LENGTH$
$LENGTH = (HEIGHT-1)/SIN\Theta$
$LENGTH = (HEIGHT-1)/SIN(ARCTAN(1/SLOPE))$



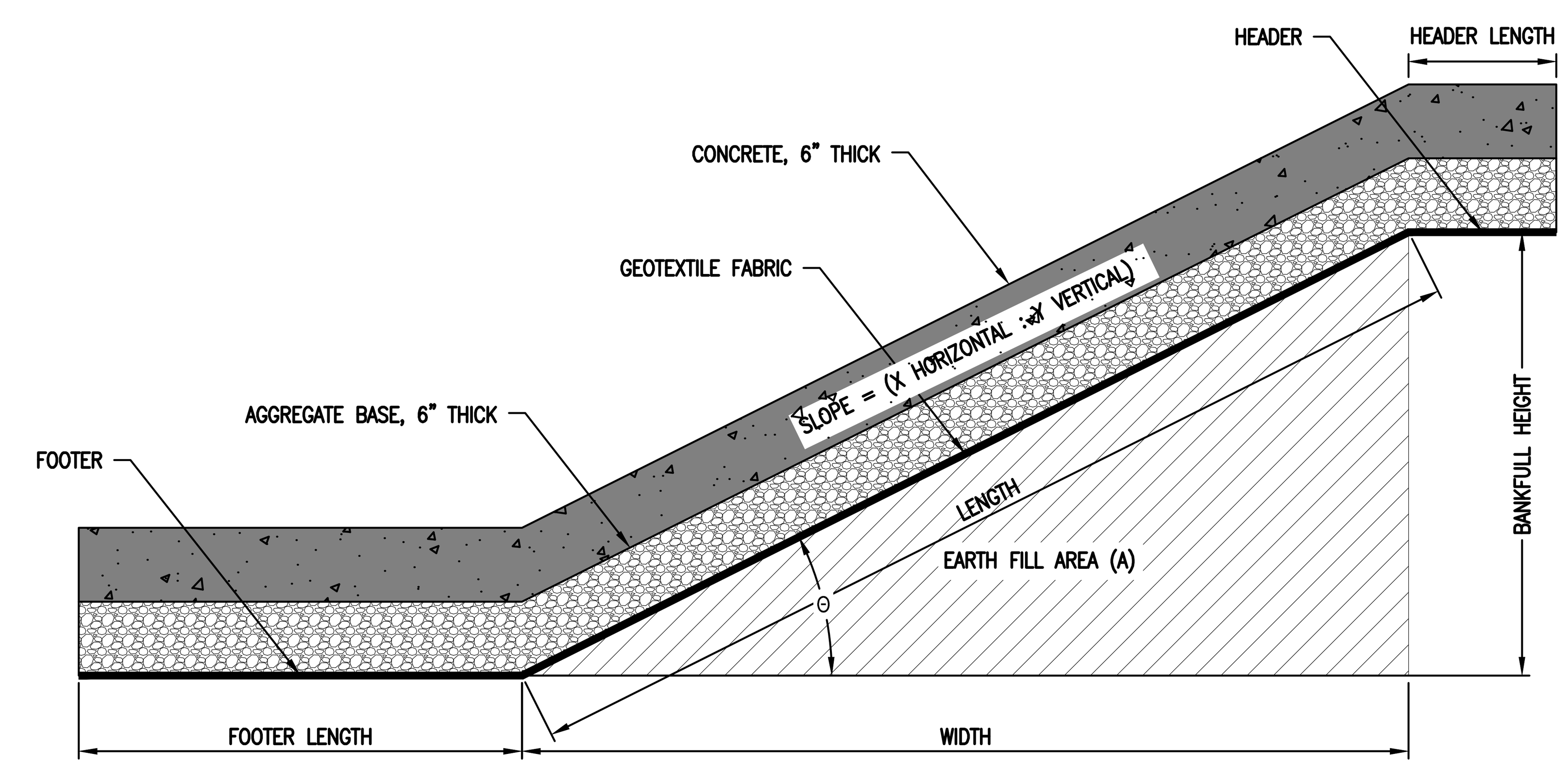
D. SOIL LIFTS WITH VEGETATION

NOTE: EARTHWORK NEGLECTED
NO. OF COIR BLOCKS = BANKFULL HEIGHT
$A = \frac{1}{2} \times (BLOCK\ SPACING + BLOCK\ WIDTH) \times (NO.\ OF\ BLOCKS - 1) \times BANKFULL\ HEIGHT$



E. SOIL LIFTS WITH LIVE STAKES

NOTE: EARTHWORK NEGLECTED
NO. OF COIR BLOCKS = BANKFULL HEIGHT
$A = \frac{1}{2} \times (BLOCK\ SPACING + BLOCK\ WIDTH) \times (NO.\ OF\ BLOCKS - 1) \times BANKFULL\ HEIGHT$



F. CONCRETE REVETMENT

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$\Theta = ARCTAN(1/SLOPE)$
$TAN\Theta = HEIGHT/WIDTH$
$WIDTH = HEIGHT/TAN\Theta = HEIGHT/TAN(ARCTAN(1/SLOPE))$
$WIDTH = HEIGHT/(1/SLOPE)$
$A = \frac{1}{2} \times (HEIGHT/(1/SLOPE)) \times HEIGHT$
$A = \frac{1}{2} \times HEIGHT^2 \times SLOPE$
$SIN\Theta = HEIGHT/LENGTH$
$LENGTH = HEIGHT/SIN\Theta$
$LENGTH = HEIGHT/SIN(ARCTAN(1/SLOPE))$

OHM
ARCHITECTS ENGINEERS PLANNERS
1145 GRISWOLD ST, SUITE 200
DETROIT, MI 48226
313-481-1250
OHM-ADVISORS.COM

REVISIONS

DATE	PROJ. NUMBER	ENG	PROJ. MGR	CADD	COUNTY	MUNICIPALITY
	0659-18-0010	MPB		MPB	WAYNE COUNTY	MULTIPLE

Huron Clinton Metro Authority
Lower Huron Streambank Stabilization
Streambank Stabilization Details

SHEET 1
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Green Infrastructure Summary

As part of the park data analysis, water quality issues in each park were identified through community outreach and GIS data analysis. Green infrastructure concept plans were created to address these issues. All green infrastructure restoration concepts recommended for use in the Metroparks are listed in individual park reports and are defined in Table 7. Each site has a unique identifier structured as follows: GI-Park Abbreviation-Number where GI stands for Green Infrastructure. Park abbreviations can be found in Table 14. Sites were initially chosen based on existing drainage patterns and infrastructure, land use, OHM field reconnaissance, soil type, impact on water quality improvement, aerial photographs, and input and approval from HCMA staff. Once approved by HCMA staff, final sizing (see Table 6 and Equation 1 for information on sizing calculations) and cost opinions for each practice were determined and can be found in each park report. Table 8 contains practice types and their design and contingency assumptions. A cost opinion summary for each park can be found in Table 7 below. Cost opinions are based on 2019 Metro Detroit contractor prices and can be adjusted in the "Costs" tab of the included spreadsheets if more specific costs are known or as prices change over time. Typical cross sections for each practice type are included in Figures 2-10 below. Detailed information for each park and individual practice can be found in the spreadsheets included with this report's data package.

Table 6. Green Infrastructure Calculation Definitions and Explanations

Drainage Areas	Each site is broken into sub-drainage areas contributing to the proposed GI practice. The areas were determined though measurements in the ArcGIS database created by OHM for this task. Contributing drainage area measurements were recorded in the "Total Drainage Area" column of the sizing spreadsheet.
Imperviousness	Impervious area for each sub-drainage area was measured using the ArcGIS database. This number was entered into the "Impervious Drainage Area" column of the sizing spreadsheet.
Soil Type (HSG)	The hydrologic soil group (HSG) for infiltration practices was determined from the USDA Web Soil Survey for each sub-area. When a practice area was predominantly HSG C or D soils, an underdrain was included in the cost estimate, unless there was no feasible structure or drainage course for connection.
Existing Runoff	Runoff volumes were calculated using the Runoff Volume Method (Equation 1) for each practice. A 2-year 24-hour storm (2.35 inches of rainfall) was used for calculations, which is common for GI design parameters. These calculations are included in the excel spreadsheets and can be manipulated to include larger or smaller storm events, but all GI practices in this document are sized based on 2.35 inches of rainfall.

Equation 1. Runoff Volume Method Equation

$$WQ_V = \frac{P * R_v * DA}{12}$$

Where WQ_V = Water Quality Volume (ft^3)

P = Design Rainfall Depth (in)

R_V = Runoff Volume Coefficient ($R_V = 0.05 + 0.009 * I$)

DA = Drainage Area of Sub-Basin (ft^2)

I = Percent Impervious Surface

Table 7. Overall Park System Green Infrastructure Recommendations

Park ID	Number of Recommended Practices	Treatment Surface Area (Ft^2)	Cost Opinion
Delhi	7	50,272	$117,708
Dexter-Huron	3	73,842	$117,986
Hudson Mills	16	166,518	$685,368
Huron Meadows	9	35,674	$255,226
Indian Springs	6	59,498	$340,492
Kensington	35	399,620	$2,612,840
Lake Erie	18	212,715	$367,892
Lake St. Clair	5	266,847	$239,116
Lower Huron	27	694,529	$2,573,526
Oakwoods	9	137,328	$545,743
Stony Creek	33	202,600	$1,363,806
Willow	35	384,705	$1,500,032
Wolcott Mill	2	59,945	$269,789
Total:	**205**	**2,744,093**	**$10,989,524**

Table 8. Green Infrastructure Practice Definitions

Practice Type	Definition and Benefits	Design Cost	Contingency Cost
Rain Garden	A Rain Garden is a shallow depression in the landscape that captures and treats stormwater runoff in an amended planting soil mix. The depression allows water to pool for a short time (less than 48 hours) after rainfall and then slowly absorb into the soil and vegetation. Native plants are used because of their deep roots, hardiness, and ability to provide habitat.	15%	15%
Naturalized Swale	A Naturalized Swale is a stormwater drainage ditch that incorporates native landscaping instead of mowed turf grass. The swale can be vegetated with a combination of grasses, shrubs, and/or trees designed to slow, filter, and possibly store or infiltrate stormwater runoff.	5%	15%
Bioswale	A Bioswale is a naturalized swale that has the additional component of planting soil mix and/or a stone sub-basin to promote additional storage and infiltration. As such, a bioswale is essentially a linear rain garden that conveys water along its length instead of serving as the capture location.	15%	15%
Native Landscaping	Native Landscaping uses native plants instead of turf grass or other higher maintenance non-native landscaping features. Native landscaping performs similar to a rain garden but without the ponding and underground storage.	5%	15%
Native Prairie	Native Prairies are extensive native areas that use native grasses and other native prairie plants (and few trees) to promote infiltration through deep rooted native plants. They are less formally planned than Native Landscaping.	5%	15%
No Mow Zone	No Mow Zones are the cheapest green infrastructure option because they are exactly what they sound like. Absence of mowing allows the native seedbank to return, increasing the depth of root systems and allowing increased infiltration.	NA	NA
Stormwater Treatment Wetland	Stormwater Treatment Wetlands are shallow naturalized detention ponds that provide temporary storage of stormwater runoff to prevent downstream flooding and attenuate runoff peaks. The plants provide water quality and habitat benefits not found in traditional stormwater ponds.	15%	15%
Pavement Removal	Pavement Removal reduces runoff from parking lots by replacing unnecessary parking space with turf, or replacing traditional impervious parking with an aggregate stone base that allows parking but also allows infiltration and storage.	5%	15%
Permeable Pavers	Porous Pavement is a stormwater management technique that combines storage and infiltration with a structural pavement. Porous pavement can consist of permeable asphalt, porous concrete or interconnected concrete paver blocks that are underlain by a storage reservoir.	15%	15%

Typical Green Infrastructure Cross Sections (provided by Drummond-Carpenter):

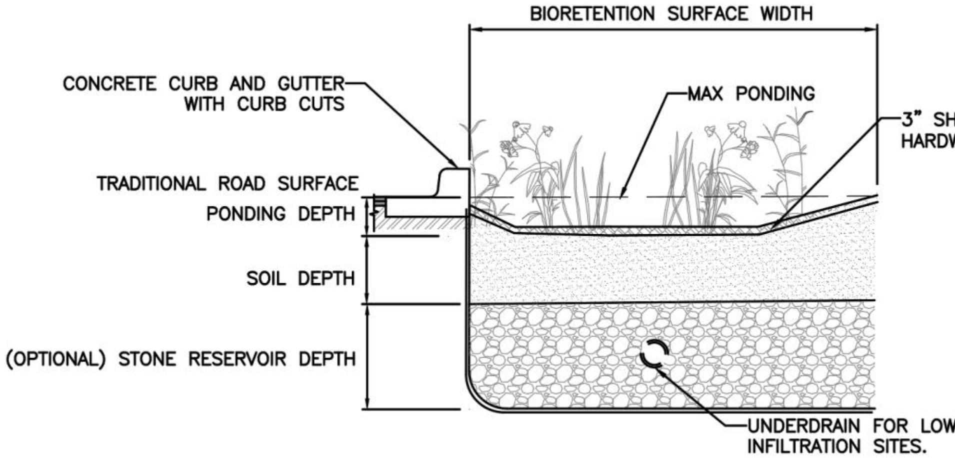


Figure 2. Rain Garden Typical Section

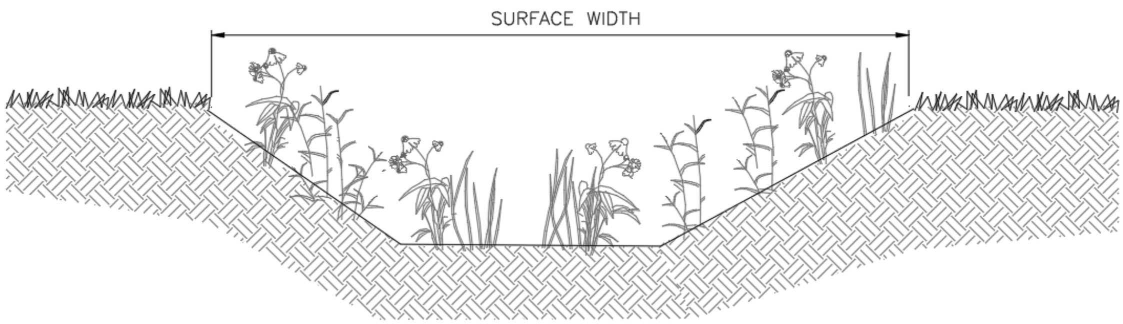


Figure 3. - Naturalized Swale Typical Section

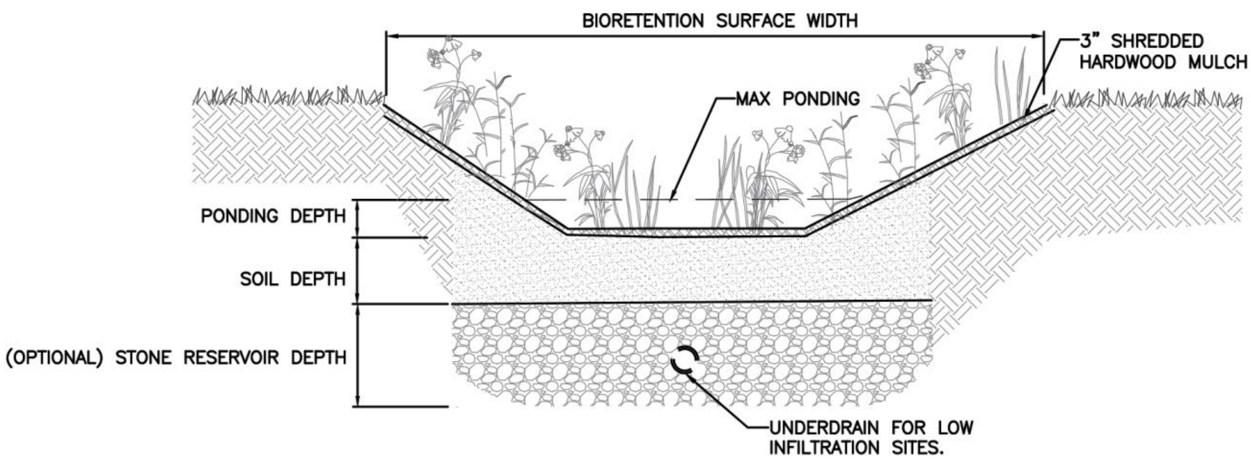


Figure 4. - Bioswale Typical Section

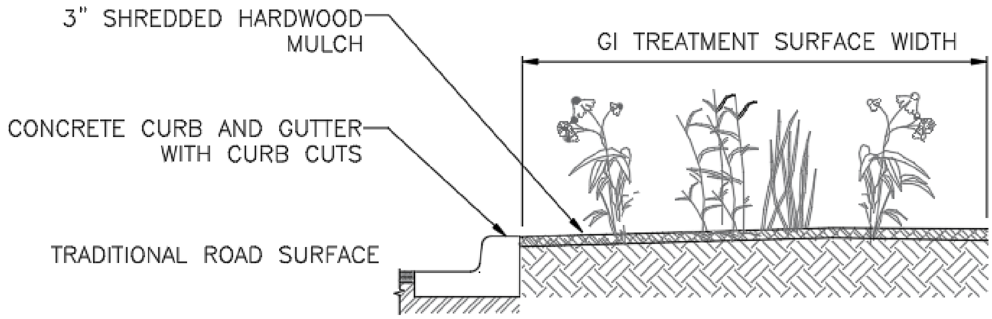


Figure 5. - Native Landscaping Typical Section

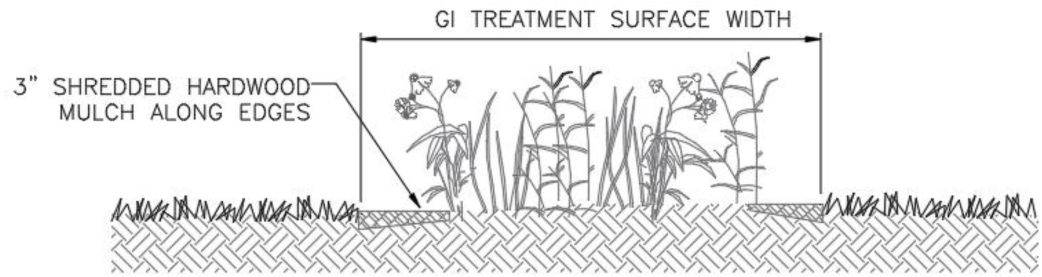


Figure 6. - Native Prairie Typical Section

Figure 7. - No Mow Zone Typical Section

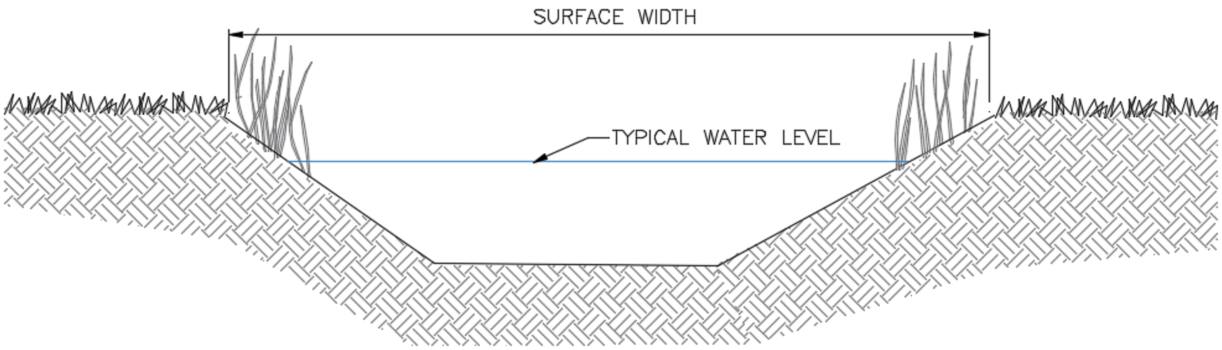


Figure 8. - Stormwater Treatment Wetland Typical Section

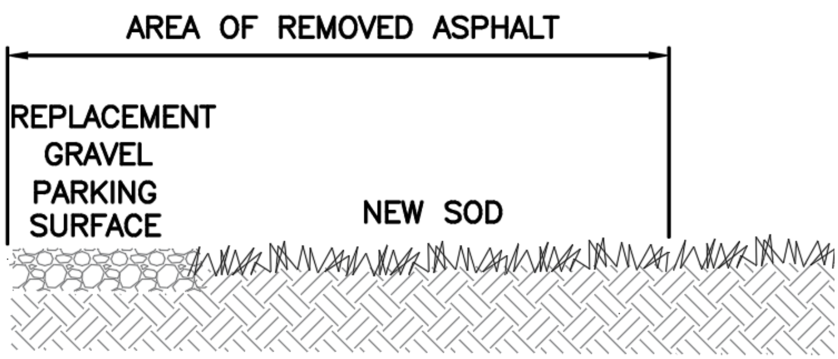


Figure 9. - Pavement Removal Typical Section

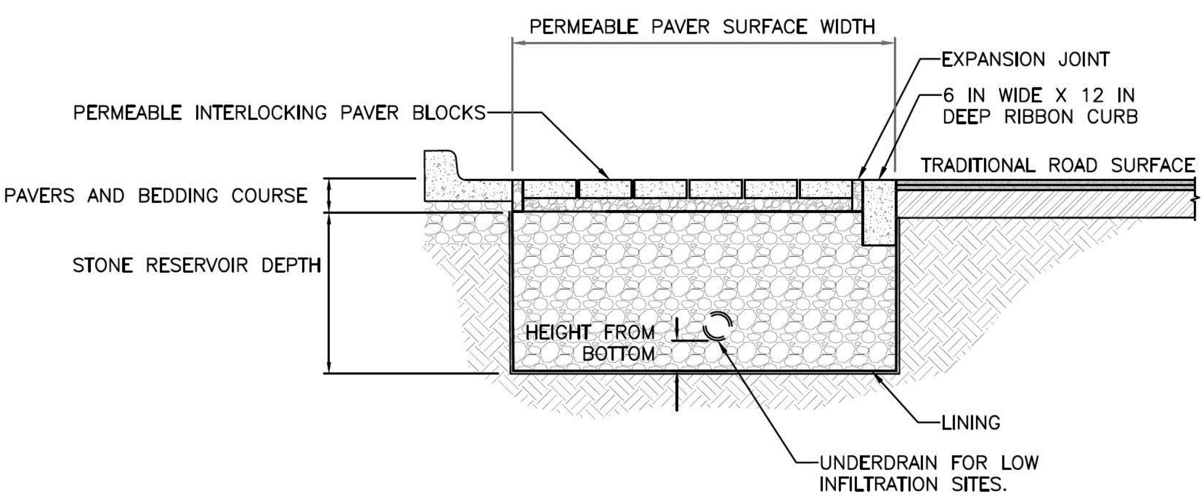


Figure 10. - Permeable Pavers Typical Section

Green Infrastructure Maintenance

As with any type of stormwater infrastructure, maintenance is a critical but often overlooked component. As such, an effective and rigorous maintenance program is crucial for the long-term sustainability and function of all Green Stormwater Infrastructure (GSI) systems. GSI systems utilize both gray stormwater infrastructure and vegetation, as such they can change over time as plant communities grow and establish. In urban environments in particular, GSI may be subject to temperature extremes, pollution, heavy sediment and debris accumulation, and an aggressive weed community. All of these factors can create a challenging environment for vegetation. Furthermore, sediment and trash, if allowed to accumulate, can create unsightly conditions and diminish functionality within the stormwater conveyance system. Proper maintenance can ensure that GSI systems remain healthy, attractive, and safe for many years to come.

The following tables provide standard operating procedures for specific maintenance tasks for a variety GSI practice types. As all sites are different it may be necessary to modify any maintenance program to ensure its effectiveness and functionality for specific site needs.

Permeable Pavement

Permeable paving is a method of paving vehicle and pedestrian pathways to enable infiltration of stormwater runoff. Permeable pavement surfaces typically include pervious concrete, porous asphalt, paving stones, and interlocking pavers. Maintenance requirements for permeable pavement can be found in Table 9**.**

Table 9. Permeable Pavement Maintenance Checklist

Inspection Checklist	Yes/No	Maintenance Type Needed
Is there sediment, litter, or organic debris deposited on the surface of the practice area?	Y/N	Remove sediment and other debris from practice area using a backpack blower, or other comparable equipment.
Is the source of the deposited sediment evident i.e. exposed soil nearby?	Y/N	Stabilize the sediment source using vegetation or other comparable measure.
Is there moss growing in the practice area?	Y/N	Sprinkle baking soda on mossy areas and allow to dry for two weeks. Remove moss then dry vacuum practice area. If moss persists treat area with lime water application followed by a dry vacuum two weeks later.
It has rained within the last 48 hours at this location and there is standing water in the practice area.	Y/N	Porosity has been reduced and the practice area should be swept or dry vacuumed to removed sediment build up.

Raingarden

A Rain Garden is a shallow depressional area in the landscape that captures and treats stormwater runoff in an amended planting soil mix. The depression (or ponding area) allows water to pool for a short time (less than 48 hours) after a rainfall and then slowly absorb into the soil and vegetation. Native plants are typically used because of their deep roots, hardiness, and ability to provide habitat. In addition to the maintenance items outlined in Table 10, non-woody vegetation will need to be cutback in late fall or early spring to allow for regrowth the following year.

Table 10. Raingarden Maintenance Checklist

Inspection Checklist	Yes/No	Maintenance Type Needed
Are weeds, or invasive plants, present in the practice?	Y/N	Hand pull any weeds or invasives, ensuring you remove the entire root to prevent re-sprouting.
Has sediment settled in the practice to a depth of 25% of the total depth? Exp. 2" in sediment in 8" deep practice.	Y/N	Remove sediment from practice area using hand tools and the proper PPE and dispose of off-site.
Is there trash, leaves, grass clippings or other debris in the practice?	Y/N	Remove all debris from practice area and address any surrounding maintenance issues that might result in reoccurrence i.e. mowing direction around practice, nearby trash receptacles.
Is anything obstructing the inlet or outlet of the practice?	Y/N	Remove any obstructions from inlet/outlet. Check surrounding area for cause of sediment infill into practice i.e. exposed soil, gravel parking lots
Is there evidence of erosion, or bare soil, in the practice?	Y/N	Add mulch to areas that have been washed out. Add plants if necessary to stabilize the surrounding soil. Add rocks near inlets to slow the flow of water into the practice
Is there standing water after 48 hours after rain in the practice?	Y/N	This indicates that the infiltration rate of the soil is too low. Further evaluation and corrective measures will be needed.
If an outlet or underdrain is present, is there standing water in the practice after 48 hours?	Y/N	Check outlets/underdrain to ensure no blockage is present. If no blockage is present, then a larger issue may exist, and further action will be needed.

Bio-Swale or Naturalized Swale

Bioswales are linear channels designed to concentrate and convey stormwater runoff while removing debris and pollution. Bioswales can also be beneficial in recharging groundwater while removing harmful pollutants. Bioswales are typically planted with a variety of native plants that are pollution tolerant and can withstand prolonged periods of root inundation and drought periods. The drainage course is typically graded to less than 6%. Maintenance requirements for bio-swales can be found in Table 11.

Table 11. Bioswale/Naturalized Swale Maintenance Checklist

Inspection Checklist	Yes/No	Maintenance Type Needed
Are the stormwater inlets clear of debris and sediment?	Y/N	Remove any debris that may be obstructing the water flow. Clear out sediment deposits and dispose of properly
Are weeds, or invasive plants, present in the practice?	Y/N	Hand pull any weeds or invasives, ensuring you remove the entire root to prevent re-sprouting.
Has sediment settled in the practice to a depth of 25% of the total depth? Exp. 2" in sediment in 8" deep practice.	Y/N	Remove sediment from practice area using hand tools and the proper PPE and dispose of off-site.
Is there trash, leaves, grass clippings or other debris in the practice?	Y/N	Remove all debris from practice area and address any surrounding maintenance issues that might result in reoccurrence i.e. mowing direction around practice, nearby trash receptacles.
Does the vegetation appear full with little to no bare areas?	Y/N	Replant, or reseed bare areas utilizing the appropriate vegetation type.
Is there evidence of erosion, or bare soil, in the practice?	Y/N	Add mulch to areas that have been washed out. Add plants if necessary to stabilize the surrounding soil. Add rocks near inlets to slow the flow of water into the practice
Is there standing water after 48 hours after rain in the practice?	Y/N	This indicates that the infiltration rate of the soil is too low. Further evaluation and corrective measures will be needed.
If an outlet or underdrain is present, is there standing water in the practice after 48 hours?	Y/N	Check outlets/underdrain to ensure no blockage is present. If no blockage is present, then a larger issue may exist, and further action will be needed.

Stormwater Treatment Wetlands

Stormwater Treatment Wetlands are shallow naturalized detention ponds that provide temporary storage of stormwater runoff to prevent downstream flooding and the attenuation of runoff peaks. The plants provide water quality and habitat benefits not found in traditional dry or wet stormwater ponds. Maintenance requirements for stormwater treatment wetlands can be found in Table 12.

Table 12. Stormwater Treatment Wetland Maintenance Checklist

Inspection Checklist	Yes/No	Maintenance Type Needed
Are the inlet structures obstructed by debris?	Y/N	Remove debris to allow flow to enter and exit the practice
Are any of the inlet structure askew or misaligned?	Y/N	Repairs are needed to realign structure inlets to prevent erosion and sedimentation of the wetland
Does the practice water smell of gasoline, contain a sheen caused by gas or oil?	Y/N	Try and identify the source of the contaminant. I pretreatment system might need to be added
Is anything obstructing the inlet or outlet of the practice?	Y/N	Remove any obstructions from inlet/outlet. Check surrounding area for cause of sediment infill into practice i.e. exposed soil, gravel parking lots
Is there evidence of erosion, or bare soil, in the practice?	Y/N	Soil stabilization will be needed to prevent future slumping and erosion. Add vegetation to increase root density.
Are weeds, or invasive plants, present in the practice?	Y/N	Hand pull any weeds or invasives, ensuring you remove the entire root to prevent re-sprouting.

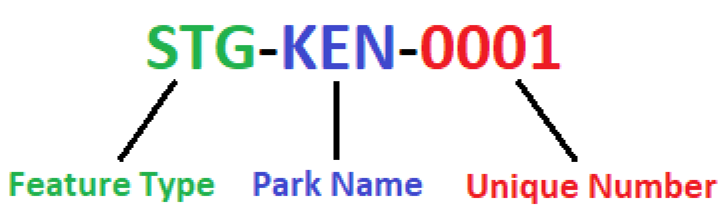
Geographic Information Systems

Geographic Information Systems (GIS) are widely used to manage utility infrastructure such as stormwater conveyance networks. Geographical location and attributes of each individual asset, such as size, depth, or condition rating, within the system prove essential to utility owners when making important decisions. Highly functioning geographic information systems rely on unique identifiers or "names" to differentiate between multiple assets of the same type in a system. By assigning a unique identifier to each asset, attribute information can be easily linked to the appropriate features in GIS.

Without unique identifiers, the time it takes to link existing or newly collected attribute data to the asset features in GIS increases tremendously and occasionally, proves impossible. Without attribute information, geographic information systems lack the information component making them merely a spatial map of the system.

After the stormwater assets within HCMA's GIS were analyzed, a list of suggested updates to increase functionality were developed. A brief description of each update can be found in the bulleted list below:

- **Create one geodatabase for all HCMA data.** Before this project, HCMA's stormwater assets were stored in multiple geodatabases based on park name. The schema (structure in which the database is set up and information stored) for each geodatabase was different and inconsistent. Therefore, a new master geodatabase was created based on the widely accepted ESRI Local Government Schema so all data could reside in one place with the data stored in a more organized, consistent manner.
- **Combine all HCMA data into the new geodatabase.** Data from each geodatabase was added to the newly created master geodatabase. An additional attribute field called "Park name" was included for each feature type, so that the flexibility to query/sort based on park name still remains. For example, all manhole features across the park system are now located in the same manhole feature class and contain the same attribute fields regardless of which park it is located in. The values inside of the "Park Name" attribute field will vary based on which park each manhole feature is located.
- **Add OHM collected data to the new database.** All stormwater network features collected by OHM have been added to the master geodatabase in the appropriate feature class. All known attributes for those new features were populated as well.
- **Convert to Local Government Naming convention.** The existing identifiers of the GIS features did not appear to have a consistent naming convention as some features displayed the exact same identifier and some features lacked an identifier altogether. In order to standardize and assure no duplicate identifiers, or lack thereof, can cause problems in the future, a new naming convention was developed. The new naming convention was based on the widely accepted Local Government Naming convention and assigns each feature its own unique identifier. The new identifiers contain three components separate by hyphens. An example of a stormwater gravity sewer/main located in Kensington Metropark can be seen below.



The Asset ID's and any other existing identifiers used in the past were kept as a "Legacy_ID" in the attribute table in case they are ever needed to be a link to join data that was stored or collected using those old identifiers.

- **Correct the flow direction for each pipe feature.** The flow direction for all pipe features was corrected to the greatest extent possible, based on the data available. The values in the "From manhole" and "To manhole" attribute fields of each pipe feature were also updated with the Legacy_ID values, since this was needed for the pipeline inspection data task.
- **Perform system wide topology checks.** To prepare the stormwater gravity main layer for integration with future data, critical topology checks must be performed to ensure connectivity throughout the system. Missing structures or discharge points were added where missing and the endpoints of the pipe features were snapped to their access point features. The stormwater features' attributes were also updated as needed.

After all geodatabase updates were completed, PACP inspection data for the stormwater sewers and culverts was analyzed. The inspections were completed by DVM Utilities Inc between June 25, 2018 and November 6, 2018. A breakdown of the inspection data used for the SAW project can be seen in the table below:

Table 13. PACP Inspection Data Breakdown

Park	Number of Inspections	Inspection Footage
Hudson Mills	11	920.9
Huron Meadows	12	691.5
Indian Springs	22	2,447.3
Kensington	87	7,147.3
Lake Erie	15	2,602.8
Lower Huron	34	5,225.7
Oakwoods	7	490.6
Stony Creek	81	6,588.3
Wolcott Mill	5	493.8
Lake St. Clair	110	13,229.2
Willow	55	5,744.0
TOTALS	**439**	**45,581.4**

After the inspection data was compiled, corrections and analyses were applied. Several brief description of the tasks completed can be found in the bulleted list below:

- **Generate unique pipe identifiers for each inspection.** None of the inspections contained the unique identifier of the pipe segment being inspected. Without a pipe identifier, there is no way to join the inspection data to the appropriate GIS feature. In order to know what inspection data pertains to each pipe, the unique feature identifier must be generated. Using the upstream and downstream features listed, a tool was used to generate as many unique pipe identifiers as possible. The remaining inspections (about 30%) were corrected manually, one by one. On all structure maps, DVM inspected pipes are represented by the last four digits of the unique identifier associated with the pipe.

- **Review PACP inspection data.** Inspections containing major defects were flagged for manual review, which consists of a trained rehabilitation expert watching the entire inspection video and manually assigning a rehab recommendation to fix the defects found during the inspection. The rest of the inspections have rehab recommendations generated automatically, if needed. It is important to note that only rehab recommendations generated from manual reviews are fully implementation ready projects. Rehab recommendations generated from the automatic calculations are meant for budgeting purposes only. These pipes should be manually reviewed before being included in a formal project plan or bid. The final estimated rehabilitation costs are then generated based on competitive pricing observed for similar and recent rehabilitation projects in the area.
- **Develop final inspection data tables.** After the inspection data has been compiled, PACP ratings generated, and rehab recommendations added, the final inspection data tables are generated. A brief description of each table can be found in the list below:
    - Media Table: Table linking all videos to each inspection/pipe segment that was inspected.
    - Conditions: Table listing all PACP defects and their associated details that were found during the inspections.
    - Inspections: Table listing all information regarding each individual inspection. The ratings at the right side of this table are each pipe segment's rating according to that particular inspection only. In other words, if a pipe segment was inspected more than once, there will be multiple rows and ratings for that pipe segment in this table.
    - Final Inspection Summary: Table listing all inspection information pertaining to each individual pipe segment. The ratings at the right side of this table are each individual pipe segment's final rating. If there are multiple inspections pertaining to the same pipe segment, the "Multiple Inspections?" column will be marked "Yes", and the defects from those inspections may be combined (if they do not overlap) to form one final rating for that particular pipe segment. In other words, there is only one row per pipe segment in this table. This eliminates the confusion of "which rating do we use?" and "how do we combine the ratings for the separate halves of the pipe?" when reversals are required and multiple inspections/ratings are generated for one pipe segment.
    - Rehab Recommendation Summary: Table listing all rehab recommendations and their associated costs per pipe segment. Restoration costs were included for any rehab methods that would require open cut work. These recommendations are also included in each individual park report.
- **Incorporate the PACP inspection data into the geodatabase.** The final inspection tables were incorporated into the geodatabase using related tables. This will allow the inspection data to analyzed, viewed and mapped within the GIS. Each feature displays only the data pertaining to that particular asset. In other words, the user won't have to sort through data tables to find the data pertaining only to that one asset.

Naming Convention Summary:

SSS-XXX-# - Streambank Stabilization Site – Park Abbreviation – Unique Number

SLR-XXX-# - Shoreline Rehabilitation – Park Abbreviation – Unique Number

SDC-XXX-# - Stormwater Discharge Culvert – Park Abbreviation — Unique Number

CUL-XXX-# - Culvert – Park Abbreviation – Unique Number

STG-XXX-# - Stormwater Gravity Main – Park Abbreviation -Unique Number

GI-XXX-# - Green Infrastructure – Park Abbreviation – Unique Number

Table 14. Park Abbreviations Used in This SWMP

Park Name	Park Abbreviation
Delhi	**DEL**
Dexter-Huron	**DEX**
Hudson Mills	**HUD**
Huron Meadows	**HUR**
Indian Springs	**IND**
Kensington	**KEN**
Lake Erie	**LE**
Lake St. Clair	**LSC**
Lower Huron	**LOW**
Oakwoods	**OAK**
Stony Creek	**STO**
Willow	**WIL**
Wolcott Mill	**WOL**

GIS Data Package Components List:

- Excel files for each park used for calculating green infrastructure practice costs and sizes
- Checklist of all recommended improvements for each park (Word format)
- Digital copy of this SAW Grant report in full and broken up by park section
- All GIS data collected for Huron-Clinton Metropark Authority as listed below:

- HCMA Analysis Data (GIS_Stage.sde\GIS_Stage.DBO.HCMA_Analysis)

Feature Class	Type / Description
Hydrology_Erosion_Survey	line for from Erosion points collected by OHM Environmental Planning
Shoreline_Condition_Survey	lines from Shoreline points collected by OHM Environmental Planning
GI_Recommnedation_Concept_Area	Don Carpenter Recommendation Concept Areas for Green Infrastructure/ polygon
sShoreline_Site	points /shoreline recommendation sites recommended by OHM / drived Data Driven maps for report
sStabilization_Site	points /stream stabilization recommendation sites recommended by OHM / drived Data Driven maps for report

- HCMA Field Data (raw data) (GIS_Stage.sde\GIS_Stage.DBO.HCMA_Analysis)

Feature Class	Type / Description
OHM_Culvert_EndPoints	OHM Field Collected Data
OHM_Erosion_Point	OHM Field Collected Data
OHM_InvasiveSpecies	OHM Field Collected Data
OHM_Obstruction	OHM Field Collected Data
OHM_Point_of_Interest	OHM Field Collected Data
OHM_Drainage_Course_Pt	OHM Field Collected Data
OHM_Drainage_Course_Line	OHM Field Collected Data
OHM_Wetlands_Point	OHM Field Collected Data

- Stormwater Infrastructure Data

Feature Class	Type / Description
HCMA_swCulvert	Line, culvert lines, created using OHM collected end points and existing HCMA culvert shapefiles
HCMA_DiscargePoint	OHM Collected and HCMA shapefiles
HCMA_swGravityMain	Line, Gravity Main
HCMA_swInlet	sw Inlet Points from HCMA
HCMA_swManhole	sw Manhole Points from HCMA
HCMA_swNetworkStructure	network structures for connectivity
HCMA_Cleanout	HCMA Shapefiles
HCMA_Oil_Grit_Separator	grease traps / other stormwater structures