1 Engineering Approach Supporting Design

1.1 Green Infrastructure Priority Areas

The current project is driven by an interest in implementation of green infrastructure to support control of CSO discharges. Therefore, a question to be addressed is: “In which locations will green infrastructure provide the most potential to reduce CSO discharges?” CSO discharges are most likely to be reduced in locations where other CSO controls can be avoided completely, or where a significant reduction in sizing of facilities is possible with green infrastructure. This ability to support CSO control must therefore be considered in conjunction with other anticipated controls that will be used in the control of the CSO discharges. These issues are addressed in an evaluation of the existing collection system and understand of potential future controls.

Additional questions relate to factors that are associated with technical feasibility. This category of evaluation is intended to identify potential areas based on the ability to support green infrastructure. This technical category considers the physical opportunities such as land area, space, slope, soils, and parcel configuration. Identification of these locations through a prioritization process can lead to areas that would benefit the collections system from pilot project opportunities.

However, it is difficult to separate the potential to reduce CSO discharges and technical siting factors with other factors that make application of green infrastructure feasible and beneficial. If social or political factors make placement of green infrastructure currently infeasible or difficult, there is not a specific benefit in the identification of these locations as priority areas. Thus, this must be taken into consideration as a key aspect in the identification process. The overlapping potential of each of the following broad categories will influence the success of green infrastructure controls. Tier II factors should be considered globally, but are best applied to those areas that have been identified in Tier I.

Table 1 identifies characteristics identified with high and low potential for identification of successful green infrastructure opportunities and demonstrations. The table identifies two categories. The first tier is based on the ability to meet the project objective of CSO reduction and the technical feasibility of implementing green infrastructure. The second tier considers social and political factors that, if met, may improve the chances of successful implementation.

Table 1: Area Selection Criteria

Category	Characteristics of High Potential	Characteristics of Low Potential
Tier I – Technical Considerations		
Collection System Configuration and Potential Future CSO Controls (Benefit for CSO Control)	• Small tributary area to individual CSO • Municipal CSO area upstream of ALCOSAN regulator • Area previously identified as basin planner as having higher feasibility for green infrastructure benefit • CSO area not directly adjacent to other combined areas. • Identified storm sewer area within combined sewer area.	• Immediately adjacent to proposed tunnel or major facility locations. • Interceptor capacity limited.

Category	Characteristics of High Potential	Characteristics of Low Potential
	• Size of precipitation event to be controlled in order to reach target	
Physical Characteristics that Promote Potential for Green Infrastructure Demonstration and Effectiveness	• Significant number of public parcels (size, location) • Large impervious areas with potential to control (e.g. parking lot directed to island GI, roof runoff diverted to pervious area or GI) • Slope (0%-8%) for majority of area • Existing permeable area available to support adjacent properties • Larger (public) rights of way • Problem drainage with small storm events	• Predominately private parcels • Small parcels with little or no impervious area • Steeply sloped areas • Narrow rights of way
Tier II – Planning, Political, Social Considerations		
Support for Green Infrastructure or Practices (institutional feasibility)	• Municipality highly supportive of green infrastructure • ALCOSAN (or other agency) focused pilot area for green infrastructure • Downspout disconnection program target areas • Street Trees • Redeveloping area/ area in transition • Political/ Council District with focused emphasis • Active stewardship community (community gardens or other citizen lead stewardship)	• Municipality not supportive of green infrastructure • Minimal redevelopment or blighted area not yet in transition • Identify underground utility

1.1.1 Approach

This project will address each criterion which has readily available data to support or can be evaluated with reasonable limited analysis. Some of the criteria identified may currently be undefined or unsupported by data. In such cases, these decision variables remain included in the listing in order to provide a comprehensive picture and suggest areas of future information development.

Area evaluation: tier I: Technical Considerations

Collection System Configuration and Potential Future CSO Controls
(Benefit for CSO Control)

1) Small tributary area to individual ALCOSAN CSO
    a) Currently available data: Sewersheds tributary to ALCOSAN regulators (GIS layer)
    b) Future data source: Updated sewersheds
    c) Proposed analysis:
        i) Note: existing data is sufficient for this analysis.

ii) Identify distribution of combined area per ALCOSAN point of connection (POC). Rank small to large. Group into thirds with smallest group being highest potential, middle group being moderate potential and large areas being smallest potential. Actual acreage associated with groupings may be modified by best professional judgment.

2) Municipal CSO area upstream of ALCOSAN regulator
   a) Currently available data: locations of existing municipal CSOs (spatial data) and tributary areas.
   b) Future data source: no change anticipated other than minor corrections to tributary areas.
   c) Proposed analysis: identify areas tributary to municipal CSO locations.
3) Area previously identified by basin planner as having higher feasibility for green infrastructure benefit
   a) Currently available data: Spatial layer from ALCOSAN showing basin planner identified areas for implementation of green practices.
   b) Future data source: Updated layer from ALCOSAN based on ongoing alternatives analysis (may or may not change)
   c) Proposed analysis: Identify areas per layer provided. Review Saw Mill Run documents as no areas were identified in the spatial layer.
4) CSO area not directly adjacent to other combined areas.
   a) Currently available data: Map of combined areas by ALCOSAN POC
   b) Future data source: No change anticipated
   c) Proposed analysis: Select areas based on extent to which they are remote from other locations. Best professional judgment. Identify by POC.
5) Not adjacent/ tributary to proposed large CSO facilities
   a) Currently available data: ALCOSAN regional planning scenarios 1 – 7
   b) Future data source: ALCOSAN updated regional planning scenarios and basin planner updated scenarios
   c) Proposed analysis: Using currently available data and best professional judgment/ inspection, eliminate areas from “high priority” that do not have municipal overflows and are immediately tributary to major CSO control facilities identified as high priority locations. The product of this will be a list of remaining POCs that may not be addressed in large/ priority facilities.
6) Identified storm sewer area within combined sewer area.
   a) Currently available data: One overall map identifying municipal sewers by type/ layer for combined sewer areas.
   b) Future data source: information on location of stream removal projects (pending from ALCOSAN).
   c) Proposed analysis: Highlight identified storm sewers within the municipal combined sewer areas. Define approximate area served and point of connection/ if municipal overflows exist in the proximity. Limit to larger areas. To be selected based on best professional judgment. Exclude stream flow removal areas as these are already being addressed.
7) Size of precipitation event to be controlled in order to reach target.
   a) Currently available data: ALCOSAN H/H models (preferred baseline conditions with stream flow removal and early action projects identified).
   b) Future data source: revised ALCOSAN H/H models
   c) Proposed analysis: For locations identified in items 1 – 6 above perform the following:

i) Define available regulator capacity: base on ALCOSAN report documenting regulator capacity. However if physical regulator capacity is > 3x DWF, limit to 3x DWF.
ii) Run H/H models identified for the typical year and develop time series data upstream of regulator to compare with regulator capacity.
iii) Define storm event thresholds that correspond with various overflow frequencies.

Physical Characteristics that Promote Potential for Green Infrastructure Demonstration and Effectiveness

1) Public parcels: assess number, size and density. Generally greater than 1 acre to allow for GI placement area.
2) Large impervious areas with potential to control within parcel boundaries. Consider size of parking area or building footprint relative to total parcel size. May be limited based on slope / soils. parking lot directed to island GI, roof runoff diverted to pervious area or GI)
3) Slope: Preferred 0%-8% for majority of area
4) Existing permeable area available to support adjacent properties: Can be evaluated based on impervious area, parks, and other parcel data
5) Larger (public) rights of way. Opportunities are improved when ROW greater than 42 feet. A street ROW layer would be beneficial if this is to be included as a criterion. Known data includes parcel data and street centerline/ street edge of pavement data, but unclear if ROWs have been defined.
6) Problem drainage with small storm events. No known data exists to summarize this in GIS format. This would be a potential future enhancement.
7) Street Trees. Existing street trees provide a current function for tree canopy (interception), as well as evapotranspiration for infiltrated stormwater. Generally, new GIs would not be considered that would require removal of established street trees.
8) Ownership type by taxing body for vacant lots

Area evaluation: tier 2: Planning, Political, Social Considerations

1) Redeveloping area/ area in transition
   a) Currently available data: *unknown: to be determined based on Allegheny County planning information*
   b) Future data source: *to be determined*
2) Municipality highly supportive of green infrastructure
   a) Currently available data: *selected municipalities/ agencies publically supportive of green infrastructure implementation, based on input from 3 Rivers, steering committee (to be requested)*
   b) Future data source to be developed: survey or assessment of support for green practices as determined by municipal resolution and review of development ordinances.
3) Downspout disconnection program
   a) Currently available data: *input from 3 Rivers regarding pilot locations for downspout disconnection practices. Also any criteria that has been developed for selection of downspout disconnection areas. Requested from 3R on 5/10/11, Beth Dutton gathering information.*
   b) Future data source to be developed: locations where downspouts are connected/ disconnected.
4) Political/ Council District with focused emphasis
   a) Currently available data: *Similar to item 2, any specific areas within a community that have been identified by that community as a focus area for green infrastructure based on local municipal priorities. To be requested from/ identified by 3 Rivers.*

   b) Future data source to be developed: TBD.
5) ALCOSAN (or other agency) focused pilot area for green
   a) Currently available data: *ALCOSAN provided map and GIS layer highlighting priority areas (received)*
   b) Future data source to be developed: NA.
6) Active stewardship community (community gardens or other citizen lead stewardship)
   a) Currently available data: *specific focal areas by other organizations (initial list to be prepared by Collective Efforts/ 3 Rivers) – to be requested*
   b) Future data source to be developed: more formalized identification of various groups who are promoting such practices.

Data required for the above analysis includes GIS data sets and hydraulic model data. Tetra Tech is currently coordinating with the 3 Rivers program manager consultant for assessing models previously provided by ALCOSAN. Models preferred for this analysis should reflect baseline conditions (essentially existing conditions + stream flow and near term projects). A listing of desirable GIS data layers is identified in Table 2. This listing is based on known existing and/ or desired data sources that would support the project. Data importance is noted with various ranking (required (R), high (H), moderate (M) or low (L).)

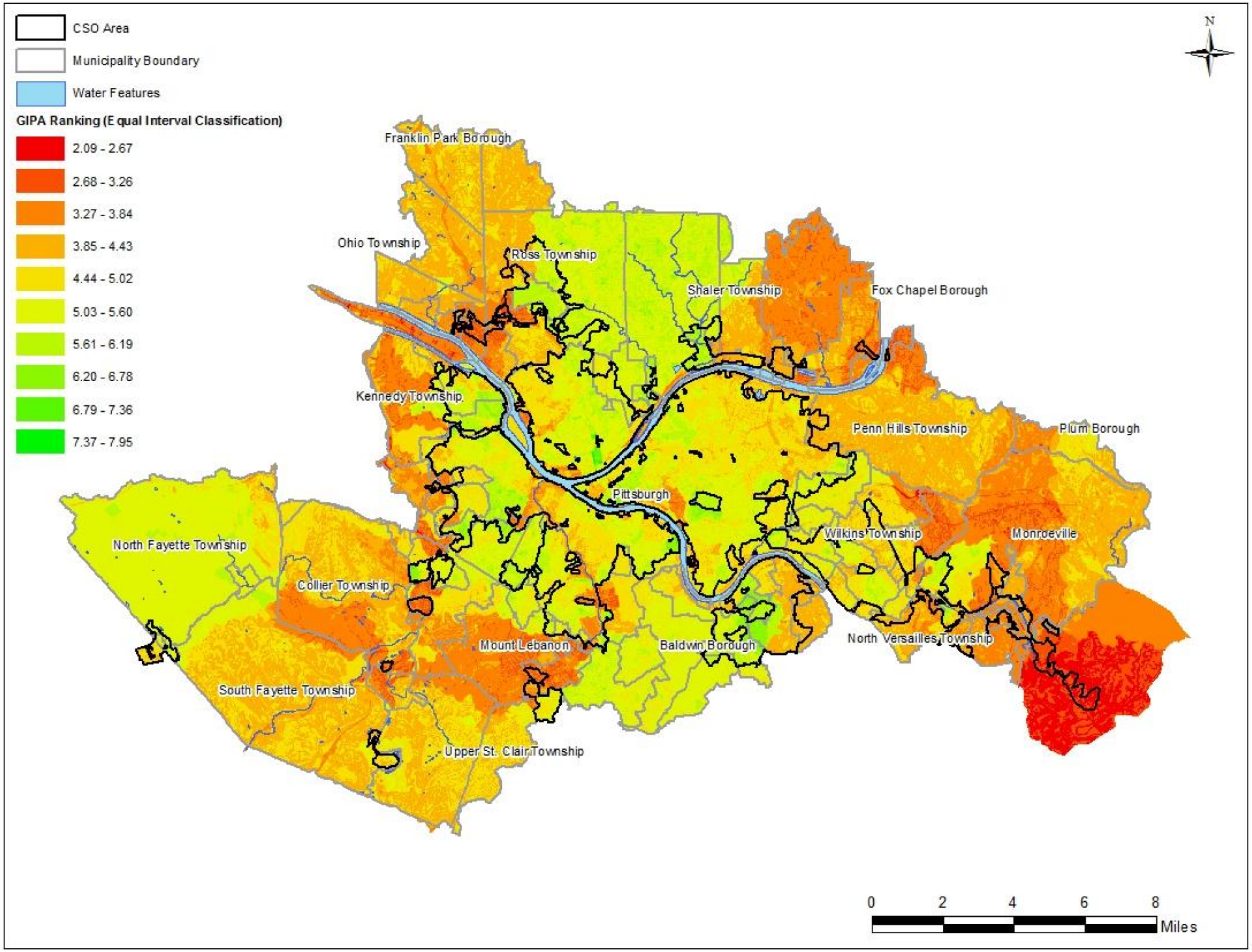
Table 2: GIS Data Layers Value: R = required; H= high, M = moderate, L = low

Item	Value	GIS Data	Known Potential Data Source if not available from 3 Rivers	Year
1	M	Abandoned Mine Land Inventory Areas, Sites and Point - has subsidence areas	PASDA	2011
2	R	Aerial Photos (Google Maps more current)	PASDA	2006-2007
3	M	Allegheny Land Trust Greenprint	ALCOSAN	2009
4		ALCOSAN identified green infrastructure potential locations	ALCOSAN	2010
5		ALCOSAN identified stream removal project areas	ALCOSAN	pending
6	L	AMD Treatment/Land Recycling Projects	PASDA	2011
7	M	Brownfields	PASDA	2009
8	H	Building Footprints	Allegheny County Website/PASDA	2008
9	M	Cemeteries	Allegheny County Website/PASDA	2002
10	L	Contours	ALCOSAN (2', 4' 10' 20' & 100')	2008
11	H		PASDA (5')	2004
12	M	Development Areas	*Unknown*	??
13	H	Downspout Disconnection Program Pilot Areas	*Unknown*	
14		Downspout Disconnection Assessment (e.g. status of downspout disconnection)		
15	L	Floodplain - 100 Yr	Allegheny County Website/PASDA	2000
16		Green Infrastructure Practices (existing)	*To be started from available information as part of this project*	
17	H	Greenways	Allegheny County Website/PASDA	2010

Item	Value	GIS Data	Known Potential Data Source if not available from 3 Rivers	Year
18	M	Hydrology Areas (water bodies)	Allegheny County Website/PASDA	2006
19	M	Hydrology Lines (streams, drainages, large river boundaries)	Allegheny County Website/PASDA	2006
20	R	Impervious (closed polygons)	ALCOSAN	2010
21	R	Land Use/Land Type** (land use/types including utilities, residential, commercial, agricultural, business	Southwestern Pennsylvania Commission (via ALCOSAN)	2006
22	R		Allegheny County Website/PASDA	2004
23	H	Landslide prone areas	nothing available, but retaining wall .shp from All. Co/PASDA	
24	R	Municipal boundaries (will not match sewershed boundaries exactly)	Allegheny County Website/PASDA	2011
25	R	Municipal sewer system -manholes	One overall map	2011
26	R	Municipal sewer system -sewers	One overall map	2011
27	M	Municipal zoning	unknown	2002
28	M	National Wetlands Inventory	Allegheny County Website/PASDA	2000
29	R	Parcels	Allegheny County Website/PASDA	2011
30	H	Parking	Allegheny County Website/PASDA	2000
31	H	Parks	Allegheny County Website/PASDA	2000
32	M	Problem drainage locations	*Unknown/ unmapped*	
33	H	Public Buildings	Allegheny County Website/PASDA	2002
34	L	Railroad Lines	Allegheny County Website/PASDA	2006
35	R	Sewershed boundaries	ALCOSAN	2011
36	R	Slopes	PASDA	2010
37	R	Soils (also http://www.pa.nrcs.usda.gov/Soils/soilsinfo.html)	Allegheny County Website/PASDA	2000
38	H	Street Centerlines	Allegheny County Website/PASDA	2006
39	H	Street Edge of Pavement	Allegheny County Website/PASDA	2006
40	H	Street Right of Way	*unknown*	
41	M	Stormwater Management Watersheds	PASDA	2002
42	M	Trees – Street	*unknown*	
43	M	Watersheds	Allegheny County Website/PASDA	2000
44	M	Wooded Areas	PASDA	2011
		Planning Documents/Offices	**Source**	
		Allegheny County Comprehensive Plan	http://www.alleghenyplaces.com/	
		City of Pittsburgh Urban Redevelopment Authority	http://www.ura.org/	

Item	Value	GIS Data	Known Potential Data Source if not available from 3 Rivers	Year
		City of Pittsburgh City Planning	http://www.city.pittsburgh.pa.us/cp/	
		*PASDA - Pennsylvania Spatial Data Access *Allegheny County GIS Website - this website links to PASDA	http://www.alleghenycounty.us/dcs/gis/available.aspx	

1.1.2 Final GIPA Scoring and Map


CSO Area
Municipality Boundary
Water Features
GIPA Ranking (Equal Interval Classification)
2.09 - 2.67
2.68 - 3.26
3.27 - 3.84
3.85 - 4.43
4.44 - 5.02
5.03 - 5.60
5.61 - 6.19
6.20 - 6.78
6.79 - 7.36
7.37 - 7.95
N
Franklin Park Borough
Ohio Township
Ross Township
Shaler Township
Fox Chapel Borough
Kennedy Township
Penn Hills Township
Plum Borough
Pittsburgh
North Fayette Township
Wilkins Township
Monroeville
Collier Township
Mount Lebanon
Baldwin Borough
North Versailles Township
South Fayette Township
Upper St. Clair Township
0
2
4
6
8
Miles

The Green Infrastructure Priority Areas (GIPA) layer highlights the locations where green infrastructure will provide the most potential to reduce CSO discharges. In order to create the GIPA layer, sixteen input datasets were identified, analyzed, ranked, weighed, and finally intersected to create the final output. All of the analysis and geospatial work was done using ESRI's ArcGIS geoprocessing tools in the ModelBuilder processing environment.

The sixteen input layers are broken down into two main categories, Technical Considerations and Planning, Political, and Social Considerations. The Technical Considerations category is furthermore divided into two groups, Collection System Configuration, and Physical Characteristics.

The following section summarizes how each of the input layers was processed and ranked.

Collection System Configuration Inputs:

1. Small tributary areas to individual ALCOSAN CSO
   a. Area summarized by POC (Point of Connection)
   b. Grouped by area into thirds, smallest 1/3 received ranking of 10, middle 1/3 received a ranking of 5, and largest 1/3 received ranking of 1.
2. Municipal CSO area upstream of ALCOSAN regulator
   a. Areas tributary to municipal CSO area received ranking of 10, all other areas received ranking of 1.
3. Basin Planner identified areas of high feasibility of green infrastructure
   a. Basin Planner identified green infrastructure areas received ranking of 10, all other areas received ranking of 1.
4. Storm sewer areas within CSO area
   a. Areas of storm sewer within CSO areas received ranking of 10, all other areas received ranking of 1.
5. Frequency of precipitation event
   a. Non-CSO areas received ranking of 1, other areas received ranking value between 2 and 10 based on frequency compared to initial abstraction.
6. Volume of precipitation event
   a. Non-CSO areas received ranking of 1, other areas received ranking value between 2 and 10 based on volume compared to initial abstraction.

Physical Characteristic Inputs:

7. Public Parcels
   a. Public parcels with an area greater than 1 acre received a ranking value of 10, public parcels with an area less than 1 acre received a ranking value of 5, and all non-public parcels received a ranking value of 1.
8. Parcels with a high percentage of impervious area
   a. Parcels with greater than 25% impervious area received a ranking value of 10, all other parcels received a value of 1.
9. Slope
   a. Slope percent was created using 10 meter elevation dataset.

   b. Slope less than 4% received ranking value of 10, slope between 4% and 8% received a ranking value of 5, all other slope values received a ranking value of 1.

10. Existing Permeable Area
    a. Permeable areas received a ranking value of 10, all other areas received a ranking value of 1.
11. Public Right-of-Ways (ROW)
    a. Public Right-of-Ways received a ranking value of 10, all other areas received a ranking value of 1.

Planning, Political, and Social Consideration Inputs:

12. ALCOSAN focused pilot area for green infrastructure
    a. ALCOSAN green infrastructure areas received a value of 10, all other areas received a ranking value of 1.

Once each of the sixteen input layers was analyzed, processed and ranked, each of the inputs was assigned a weight based on its level of significance. The weights were assigned as follows:

Input Layer	Weight
1. Small tributary areas to individual ALCOSAN CSO	0.05
2. Municipal CSO area upstream of ALCOSAN regulator	0.1
3. Basin Planner identified areas of high feasibility of green infrastructure	0.08
4. Storm sewer areas within CSO area	0.05
5. Frequency of precipitation event	0.07
6. Volume of precipitation event	0.07
7. Public Parcels	0.05
8. Parcels with a high percentage of impervious area	0.1
9. Slope	0.05
10. Existing Permeable Area	0.05
11. Public Right-of-Ways (ROW)	0.05
12. Problem drainage areas	0.05
13. Redeveloping and transition areas	0.04
14. Municipality or council district supportive of green infrastructure	0.05
15. Downspout disconnection program areas	0.04
16. ALCOSAN focused pilot area for green infrastructure	0.05
17. Active stewardship community	0.05
TOTALS	1

The final step in the process was to combine all sixteen inputs through an overlay process and to remove any water features (rivers, lakes, ponds, etc.) from the layer. Once this was completed the layer was then classified into 10 groups based on the Natural Breaks (Jenks) classification method.

1.2 GI Placement

The siting tool developed by Tetra Tech for EPA *SUSTAIN* model was used to identify suitable sites for placement of GIs on the basis of suitability criteria including elevation, slope, soil type, urban land use, roads, stream location, and drainage area. The siting tool was developed to assist users in selecting suitable locations for different types of low impact development (LID) techniques or conventional GIs. The following tables list the GIS data, the data format, and the default site suitability criteria for the siting tool taken from EPA published report (Shoemaker et al. 2009; http://www.epa.gov/nrmrl/wswrd/wq/models/sustain) to identifying potential site locations. A suitable location map for potential GI types was created and is available for the user through the web-based interfaces as guidance.

GIS Data Requirement for GI Suitability Analysis

GIS Layer	Format	Description
DEM	Raster file	The DEM is used to calculate the drainage slope and drainage areas that are used to identify the suitable locations for GIs.
NLCD Land Use	Raster file	The USGS Multi-Resolution Land Characteristics Consortium NLCD land use grid is used to eliminate the unsuitable areas for GIs.
Percent Imperviousness	Raster file	The impervious grid is used to identify the suitable locations for GIs for the given suitability criteria.
Soil	Shape file	The soil data contain the soil properties such as hydrological soil group, which are used to identify suitable locations for GIs.
Urban Land Use	Shape file	The urban land use data contain the boundaries for the buildings and the impervious areas needed to identify suitable locations for LIDs.
Road	Shape file	The road layer is used to identify suitable locations for some GIs that must be placed within a specific road buffer area.
Stream	Shape file	The stream layer is used to define a buffer so that certain GI types can be placed outside the buffer to minimize the impact on streams.
Groundwater Table Depth	Shape file	The groundwater table depth layer is used to identify suitable locations for the infiltration GIs; derived from monitoring data.

GIS Data Format Requirement for GI Suitability Analysis

GIS Layer	Data Type	Field Name	Field Type	Field Value / Description

GIS Layer	Data Type	Field Name	Field Type	Field Value / Description
DEM	Raster file	VALUE	Floating	ESRI grid
NLCD Land Use	Raster file	VALUE	Integer	ESRI grid
Land Use Lookup	Table	LUCODE	Integer	should be same as in the VALUE field in NLCD Land Use layer
		LUNAME	String	Description about the land use type
		SUITABLE	Short	1 or 0 (1 = suitable; 0 = unsuitable)
Percent Imperviousness	Raster file	VALUE	Integer	0 – 100
Soil	Shape file	MUKEY	String	Hydrological soil classification (STATSGO or SSURGO or local dataset)
Soil Lookup	Table	MUKEY	String	should be same as in the MUKEY field
		HYDGRP	String	A or B or C or D
Urban Land Use	Shape file	LU_DESC	String	Buildings or Roadways or Parking Lots
Road	Shape file	N/A	N/A	N/A
Stream	Shape file	N/A	N/A	N/A
Groundwater Table Depth	Shape file	GWDEP_FT	Double	Depth to groundwater table

GI Criteria for Suitable Locations Used in the Siting Tool

GI Type	Drainage Area (acre)	Drainage Slope (%)	Impervious (%)	Hydrological Soil Group	Water Table Depth (ft)	Road Buffer (ft)	Stream Buffer (ft)	Building Buffer (ft)
Bioretention	< 2	< 5%	> 0%	A–D	> 2	< 100	> 100	-
Constructed Wetland	> 25	< 15%	> 0%	A–D	> 4	--	> 100	--
Dry Pond	> 10	< 15%	> 0%	A–D	> 4	--	> 100	--
Grassed Swale / Bioswale	< 5	< 4%	> 0%	A–D	> 2	< 100	--	--
Green Roof	--	--	--	--	--	--	--	--

GI Type	Drainage Area (acre)	Drainage Slope (%)	Impervious (%)	Hydrological Soil Group	Water Table Depth (ft)	Road Buffer (ft)	Stream Buffer (ft)	Building Buffer (ft)
Infiltration Basin	< 10	< 15%	> 0%	A–B	> 4	--	> 100	--
Infiltration Trench	< 5	< 15%	> 0%	A–B	> 4	--	> 100	--
Porous Pavement (Concrete/ Asphalt) / Permeable Interlocking Paver	< 3	< 1%	> 0%	A–B	> 2	--	--	--
Rain Barrel	--	-	--	--	--	--	--	< 30
Sand Filter (non-surface)	< 2	< 10%	> 0%	A–D	> 2	--	> 100	--
Sand Filter (surface)	< 10	< 10%	> 0%	A–D	> 2	--	> 100	--
Vegetated Filter Strip / Grass Buffer	--	< 10%	> 0%	A–D	> 2	< 100	--	--
Wet Pond	> 25	< 15%	> 0%	A–D	> 4	--	> 100	--

1.3 GI Performance and Cost

The GI performance curves represent a computationally efficient and technically defensible way of predicting a GI response, while eliminating the need for on-the-fly, computationally intensive modeling through the web. The step-by-step approach used to developing the GI performance curves is outlined below:

- Developed unique Hydrologic Response Units (HRUs) by overlaying landuse (pervious, rooftops, and impervious areas), soil (hydrologic soil group B, C, and D), and slope (low, moderate, and high) GIS layers for the study area. The HRU layer provides 13 unique combinations of slope, soil and landuse that potentially have a different rainfall-runoff response.

- NEXRAD precipitation data for the ALCOSAN service area for the 2003 Typical Year was used in this study.
- Modeled the rainfall-runoff response from each HRU on unit area basis (one acre) for the selected rainfall data. An existing ALCOSAN sewershed model (calibrated for the study area) was used to develop the HRU timeseries as a boundary condition to the *SUSTAIN* GI modeling effort.
- A set of 131 unique *SUSTAIN* modeling scenarios were developed for a unique combination of 16 GI types, 3 GI footprint soil type with low, medium, and high infiltration rates, and with an option of underdrain for poorly drained soil types.
- The EPA *SUSTAIN* model was run for a range of treatment depth (i.e. runoff depth to be captured) versus treatment capacity (i.e. GI size) for each scenario to develop 131 performance curves. Each performance curve provides the runoff volume captured and the GI cost for the given treatment depth or treatment capacity.

1.3.1 Hydrologic Response Unit Types

HRU Type	Description
HRU1	Building
HRU2	Impervious, high slope
HRU3	Impervious, moderate slope
HRU4	Impervious, low slope
HRU5	Pervious, high slope, soil D
HRU6	Pervious, high slope, soil C
HRU7	Pervious, high slope, soil B
HRU8	Pervious, moderate slope, soil D
HRU9	Pervious, moderate slope, soil C
HRU10	Pervious, moderate slope, soil B
HRU11	Pervious, low slope, soil D
HRU12	Pervious, low slope, soil C
HRU13	Pervious, low slope, soil B

1.3.2 Data Used

- Elevation data (DEM) to generate slope.
- Land use (pervious and impervious).
- Soil (Hydrologic Soil Group).
- NEXRAD precipitation data for the 2003 Typical Year.
- An existing ALCOSAN sewershed model (baseline scenario).

- GI cost information.

1.3.3 Model Input and Specifications

The following variables went into calculating the performance and cost of the GIs. The height, width and length of GIs defined the surface storage capacity. This also serves as the key for Appendix A, Appendix B, and Appendix C which are the criteria values used in the model.

GI Size Key – the following table shows the GI size specification used in the model.

BMPSITE	GI dimension group identifier
WIDTH	Basin bottom width (ft)
LENGTH	Basin bottom length (ft) / diameter (ft) for rain barrel
OHEIGHT	Orifice Height (ft)
DIAM	Orifice Diameter (in)
EXTP	Discharge Coefficient (0-0.99 or 1=1.0, 2=0.61, 3=0.61, 4=0.5)
RELTP	Release Type (1-Cistern, 2-Rain barrel, 3-others)
DDAYS	Number of dry days (Rain Barrel Option)
WEIRTP	Weir Type (1-Rectangular,2-Triangular)
WEIRH	Weir Height (ft)
WEIRW	(weir type 1) Weir width (ft)
THETA	(weir type 2) Weir angle (degrees)

GI Substrate Key – the following table shows the GI soil media specification.

BMPSITE	GI dimension group identifier
INFILTM	Infiltration Method (0-Holtan, 1-Green Ampt)
POLROTM	Pollutant Routing Method (1-Completely mixed, >1-number of CSTRs in series)
POLREMM	Pollutant Removal Method (0-1st order decay, 1-kadlec and knight method)
SDEPTH	Soil Depth (ft)
POROSITY	Soil Porosity (0-1)
FCAPACITY	Soil Field Capacity (ft/ft)
WPOINT	Soil Wilting Point (ft/ft)
AVEG	Vegitative Parameter A (0.1-1.0) (Empirical), only required for Holtan infiltration method
FINFILT	Soil layer infiltration rate (in/hr)

UNDSWITCH	Consider underdrain (1), Do not consider underdrain (0)
UNDDEPTH	Depth of storage media below underdrain (ft)
UNDVOID	Fraction of underdrain storage depth that is void space (0-1)
UNDINFILT	Background infiltration rate, below underdrain (in/hr)
SUCTION	Average value of soil capillary suction along the wetting front, value must be greater than zero (in)
HYDCON	Soil saturated hydraulic conductivity, value must be greater than zero (in/hr)
IMDMAX	Difference between soil porosity and initial moisture content, value must be greater than or equal to zero (a fraction)

Note: Pollution Reduction and Pollution Removal was not used as these apply only to Water Quality based calculations.

1.3.4 GI Performance Curves

Below are the GI Effectiveness calculations for each of the GI-HRU combinations. These calculations are used in the Engineering and Homeowner Tool for GI Size/Performance.

For each GI, the user defines the percentage of each HRU's runoff that routes to that GI. This is calculated in the following way:

$$V_{Runon} = \sum_{i=1}^{n} A_{HRU,i} D_{HRU,i} + \sum_{j=1}^{m} V_{BMP,j}$$

Where V is the volume (acre-inches) of runoff routed to the GI, $A_{HRU,i}$ is the area (acre) of an HRU, $D_{HRU,i}$ is the annual runoff depth (inches) per unit area for that HRU, n is the number of HRUs in the sewershed, $V_{BMP,j}$ is the effluent volume for an upstream GI, and m is the number of upstream GIs.

This volume is then converted to an equivalent impervious drainage area using the following equation:

$$A_{impervious} = \frac{V_{Runon}}{D_{impervious}}$$

Where $A_{impervious}$ is the equivalent impervious drainage area (acres), V_{runon} is the volume of water routed to the GI, and $D_{impervious}$ is the annual runoff depth from one acre of impervious area, which happens to be 31.24 inches for the typical year 2003.

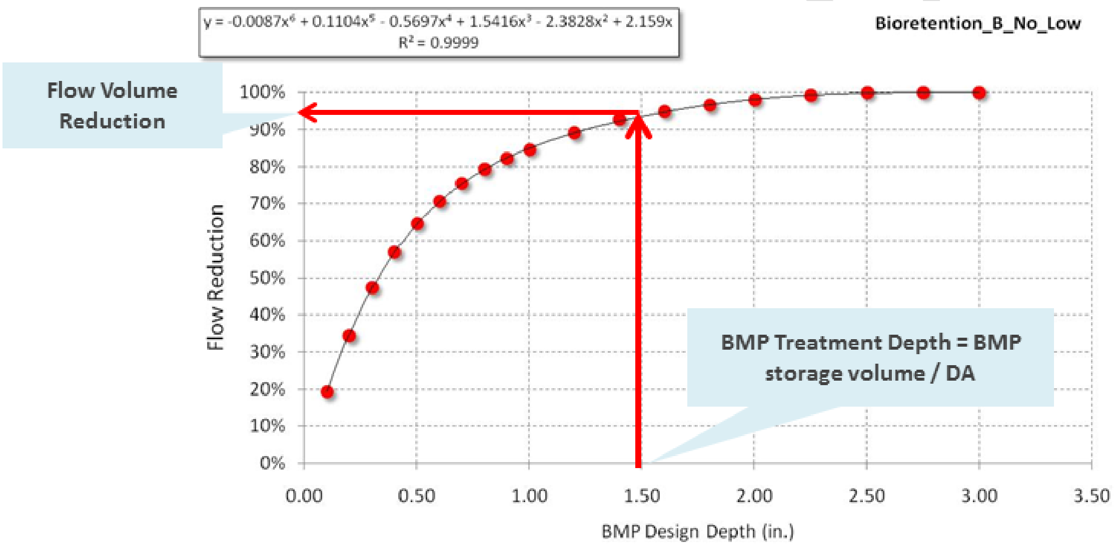
This area is then used to calculate the impervious runoff treatment depth based on the user specified GI size and the given GI per unit area capacity.

$$D_{treatment} = \frac{V_{GI-Capacity}}{A_{impervious}}$$

Where $D_{treatment}$ is the treatment depth (inches), $V_{GI\text{-}Capacity}$ is the GI capacity volume calculated from per unit area capacity and the GI size (surface area), and $A_{impervious}$ is the equivalent impervious drainage area.

Once this treatment depth has been calculated, the performance curve can be used to find an equivalent flow volume reduction, shown below.

Example Performance Curve used to Generate Reduction.



If the user specifies the runoff treatment depth in the engineering tool interface, then the reduction is simply directly looked up using the performance curve and the size of the GI is calculated based on the given runoff treatment depth and the equivalent impervious drainage area.

Appendix A: GI Sizing Data

BMPType	SoilType	Underdrain	Infiltration	WIDTH	LENGTH	OHEIGHT	DIAM	EXITYPE	RELEASETYPE	WEIRTYPE	WEIRH	WEIRW
GreenRoof	B/C/D	Yes	0 (lined)	1	819.4	0	0	2	3	1	0.2	41.0
PanterBox	B/C/D	Yes	0 (lined)	1	230.5	0	0	2	3	1	0.5	11.5
Wetland/Wetpond	B/C/D	Yes	0 (lined)	1	144.6	1	6	2	3	1	2.5	7.2
Bioretention-lined	B/C/D	Yes	0 (lined)	1	220.0	0	0	2	3	1	0.75	11.0
SandFilter-lined	B/C/D	Yes	0 (lined)	1	230.5	0	0	2	3	1	0.5	11.5
VegetatedSwale-lined	B/C/D	Yes	0 (lined)	1	465.4	0	0	2	3	1	0.3	23.3
PermeablePaver-lined	B/C/D	Yes	0 (lined)	1	1125.6	0	0	2	3	1	0.01	56.3
PorousConcrete/Asphalt-lined	B/C/D	Yes	0 (lined)	1	1423.5	0	0	2	3	1	0.01	71.2
Bioretention	B	No	Low	1	250.3	0	0	2	3	1	0.75	12.5
SandFilter	B	No	Low	1	264.0	0	0	2	3	1	0.5	13.2
VegetatedSwale	B	No	Low	1	625.9	0	6	2	3	1	0.3	31.3
Bioswale	B	No	Low	1	354.1	0	0	2	3	1	0.5	17.7
InfiltrationTrench	B	No	Low	1	196.2	0	0	2	3	1	0.5	9.8
PermeablePaver	B	No	Low	1	355.0	0	0	2	3	1	0.01	17.8
InfiltrationBasin	B	No	Low	1	302.5	0	0	2	3	1	0.5	15.1
DryPond	B	No	Low	1	114.3	0	0	2	3	1	3	5.7
PorousConcrete/Asphalt	B	No	Low	1	380.1	0	0	2	3	1	0.01	19.0
DownspoutDisconnection	B	No	Low	1	2420.0	0	0	2	3	1	0.05	121.0
FilterStrip	B	No	Low	1	2792.3	0	0	2	3	1	0.03	139.6
Bioretention	B	No	Med	1	250.3	0	0	2	3	1	0.75	12.5
SandFilter	B	No	Med	1	264.0	0	0	2	3	1	0.5	13.2
VegetatedSwale	B	No	Med	1	625.9	0	0	2	3	1	0.3	31.3
Bioswale	B	No	Med	1	354.1	0	0	2	3	1	0.5	17.7
InfiltrationTrench	B	No	Med	1	196.2	0	0	2	3	1	0.5	9.8
PermeablePaver	B	No	Med	1	355.0	0	0	2	3	1	0.01	17.8
InfiltrationBasin	B	No	Med	1	302.5	0	0	2	3	1	0.5	15.1
DryPond	B	No	Med	1	114.3	0	0	2	3	1	3	5.7
PorousConcrete/Asphalt	B	No	Med	1	380.1	0	0	2	3	1	0.01	19.0
DownspoutDisconnection	B	No	Med	1	2420.0	0	0	2	3	1	0.05	121.0
FilterStrip	B	No	Med	1	2792.3	0	0	2	3	1	0.03	139.6
Bioretention	B	No	High	1	250.3	0	0	2	3	1	0.75	12.5
SandFilter	B	No	High	1	264.0	0	0	2	3	1	0.5	13.2
VegetatedSwale	B	No	High	1	625.9	0	0	2	3	1	0.3	31.3
Bioswale	B	No	High	1	354.1	0	0	2	3	1	0.5	17.7
InfiltrationTrench	B	No	High	1	196.2	0	0	2	3	1	0.5	9.8
PermeablePaver	B	No	High	1	355.0	0	0	2	3	1	0.01	17.8
InfiltrationBasin	B	No	High	1	302.5	0	0	2	3	1	0.5	15.1
DryPond	B	No	High	1	114.3	0	0	2	3	1	3	5.7
PorousConcrete/Asphalt	B	No	High	1	380.1	0	0	2	3	1	0.01	19.0
DownspoutDisconnection	B	No	High	1	2420.0	0	0	2	3	1	0.05	121.0
FilterStrip	B	No	High	1	2792.3	0	0	2	3	1	0.03	139.6
Bioretention	B	Yes	Low	1	220.0	0	0	2	3	1	0.75	11.0
SandFilter	B	Yes	Low	1	230.5	0	0	2	3	1	0.5	11.5

BMPType	SoilType	Underdrain	Infiltration	WIDTH	LENGTH	OHEIGHT	DIAM	EXITYPE	RELEASETYPE	WEIRTYPE	WEIRH	WEIRW
VegetatedSwale	B	Yes	Low	1	465.4	0	0	2	3	1	0.3	23.3
Bioswale	B	Yes	Low	1	296.3	0	0	2	3	1	0.5	14.8
PermeablePaver	B	Yes	Low	1	393.5	0	0	2	3	1	0.01	19.7
PorousConcrete/Asphalt	B	Yes	Low	1	424.6	0	0	2	3	1	0.01	21.2
Bioretention	B	Yes	Med	1	220.0	0	0	2	3	1	0.75	11.0
SandFilter	B	Yes	Med	1	230.5	0	0	2	3	1	0.5	11.5
VegetatedSwale	B	Yes	Med	1	465.4	0	0	2	3	1	0.3	23.3
Bioswale	B	Yes	Med	1	296.3	0	0	2	3	1	0.5	14.8
PermeablePavement	B	Yes	Med	1	257.0	0	0	2	3	1	0.5	12.8
PorousConcrete/Asphalt	B	Yes	Med	1	424.6	0	0	2	3	1	0.01	21.2
Bioretention	B	Yes	High	1	220.0	0	0	2	3	1	0.75	11.0
SandFilter	B	Yes	High	1	230.5	0	0	2	3	1	0.5	11.5
VegetatedSwale	B	Yes	High	1	465.4	0	0	2	3	1	0.3	23.3
Bioswale	B	Yes	High	1	296.3	0	0	2	3	1	0.5	14.8
PermeablePaver	B	Yes	High	1	393.5	0	0	2	3	1	0.01	19.7
PorousConcrete/Asphalt	B	Yes	High	1	424.6	0	0	2	3	1	0.01	21.2
VegetatedSwale	C	No	Low	1	625.9	0	0	2	3	1	0.3	31.3
Bioswale	C	No	Low	1	354.1	0	0	2	3	1	0.5	17.7
DryPond	C	No	Low	1	114.3	0	0	2	3	1	3	5.7
DownspoutDisconnection	C	No	Low	1	2420.0	0	0	2	3	1	0.05	121.0
FilterStrip	C	No	Low	1	2792.3	0	0	2	3	1	0.03	139.6
VegetatedSwale	C	No	Med	1	625.9	0	0	2	3	1	0.3	31.3
Bioswale	C	No	Med	1	354.1	0	0	2	3	1	0.5	17.7
DryPond	C	No	Med	1	114.3	0	0	2	3	1	3	5.7
DownspoutDisconnection	C	No	Med	1	2420.0	0	0	2	3	1	0.05	121.0
FilterStrip	C	No	Med	1	2792.3	0	0	2	3	1	0.03	139.6
VegetatedSwale	C	No	High	1	625.9	0	0	2	3	1	0.3	31.3
Bioswale	C	No	High	1	354.1	0	0	2	3	1	0.5	17.7
DryPond	C	No	High	1	114.3	0	0	2	3	1	3	5.7
DownspoutDisconnection	C	No	High	1	2420.0	0	0	2	3	1	0.05	121.0
FilterStrip	C	No	High	1	2792.3	0	0	2	3	1	0.03	139.6
Bioretention	C	Yes	Low	1	220.0	0	0	2	3	1	0.75	11.0
SandFilter	C	Yes	Low	1	230.5	0	0	2	3	1	0.5	11.5
VegetatedSwale	C	Yes	Low	1	465.4	0	0	2	3	1	0.3	23.3
Bioswale	C	Yes	Low	1	296.3	0	0	2	3	1	0.5	14.8
PermeablePaver	C	Yes	Low	1	393.5	0	0	2	3	1	0.01	19.7
PorousConcrete/Asphalt	C	Yes	Low	1	424.6	0	0	2	3	1	0.01	21.2
InfiltrationTrench	C	Yes	Low	1	177.1	0	0	2	3	1	0.5	8.9
InfiltrationBasin	C	Yes	Low	1	259.3	0	0	2	3	1	0.5	13.0
Bioretention	C	Yes	Med	1	220.0	0	0	2	3	1	0.75	11.0
SandFilter	C	Yes	Med	1	230.5	0	0	2	3	1	0.5	11.5
VegetatedSwale	C	Yes	Med	1	465.4	0	0	2	3	1	0.3	23.3
Bioswale	C	Yes	Med	1	296.3	0	0	2	3	1	0.5	14.8
PermeablePavement	C	Yes	Med	1	257.0	0	0	2	3	1	0.5	12.8
PorousConcrete/Asphalt	C	Yes	Med	1	424.6	0	0	2	3	1	0.01	21.2
InfiltrationTrench	C	Yes	Med	1	177.1	0	0	2	3	1	0.5	8.9

BMPType	SoilType	Underdrain	Infiltration	WIDTH	LENGTH	OHEIGHT	DIAM	EXITYPE	RELEASETYPE	WEIRTYPE	WEIRH	WEIRW
InfiltrationBasin	C	Yes	Med	1	259.3	0	0	2	3	1	0.5	13.0
Bioretention	C	Yes	High	1	220.0	0	0	2	3	1	0.75	11.0
SandFilter	C	Yes	High	1	230.5	0	0	2	3	1	0.5	11.5
VegetatedSwale	C	Yes	High	1	465.4	0	0	2	3	1	0.3	23.3
Bioswale	C	Yes	High	1	296.3	0	0	2	3	1	0.5	14.8
PermeablePaver	C	Yes	High	1	393.5	0	0	2	3	1	0.01	19.7
PorousConcrete/Asphalt	C	Yes	High	1	424.6	0	0	2	3	1	0.01	21.2
InfiltrationTrench	C	Yes	High	1	177.1	0	0	2	3	1	0.5	8.9
InfiltrationBasin	C	Yes	High	1	259.3	0	0	2	3	1	0.5	13.0
VegetatedSwale	D	No	Low	1	625.9	0	0	2	3	1	0.3	31.3
Bioswale	D	No	Low	1	354.1	0	0	2	3	1	0.5	17.7
DryPond	D	No	Low	1	114.3	0	0	2	3	1	3	5.7
DownspoutDisconnection	D	No	Low	1	2420.0	0	0	2	3	1	0.05	121.0
FilterStrip	D	No	Low	1	2792.3	0	0	2	3	1	0.03	139.6
VegetatedSwale	D	No	Med	1	625.9	0	0	2	3	1	0.3	31.3
Bioswale	D	No	Med	1	354.1	0	0	2	3	1	0.5	17.7
DryPond	D	No	Med	1	114.3	0	0	2	3	1	3	5.7
DownspoutDisconnection	D	No	Med	1	2420.0	0	0	2	3	1	0.05	121.0
FilterStrip	D	No	Med	1	2792.3	0	0	2	3	1	0.03	139.6
VegetatedSwale	D	No	High	1	625.9	0	0	2	3	1	0.3	31.3
Bioswale	D	No	High	1	354.1	0	0	2	3	1	0.5	17.7
DryPond	D	No	High	1	114.3	0	0	2	3	1	3	5.7
DownspoutDisconnection	D	No	High	1	2420.0	0	0	2	3	1	0.05	121.0
FilterStrip	D	No	High	1	2792.3	0	0	2	3	1	0.03	139.6
Bioretention	D	Yes	Low	1	220.0	0	0	2	3	1	0.75	11.0
SandFilter	D	Yes	Low	1	230.5	0	0	2	3	1	0.5	11.5
VegetatedSwale	D	Yes	Low	1	465.4	0	0	2	3	1	0.3	23.3
Bioswale	D	Yes	Low	1	296.3	0	0	2	3	1	0.5	14.8
PermeablePaver	D	Yes	Low	1	393.5	0	0	2	3	1	0.01	19.7
PorousConcrete/Asphalt	D	Yes	Low	1	424.6	0	0	2	3	1	0.01	21.2
Bioretention	D	Yes	Med	1	220.0	0	0	2	3	1	0.75	11.0
SandFilter	D	Yes	Med	1	230.5	0	0	2	3	1	0.5	11.5
VegetatedSwale	D	Yes	Med	1	465.4	0	0	2	3	1	0.3	23.3
Bioswale	D	Yes	Med	1	296.3	0	0	2	3	1	0.5	14.8
PermeablePavement	D	Yes	Med	1	257.0	0	0	2	3	1	0.5	12.8
PorousConcrete/Asphalt	D	Yes	Med	1	424.6	0	0	2	3	1	0.01	21.2
Bioretention	D	Yes	High	1	220.0	0	0	2	3	1	0.75	11.0
SandFilter	D	Yes	High	1	230.5	0	0	2	3	1	0.5	11.5
VegetatedSwale	D	Yes	High	1	465.4	0	0	2	3	1	0.3	23.3
Bioswale	D	Yes	High	1	296.3	0	0	2	3	1	0.5	14.8
PermeablePaver	D	Yes	High	1	393.5	0	0	2	3	1	0.01	19.7
PorousConcrete/Asphalt	D	Yes	High	1	424.6	0	0	2	3	1	0.01	21.2

Appendix B: GI Substrate Data

BMPType	SoilType	Underdrain	Infiltration	INFILTM	SDEPTH	POROSITY	FCAPACITY	WPOINT	AVEG	FINFILT	UNDSWITCH	UNDDEPTH	UNDVOID	UNDINFILT
GreenRoof	B/C/D	Yes	0 (lined)	2	0.5	0.35	0.25	0.1	0.6	2	1	0.17	0.4	0
PanterBox	B/C/D	Yes	0 (lined)	2	2.5	0.35	0.25	0.1	0.6	2	1	0.5	0.4	0
Wetland/Wetpond	B/C/D	Yes	0 (lined)	2	0.1	0.1	0.1	0.1	0.6	0.1	0	0	0	0
Bioretention-lined	B/C/D	Yes	0 (lined)	2	2	0.35	0.25	0.1	0.6	2	1	0.5	0.4	0
SandFilter-lined	B/C/D	Yes	0 (lined)	2	2.5	0.35	0.06	0.02	1	2	1	0.5	0.4	0
VegetatedSwale-lined	B/C/D	Yes	0 (lined)	2	0.8	0.35	0.25	0.1	0.6	2	1	0.5	0.4	0
PermeablePaver-lined	B/C/D	Yes	0 (lined)	2	0.25	0.45	0.06	0.02	1	2	1	0.5	0.4	0
PorousConcrete/Asphalt-lined	B/C/D	Yes	0 (lined)	2	0.1	0.45	0.06	0.02	1	2	1	0.5	0.4	0
Bioretention	B	No	Low	2	2	0.35	0.25	0.1	0.6	0.3	0	0	0	0.3
SandFilter	B	No	Low	2	2.5	0.35	0.06	0.02	1	0.3	0	0	0	0.3
VegetatedSwale	B	No	Low	2	0.8	0.35	0.25	0.1	0.6	0.3	0	0	0	0.3
Bioswale	B	No	Low	2	1.5	0.35	0.25	0.1	0.6	0.3	0	0	0	0.3
InfiltrationTrench	B	No	Low	2	3	0.45	0.06	0.02	1	0.3	0	0	0	0.3
PermeablePaver	B	No	Low	2	2.25	0.45	0.06	0.02	1	0.3	0	0	0	0.3
InfiltrationBasin	B	No	Low	2	2	0.35	0.06	0.02	0.4	0.3	0	0	0	0.3
DryPond	B	No	Low	2	0.5	0.35	0.25	0.1	0.3	0.3	0	0	0	0.3
PorousConcrete/Asphalt	B	No	Low	2	2.1	0.45	0.06	0.02	1	0.3	0	0	0	0.3
DownspoutDisconnection	B	No	Low	2	0.5	0.2	0.15	0.08	0.3	0.3	0	0	0	0.3
FilterStrip	B	No	Low	2	0.5	0.2	0.15	0.08	0.4	0.3	0	0	0	0.3
Bioretention	B	No	Med	2	2	0.35	0.25	0.1	0.6	0.8	0	0	0	0.8
SandFilter	B	No	Med	2	2.5	0.35	0.06	0.02	1	0.8	0	0	0	0.8
VegetatedSwale	B	No	Med	2	0.8	0.35	0.25	0.1	0.6	0.8	0	0	0	0.8
Bioswale	B	No	Med	2	1.5	0.35	0.25	0.1	0.6	0.8	0	0	0	0.8
InfiltrationTrench	B	No	Med	2	3	0.45	0.06	0.02	1	0.8	0	0	0	0.8
PermeablePaver	B	No	Med	2	2.25	0.45	0.06	0.02	1	0.8	0	0	0	0.8
InfiltrationBasin	B	No	Med	2	2	0.35	0.06	0.02	0.4	0.8	0	0	0	0.8
DryPond	B	No	Med	2	0.5	0.35	0.25	0.1	0.3	0.8	0	0	0	0.8
PorousConcrete/Asphalt	B	No	Med	2	2.1	0.45	0.06	0.02	1	0.8	0	0	0	0.8
DownspoutDisconnection	B	No	Med	2	0.5	0.2	0.15	0.08	0.3	0.8	0	0	0	0.8
FilterStrip	B	No	Med	2	0.5	0.2	0.15	0.08	0.4	0.8	0	0	0	0.8
Bioretention	B	No	High	2	2	0.35	0.25	0.1	0.6	1	0	0	0	1
SandFilter	B	No	High	2	2.5	0.35	0.06	0.02	1	1	0	0	0	1
VegetatedSwale	B	No	High	2	0.8	0.35	0.25	0.1	0.6	1	0	0	0	1
Bioswale	B	No	High	2	1.5	0.35	0.25	0.1	0.6	1	0	0	0	1
InfiltrationTrench	B	No	High	2	3	0.45	0.06	0.02	1	1	0	0	0	1
PermeablePaver	B	No	High	2	2.25	0.45	0.06	0.02	1	1	0	0	0	1

BMPType	SoilType	Underdrain	Infiltration	INFILTM	SDEPTH	POROSITY	FCAPACITY	WPOINT	AVEG	FINFILT	UNDSWITCH	UNDDEPTH	UNDVOID	UNDINFILT
InfiltrationBasin	B	No	High	2	2	0.35	0.06	0.02	0.4	1	0	0	0	1
DryPond	B	No	High	2	0.5	0.35	0.25	0.1	0.3	1	0	0	0	1
PorousConcrete/Asphalt	B	No	High	2	2.1	0.45	0.06	0.02	1	1	0	0	0	1
DownspoutDisconnection	B	No	High	2	0.5	0.2	0.15	0.08	0.3	1	0	0	0	1
FilterStrip	B	No	High	2	0.5	0.2	0.15	0.08	0.4	1	0	0	0	1
Bioretention	B	Yes	Low	2	2	0.35	0.25	0.1	0.6	2	1	0.5	0.4	0.3
SandFilter	B	Yes	Low	2	2.5	0.35	0.06	0.02	1	2	1	0.5	0.4	0.3
VegetatedSwale	B	Yes	Low	2	0.8	0.35	0.25	0.1	0.6	2	1	0.5	0.4	0.3
Bioswale	B	Yes	Low	2	1.5	0.35	0.25	0.1	0.6	2	1	0.5	0.4	0.3
PermeablePaver	B	Yes	Low	2	0.25	0.45	0.06	0.02	1	2	1	2	0.4	0.3
PorousConcrete/Asphalt	B	Yes	Low	2	0.1	0.45	0.06	0.02	1	2	1	2	0.4	0.3
Bioretention	B	Yes	Med	2	2	0.35	0.25	0.1	0.6	2	1	0.5	0.4	0.8
SandFilter	B	Yes	Med	2	2.5	0.35	0.06	0.02	1	2	1	0.5	0.4	0.8
VegetatedSwale	B	Yes	Med	2	0.8	0.35	0.25	0.1	0.6	2	1	0.5	0.4	0.8
Bioswale	B	Yes	Med	2	1.5	0.35	0.25	0.1	0.6	2	1	0.5	0.4	0.8
PermeablePavement	B	Yes	Med	2	0.25	0.45	0.06	0.02	1	2	1	2	0.4	0.8
PorousConcrete/Asphalt	B	Yes	Med	2	0.1	0.45	0.06	0.02	1	2	1	2	0.4	0.8
Bioretention	B	Yes	High	2	2	0.35	0.25	0.1	0.6	2	1	0.5	0.4	1
SandFilter	B	Yes	High	2	2.5	0.35	0.06	0.02	1	2	1	0.5	0.4	1
VegetatedSwale	B	Yes	High	2	0.8	0.35	0.25	0.1	0.6	2	1	0.5	0.4	1
Bioswale	B	Yes	High	2	1.5	0.35	0.25	0.1	0.6	2	1	0.5	0.4	1
PermeablePaver	B	Yes	High	2	0.25	0.45	0.06	0.02	1	2	1	2	0.4	1
PorousConcrete/Asphalt	B	Yes	High	2	0.1	0.45	0.06	0.02	1	2	1	2	0.4	1
VegetatedSwale	C	No	Low	2	0.8	0.35	0.25	0.1	0.6	0.1	0	0	0	0.1
Bioswale	C	No	Low	2	1.5	0.35	0.25	0.1	0.6	0.1	0	0	0	0.1
DryPond	C	No	Low	2	0.5	0.35	0.25	0.1	0.3	0.1	0	0	0	0.1
DownspoutDisconnection	C	No	Low	2	0.5	0.2	0.15	0.08	0.3	0.1	0	0	0	0.1
FilterStrip	C	No	Low	2	0.5	0.2	0.15	0.08	0.4	0.1	0	0	0	0.1
VegetatedSwale	C	No	Med	2	0.8	0.35	0.25	0.1	0.6	0.2	0	0	0	0.2
Bioswale	C	No	Med	2	1.5	0.35	0.25	0.1	0.6	0.2	0	0	0	0.2
DryPond	C	No	Med	2	0.5	0.35	0.25	0.1	0.3	0.2	0	0	0	0.2
DownspoutDisconnection	C	No	Med	2	0.5	0.2	0.15	0.08	0.3	0.2	0	0	0	0.2
FilterStrip	C	No	Med	2	0.5	0.2	0.15	0.08	0.4	0.2	0	0	0	0.2
VegetatedSwale	C	No	High	2	0.8	0.35	0.25	0.1	0.6	0.25	0	0	0	0.25
Bioswale	C	No	High	2	1.5	0.35	0.25	0.1	0.6	0.25	0	0	0	0.25
DryPond	C	No	High	2	0.5	0.35	0.25	0.1	0.3	0.25	0	0	0	0.25
DownspoutDisconnection	C	No	High	2	0.5	0.2	0.15	0.08	0.3	0.25	0	0	0	0.25
FilterStrip	C	No	High	2	0.5	0.2	0.15	0.08	0.4	0.25	0	0	0	0.25
Bioretention	C	Yes	Low	2	2	0.35	0.25	0.1	0.6	2	1	0.5	0.4	0.1

BMPType	SoilType	Underdrain	Infiltration	INFILTM	SDEPTH	POROSITY	FCAPACITY	WPOINT	AVEG	FINFILT	UNDSWITCH	UNDDEPTH	UNDVOID	UNDINFILT
SandFilter	C	Yes	Low	2	2.5	0.35	0.06	0.02	1	2	1	0.5	0.4	0.1
VegetatedSwale	C	Yes	Low	2	0.8	0.35	0.25	0.1	0.6	2	1	0.5	0.4	0.1
Bioswale	C	Yes	Low	2	1.5	0.35	0.25	0.1	0.6	2	1	0.5	0.4	0.1
PermeablePaver	C	Yes	Low	2	0.25	0.45	0.06	0.02	1	2	1	2	0.4	0.1
PorousConcrete/Asphalt	C	Yes	Low	2	0.1	0.45	0.06	0.02	1	2	1	2	0.4	0.1
InfiltrationTrench	C	Yes	Low	2	3	0.45	0.06	0.02	1	2	1	0.5	0.4	0.1
InfiltrationBasin	C	Yes	Low	2	2	0.35	0.06	0.02	0.4	2	1	0.5	0.4	0.1
Bioretention	C	Yes	Med	2	2	0.35	0.25	0.1	0.6	2	1	0.5	0.4	0.2
SandFilter	C	Yes	Med	2	2.5	0.35	0.06	0.02	1	2	1	0.5	0.4	0.2
VegetatedSwale	C	Yes	Med	2	0.8	0.35	0.25	0.1	0.6	2	1	0.5	0.4	0.2
Bioswale	C	Yes	Med	2	1.5	0.35	0.25	0.1	0.6	2	1	0.5	0.4	0.2
PermeablePavement	C	Yes	Med	2	0.25	0.45	0.06	0.02	1	2	1	2	0.4	0.2
PorousConcrete/Asphalt	C	Yes	Med	2	0.1	0.45	0.06	0.02	1	2	1	2	0.4	0.2
InfiltrationTrench	C	Yes	Med	2	3	0.45	0.06	0.02	1	2	1	0.5	0.4	0.2
InfiltrationBasin	C	Yes	Med	2	2	0.35	0.06	0.02	0.4	2	1	0.5	0.4	0.2
Bioretention	C	Yes	High	2	2	0.35	0.25	0.1	0.6	2	1	0.5	0.4	0.25
SandFilter	C	Yes	High	2	2.5	0.35	0.06	0.02	1	2	1	0.5	0.4	0.25
VegetatedSwale	C	Yes	High	2	0.8	0.35	0.25	0.1	0.6	2	1	0.5	0.4	0.25
Bioswale	C	Yes	High	2	1.5	0.35	0.25	0.1	0.6	2	1	0.5	0.4	0.25
PermeablePaver	C	Yes	High	2	0.25	0.45	0.06	0.02	1	2	1	2	0.4	0.25
PorousConcrete/Asphalt	C	Yes	High	2	0.1	0.45	0.06	0.02	1	2	1	2	0.4	0.25
InfiltrationTrench	C	Yes	High	2	3	0.45	0.06	0.02	1	2	1	0.5	0.4	0.25
InfiltrationBasin	C	Yes	High	2	2	0.35	0.06	0.02	0.4	2	1	0.5	0.4	0.25
VegetatedSwale	D	No	Low	2	0.8	0.35	0.25	0.1	0.6	0.02	0	0	0	0.02
Bioswale	D	No	Low	2	1.5	0.35	0.25	0.1	0.6	0.02	0	0	0	0.02
DryPond	D	No	Low	2	0.5	0.35	0.25	0.1	0.3	0.02	0	0	0	0.02
DownspoutDisconnection	D	No	Low	2	0.5	0.2	0.15	0.08	0.3	0.02	0	0	0	0.02
FilterStrip	D	No	Low	2	0.5	0.2	0.15	0.08	0.4	0.02	0	0	0	0.02
VegetatedSwale	D	No	Med	2	0.8	0.35	0.25	0.1	0.6	0.06	0	0	0	0.06
Bioswale	D	No	Med	2	1.5	0.35	0.25	0.1	0.6	0.06	0	0	0	0.06
DryPond	D	No	Med	2	0.5	0.35	0.25	0.1	0.3	0.06	0	0	0	0.06
DownspoutDisconnection	D	No	Med	2	0.5	0.2	0.15	0.08	0.3	0.06	0	0	0	0.06
FilterStrip	D	No	Med	2	0.5	0.2	0.15	0.08	0.4	0.06	0	0	0	0.06
VegetatedSwale	D	No	High	2	0.8	0.35	0.25	0.1	0.6	0.1	0	0	0	0.1
Bioswale	D	No	High	2	1.5	0.35	0.25	0.1	0.6	0.1	0	0	0	0.1
DryPond	D	No	High	2	0.5	0.35	0.25	0.1	0.3	0.1	0	0	0	0.1
DownspoutDisconnection	D	No	High	2	0.5	0.2	0.15	0.08	0.3	0.1	0	0	0	0.1
FilterStrip	D	No	High	2	0.5	0.2	0.15	0.08	0.4	0.1	0	0	0	0.1
Bioretention	D	Yes	Low	2	2	0.35	0.25	0.1	0.6	2	1	0.5	0.4	0.02

BMPType	SoilType	Underdrain	Infiltration	INFILTM	SDEPTH	POROSITY	FCAPACITY	WPOINT	AVEG	FINFILT	UNDSWITCH	UNDDEPTH	UNDVOID	UNDINFILT
SandFilter	D	Yes	Low	2	2.5	0.35	0.06	0.02	1	2	1	0.5	0.4	0.02
VegetatedSwale	D	Yes	Low	2	0.8	0.35	0.25	0.1	0.6	2	1	0.5	0.4	0.02
Bioswale	D	Yes	Low	2	1.5	0.35	0.25	0.1	0.6	2	1	0.5	0.4	0.02
PermeablePaver	D	Yes	Low	2	0.25	0.45	0.06	0.02	1	2	1	2	0.4	0.02
PorousConcrete/Asphalt	D	Yes	Low	2	0.1	0.45	0.06	0.02	1	2	1	2	0.4	0.02
Bioretention	D	Yes	Med	2	2	0.35	0.25	0.1	0.6	2	1	0.5	0.4	0.06
SandFilter	D	Yes	Med	2	2.5	0.35	0.06	0.02	1	2	1	0.5	0.4	0.06
VegetatedSwale	D	Yes	Med	2	0.8	0.35	0.25	0.1	0.6	2	1	0.5	0.4	0.06
Bioswale	D	Yes	Med	2	1.5	0.35	0.25	0.1	0.6	2	1	0.5	0.4	0.06
PermeablePavement	D	Yes	Med	2	0.25	0.45	0.06	0.02	1	2	1	2	0.4	0.06
PorousConcrete/Asphalt	D	Yes	Med	2	0.1	0.45	0.06	0.02	1	2	1	2	0.4	0.06
Bioretention	D	Yes	High	2	2	0.35	0.25	0.1	0.6	2	1	0.5	0.4	0.1
SandFilter	D	Yes	High	2	2.5	0.35	0.06	0.02	1	2	1	0.5	0.4	0.1
VegetatedSwale	D	Yes	High	2	0.8	0.35	0.25	0.1	0.6	2	1	0.5	0.4	0.1
Bioswale	D	Yes	High	2	1.5	0.35	0.25	0.1	0.6	2	1	0.5	0.4	0.1
PermeablePaver	D	Yes	High	2	0.25	0.45	0.06	0.02	1	2	1	2	0.4	0.1
PorousConcrete/Asphalt	D	Yes	High	2	0.1	0.45	0.06	0.02	1	2	1	2	0.4	0.1

Appendix C: GI Cost Data

Description	Drainage Area Cost ($/sq ft)	Annual O&M ($/sq ft)	New Constructio n ($/sq ft)	New Construction (underdrain) ($/sq ft)	Lifespa n (years)
Bioretention		1.6	20.5	26.2	20
Bioretention (Lined)		1.6	43.75	43.75	20
Bioswale		1.59	20.5	26.2	20
Dry Pond		0.08	3.8		20
Filter Strip/Grass Buffer		1	0.75		20
Vegetated Filter Strip/Grass Buffer		1	0.75		20
Green Roof		0.44	28.1	28.1	20
Infiltration Basin/Dry Pond		0.64	20.5	26.2	20
Infiltration Trench/Basin		0.64	16	21.7	20
Permeable Pavement		0.41	8.8	12.95	20
Permeable Interlocking Paver		0.41	8.8		20
Permeable Interlocking Paver (Lined)		0.41	14.5	14.5	20
Planter Box		1.6	42.6	42.6	20
Porous Asphalt		0.41	6.8	10.95	20
Porous Asphalt (Lined)		0.41		12.5	20
Porous Concrete		0.41	9.25	0.41	20
Porous Concrete (Lined)		0.41		16.5	20

Description	Drainage Area Cost ($/sq ft)	Annual O&M ($/sq ft)	New Construction ($/sq ft)	New Construction (underdrain) ($/sq ft)	Lifespan (years)
Rain Barrels	0.3				20
Sand Filter		0.64	12.8	18.5	20
Sand Filter (Lined)		0.64		34.9	20
Vegetated Swale		1	2.41	8.11	20
Vegetated Swale (Lined)		1		9.66	20
Wetlands		0.09	2.3		20
Wet Pond		0.26	6.6		20
Filter Strip with Level Spreaders	4.7	1			20
Dry Wells		1.34	26.1		20
Disconnected Downspouts	0.3				20